Research Article

Vysikaylo' Laser for Electron de Broglie's Waves on the Protection of the Earth from Meteoroids

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Abstract

We discuss our proposed general mechanism that explains all phenomena observed in nature during the propagation of electric arcs, lightning, and all phenomena during the fall introduction of the Chelyabinsk 2013 meteorite into the Earth's atmosphere. All these positively charged cumulative-dissipative plasma structures are surrounded by the Vysikaylo's incongruent shock waves of the electric field, as studied by the author and co-authors earlier. We prove that de Broglie' waves of free electrons in the plasma tail of a meteoroid behave like electromagnetic waves in a quantum resonator (laser) and form a beam (jet) of high-energy electrons escaping into the meteoroid and thereby exploding it with a Coulomb's explosion. We prove that lasers for de Broglie waves of electrons with a resonator length from 10 cm to 30 km and a diameter of about 18 m are realized in nature and can be described theoretically. This gives us reason to use this mechanism to explain the joint organization of the opposing jets of protons from black holes and electrons directed into black holes. These laser-like jets have already been observed in Hubble-type telescopes and have a length of up to 1.5 kpc. Therefore, our cumulative-dissipative (reactive) mechanism can explain the increased velocities of the active neutron stars. Based on our analysis, we proposed and investigated a new 4D inertial-polarization-quantum cumulative-dissipative Vysikaylo's mechanism for the fragmentation of meteoroids and small asteroids (self-defense of the Earth from meteoroids) into simple ions and electrons. On this basis, we have proposed a new mechanism for an external combustion engine with an efficiency of 50% and detailed the Le Chatelier-Browne principle.

Keywords: Vysikaylo's Plasma Cumulative Dissipative Structures, Coulomb Explosion, Runaway Electrons, Impulse Advancement of Lightning, Schonland's Lightning Experiments (1934-1937), Vysikaylo's Mechanism of Meteoroid Fragmentation

1. Introduction

De Broglie reported that particles behave like waves. The author proves that de Broglie waves of free electrons in the plasma tail of a meteoroid behave like electromagnetic waves in a quantum resonator (laser) and form a beam (jet) of high-energy electrons directed into the meteoroid. A jet of high-energy electrons formed in the plasma tail behind the meteoroid sprays the meteoroid with the help of a Coulomb explosion (or a series of them). This phenomenon in the Vysikaylo's plasma cumulative-dissipative structure radially limited by Coulomb barriers [1-8] in the plasma tail behind the meteoroid ~30 km long (Fig.1), is associated with the cumulative and dissipative processes of the transformation of the mechanical energy of the entire meteoroid into electrical energy and then into the energy of meteoroid destruction and its spray up to positive ions and electrons. These phenomena have an energy threshold and occur when it is reached. The author proves that in the case of the Chelyabinsk meteoroid, its energy (speed) is sufficient to form a beam of high-energy electrons fragmenting the meteoroid (by striking from behind) with a Coulomb explosion. The kinetic energy of the

meteoroid is sufficient for this with a margin.

In this phenomenon, as proved in this article, the virial theorem is fulfilled: half of the Coulomb energy (equal to the kinetic energy of the meteoroid) goes to form a beam of high-energy electrons catching up with the meteoroid, and the other half goes to dumping positive ions along the plasma tail behind the meteoroid, in the direction opposite to the motion of the meteoroid. In the radial direction in the plasma trail, visible plasma self-focusing occurs. This self-cumulation is due to the formation of a Coulomb barrier for electrons, similar to the Coulomb barrier in linear lightning. The plasma trail behind the Chelyabinsk meteoroid reaches a length of 30 km, which corresponds to a characteristic relaxation process time of 1.5 s. This is how Vysikaylo's cannon is formed, shooting at the meteoroid into the meteoroid by electrons accelerated in a positively charged plasma column behind the meteoroid.

Positive ions are ejected in the opposite direction of the meteoroid motion through the plasma channel created by the

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meteoroid. Based on this idea, we proposed and investigated a new 4D inertial-polarization-quantum cumulative-dissipative Vysikaylo's mechanism for the fragmentation of meteoroids and small comets (self-protection of the Earth from meteoroids) into simple ions and electrons. The mechanism is based on the similar coherent behavior of the de Broglie waves of electrons in the plasma tail behind the meteoroid and in front of the pulsed lightning from the negatively charged clouds. The formation of a cumulative electron jet in front of an impulsively moving lightning was studied in detail in the experiments of Schonland et al. in 1934-1937 [9]. The physical explanation of such functioning of lightning (~2 km in size) from negatively charged clouds to positively charged clouds was first given in [3]. In this work, based on experimental and photographic observations of the Chelyabinsk meteoroid penetration, the author has formulated a theoretical model of all accompanying phenomena.

2. Date and Methods
2.1. Observations of Events Near Chelyabinsk
On 15 February 2013, NASA scientists reported that an explosion with a capacity of 300 kilotons in TNT equivalent of a space object measuring $\sim$ 15 meters in diameter occurred near Chelyabinsk. As is known, sensors installed on geostationary satellites operating in the interests of the US Department of Defense and Department of Energy can track both airborne nuclear explosions and measure the luminosity curves of fireballs burning up in the atmosphere. Based on them, on 1 March 2013, NASA became aware of updated data on the total luminosity of the super-bolide, which amounted to $E_0 = 3.75 \cdot 10^{14}$ J or 90 kt, from which, according to the empirical formula for the total energy of

the explosion, follows $E = 8.2508 \, E_0^{0.885}$, which is 440 kt. The speed of the fireball according to the same data at the moment of maximum brightness was 18.3 km/s, and the event occurred at an altitude of 23.3 km [10]. The estimated mass and size of the meteoroid at a density of 3.6 t/m^3 were 11,000 tons and a diameter of about 18 meters.

NASA estimates that it is the largest known celestial body to hit Earth since the Tunguska meteorite fell in 1908, and corresponds to an event that occurs on average once every 100 years. Due to the trajectory of the body's entry, only a relatively small part of the explosion energy reached the populated areas. The shockwave injured 1,613 people, most from broken windows. According to various sources, from 40 to 112 people were hospitalized; two victims were placed in intensive care. The shock wave damaged the buildings. Material damage was preliminary estimated from 400 million to 1 billion rubles ($15 million). Where the bulk and energy of the meteoroid went is still a mystery to mechanical astrophysicists.

Only Marat Akhmetvaleev, a nature lover of his region, and another photographer unknown to me managed to photograph and present to the public the unique details of this event (Fig. 1). Based on his photographs and our knowledge of the physics of the Vysikaylo's cumulative dissipative plasma structures, we will explain where the main part of the meteoroid went and how kinetic energy was dissipated in the atmosphere and ionosphere of the Earth. We detail the pulse-periodic mode of execution of the virial theorem.

Figure 1: Photographic Evidence of Plasma Cumulation in a Meteoroid's Wake. This is a Photograph (Marat Akhmetvaleev, 2013) of the Coulomb Explosion (Vysikaylo, 2013) [3] that Breaks the 2013 Chelyabinsk Meteoroid to Ions and Electrons. This Phenomenon is Clearly Electrical in Nature, like the Sparking of Contacts in a Trolleybus or Tram, or a Cathode Spot that "Spits Out Pieces" of the Cathode (See (Vysikaylo,2013; Vysikaylo, 2023) [3,8] for More Details)

From the photograph (Figure.1), we can see that the length of the plasma tail is significantly 1.5 times greater than the height of the explosion 23 km. From the rough geometric comparisons, this length is about 30 km. This indicates the existence of plasma for $\sim$ 1.5 seconds after the meteoroid passes. In this case, the plasma does not scatter as a neutral medium, but is focused by the forces of cylindrical cumulation, as in the case of cylindrical lightning. This clearly indicates the similarity of the self-focusing processes of cylindrical plasmoids to their cumulation lines [5].

Of particular scientific and practical interest is the behavior of the meteoroid fragments in Fig. 1. They fly not only in different directions from the meteoroid's body, but even forward, accelerated by some force acting behind the meteoroid. This clearly indicates a new mechanism for the fragmentation of meteoroids. It should be noted here that the speed of the meteoroid at the moment of its destruction is 18.3 km/s, which is significantly higher than the speed of any detonation waves of any explosives known to mankind. Therefore, such velocities can occur only in electron beams

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accelerating in an electric field in the wake of a meteoroid! These phenomena and interactions occur at the speed of light or close to this speed with an increase in the characteristic sizes of the positively charged Vysikaylo's cumulative-dissipative structures (+CDS) [3,8].

The fall of Chelyabinsk's 2013 meteoroid was accompanied by the phenomenon of an "electrophone fireball," that is, sounds (crackling) caused by electromagnetic discharges in the atmosphere that appeared from the passage of the fireball. Several dozen witnesses reported that during the passage of the meteoroid, a few minutes before the arrival of the shock wave, they heard a hissing sound similar to the sound of sparklers burning, i.e. long before the arrival of the shock wave. As Stanislav Korotky, head of scientific projects at the Ka-Dar observatory, suggested, since sound waves cannot travel distances of tens of kilometers in a fraction of a second, we are talking about the phenomenon of an "electrophone fireball." However, he did not propose a mechanism for accelerating electrons. This phenomenon can only be explained by the electromagnetic interaction of polarized charged structures or the precipitation of high-energy electrons from positively charged plasma cumulative-dissipative structures such as lightning [3,8], as presented in Fig. 1. These phenomena and interactions occur at the speed of light or close to this speed as the characteristic dimensions of these structures increase.

A few days after the fall of the Chelyabinsk meteorite, reports of observations of anomalous noctilucent clouds appeared at altitudes of 75-80 km. A similar phenomenon occurred in 1908 after the fall of the Tunguska meteorite. This time, ground-based observations of the noctilucent clouds were confirmed by satellite data. Mechanical models cannot explain the release of water vapor from the meteoroid to such heights.

The search for the remains of the meteorite resulted in a mass not exceeding 1 ton (~0.01% of the total mass of the meteoroid). All services involved in space, astrophysics and protecting the Earth from meteoroids in Russia were unable to provide video materials of this unique phenomenon and did not offer the public a single photograph of a meteoroid explosion. Protecting the Earth is still the business of all ordinary earthlings. We are grateful to Marat Akhmetvaleev and other authors of photographs and videos for visualizing this phenomenon (Fig.1).

According to RIA Novosti data dated March 21, 2013, the Chelyabinsk fireball (luminous meteoroid) caused magnetic storms in the Earth's ionosphere, similar to storms that occur when solar wind penetrates into the Earth's ionosphere (RIA News 03/21/2013). At the same time, according to a statement by IZMIRAN employees, the disturbances affected almost the entire ionosphere. Thus, according to Givi Givishvili, fluctuations in the concentration of electrons in the F2 ionospheric layer (about 250 kilometers high) were recorded 5.5 h after the explosion at the ionospheric station in Yekaterinburg (V_a = 10 m/s), 6 h later in Rostov-on-Don (V_a = 79 m/s) and 7 h later in Moscow (V_a = 60 m/s). The speed

of longitudinal propagation of plasma disturbance along the trajectory of the meteoroid in the direction of Moscow (it was flying from Omsk) after its destruction is equal to 1,500 km/7 hours = 214 km/hour = **60 m/s**. This speed is more than 4 times less than the speed of sound at altitudes from 20 to 500 km. This velocity corresponds well to the maximum possible velocity of ambipolar drift in nitrogen plasma in breakdown fields) [6]. "The electron concentration at altitude changed by 2.7 times, while the height of the F_2 layer was 270 and suddenly decreased to 220 km, the layer "bent" down. "This is similar to magnetic storms provoked by coronal ejections on the Sun," experts said at a seminar at the Sternberg Astronomical Institute. "At an altitude of 100 km, this has been observed many times with the influence of fireballs and meteor showers on the ionosphere, but never before have their effects affected altitudes above 100 km. At an altitude of 100 km, this has been observed many times, but now it turns out that the entire ionosphere is breathing, even at an altitude of 250 km. Breathing was observed, but there was no real explanation.

According to their terminology, they believe that magnetic fields determine everything in these processes. The author proves in his works that flows of charged particles (caused by electric fields) are the source of magnetic fields, the role of which is small (in the parameter v/c) compared to electric fields.

These experts are still trying to understand exactly what mechanisms provoked such disturbances." The disturbance zone was local—it was a long "tongue" moving westward, the width of which in the Yekaterinburg region was about 100 km, and on the Moscow-Rostov meridian was about 500-600 kilometers. Without considering the violation of electrical neutrality and the formation of cumulative oppositely directed jets of electrons and positive ions, none of the astrophysicists for 12 years could explain all these phenomena (Fig. 1).

2.2. Mechanical Models and Their Problems
2.2.1. In Explaining the Phenomena of Meteoroid Destruction
Recently, the problem of the asteroid-comet threat has received considerable attention (in words). Scientific conferences are held regularly, hundreds of articles and a number of books have been published see, for example [11-14].

The theoretical state of the issue of the destruction of cosmic bodies upon entry into the atmosphere in the times preceding the Chelyabinsk meteoroid was briefly and essentially presented by a mechanician, academician of the Russian Academy of Sciences S.S. Grigoryan (Institute of Mechanics of M.V. Lomonosov Moscow State University, Moscow) in [15]. S.S. Grigoryan completed two works, in which quantitative estimates were made of all the effects accompanying the movement of bodies in the atmosphere at cosmic speeds, and a relatively simple quantitative theory of the phenomenon was constructed, understandable not only to narrow specialists [16,17]. Much later (17 and 14 years

later) this theory was "rebuilt" by the Americans (J.N. Hills, M.P. Goda). According to, V.A. Bronshten supplemented the theory of S.S. Grigoryan, taking into account the ablation (evaporation) of meteoroid material, which gives a slight correction to the main dynamics [15,18]]. Thus, according to, the problem was solved in principle. Figure 2 shows a diagram of the destruction of meteoroids in accordance with the mechanical model of S.S [15]. Grigoryan. The work of S. S. Grigoryan, devoted to the theory of fragmentation of very large and giant meteoroids, with characteristic dimensions of 10-100 m [17]. This makes it possible to neglect the loss of mass due to evaporation, i.e. to consider the motion of a body of constant mass. In the work not only the fragmentation itself is considered, but also the deformation and spreading of the fragmenting mass, taking into account the braking of the fragments [17]. Under the action of the pressure of the oncoming air flow, the destruction of the body occurs. The main role in it is played by compressive stresses (in contrast to the case of peeling), and the destruction front spreads further along the body as it penetrates into increasingly dense

layers of the atmosphere. Then the deformation of the body occurs, melting of its surface begins (bodies fly and melt, like an eskimo according to Putin, even at a speed of 3 km/s as in the case of Oreshnik) and dispersion of the fragmented material. There is no doubt that the basic principles of Grigoryan's theory can also be applied to the case of smaller bodies, when it is necessary to take into account the parallel processes of evaporation and fragmentation.

According to Bronshten, "we still have a poor understanding of how the fragmentation process itself occurs [12]. To clarify this issue, special experiments are needed, as well as further theoretical studies. "And so we are presented with experiments of nature in the form of the Chelyabinsk meteoroid and in the form of photographs by Marat Akhmetvaleev (Fig. 1). In addition, there are still no explanations for all the phenomena observed during the penetration of the Chelyabinsk asteroid into the Earth's atmosphere. My works are an exception [4].
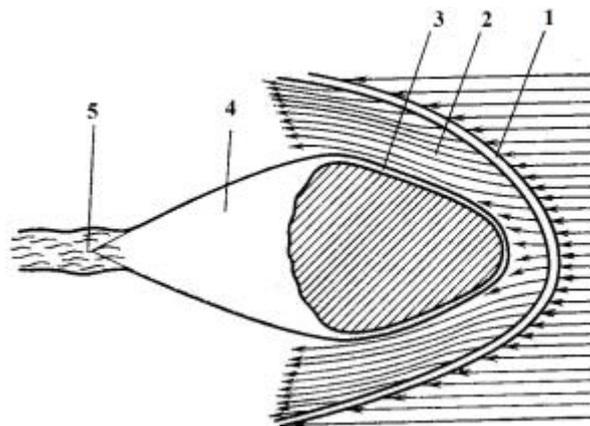

Figure 2: General 3D Diagram of Shock Wave Elements: 1 – Shock Wave Front, 2 – Shock (Compressed) Layer, 3 – Boundary Layer, 4 – Stagnant Zone, 5 – Trail

From a comparison of Grigoryan's model (Fig. 2) with the photograph in Fig.1 it is clear that:

- When a meteoroid is destroyed, its parts acquire additional acceleration not only in the direction perpendicular to the vector of its speed, but also in the direction of its movement. Note that the speed of the meteoroid is 18.3 km/s. The speed of detonation waves in explosives is significantly lower (less than 10 km/s). Within the framework of the mechanical model (Fig.2), this behavior of the meteoroid explosion (Fig.1) is inexplicable. To explain this behavior of parts of the meteoroid, it is necessary to have particles moving behind the meteoroid at speeds significantly greater than the speed of the meteoroid (18.3 km/s). Only electrons can be such particles due to their low mass.

- The plasma tail (train) of the meteoroid in Fig. 1 clearly does not correspond to Grigoryan's mechanical model with an expanding tail (Fig. 2). Within the framework of the mechanical model, there are no processes that cumulate plasma in the trail, therefore the physics of the narrowing in the tail in Fig. 2 is not revealed. All mechanical models are unable to explain the clearly

observed phenomenon of plasma cumulation in the tail of the meteoroid over 1.5÷2 s (Fig. 1). According to the mechanical model, the characteristic size of the meteoroid's tail should expand at the speed of the Mach shock wave (Fig. 2).

- Grigoryan's model does not take into account and does not discuss the virial theorem, which is valid for any mechanical system, including atoms and even atomic nuclei [19]. According to this theorem, half of the meteoroid's potential energy must return to the meteoroid's arrival region. We detail this process in the introduction of asteroids and meteoroids into the planetary atmosphere.

Thus, comparison of photograph 1 with Fig. 2 shows the inconsistency of Samvel Samvelovich Grigoryan's mechanical model for explaining even the results presented in Fig. 1. The remaining modifications of his mechanical theory, including those made by Chernogor for other meteoroids, do not deserve close attention. His research led to the conclusion: "The role of the dust component of the plasma was insignificant" [20-23].

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In works based on mechanical models of destruction of meteoroids and asteroids, only Mach shock waves are considered. Mach shock waves compress bodies penetrating the Earth's atmosphere (Fig. 2) and thus destroy this body by acting on it from the front.

The author draws attention to the formation of the Vysikaylo shock waves of electric field, leading to the action of Coulomb forces on such bodies from behind.

2.3. Vysikaylo's Classification of Shock Waves
Three types of shock waves are currently known [24,25]:
- Shock waves (or sharp jumps in parameters) in gas dynamics. Their study began with the work of Mach (1881) - Austrian physicist, born in Czechoslovakia.
- Magnetic field shock waves were described by R.Z. Sagdeev in 1961-1962 in the USSR.
- Shock waves of the electric field, described theoretically and experimentally in detail in the works of P.I. Vysikaylo in the USSR, see references in [6,24]. Although, Vysikaylo's shock waves were observed by Faraday, then by Klyarfel'd (1952) in the form of standing and traveling layers in gas-discharge plasma in tubes, and by Gunn (1963) in the form of current oscillations in semiconductors. The cumulation of shock electromagnetic waves was of theoretical interest to E.I. Zababakhin (1957; 1965; 1988). However, the main results on experimental and theoretical research and proof of the existence of electric field shock waves were obtained in the works of P.I. Vysikaylo and his co-authors for almost 40 years, see references in [6,24-26].

2.4. General Analysis of the Chelyabinsk's 2013 Meteoroid Phenomenon
Therefore, according to NASA calculations, a meteoroid with a diameter of about 18 meters and a mass of about 11 thousand tons entered the Earth's atmosphere in the Chelyabinsk region at a speed of about 18.3 km/s and almost all disappeared into the electronegative (air) atmosphere of the Earth. The entire kinetic energy of the meteoroid is on the order of $WM \approx 2 \cdot 10^{15}$ J. How was all this energy and mass of the meteoroid focused and where did they go? They brought such insignificant damage to the population of Russia. Judging by the duration of the atmospheric flight, the meteoroid entered at a very acute angle. About 32.5 seconds after entering the atmosphere, the celestial body completely collapsed at an altitude of 23.3 km from the Earth, where the air density does not exceed 4% of the density on the Earth's surface. According to statements by participants in the event, the destruction was a series of phenomena accompanied by the spread of shock waves and crackling sounds, creating the impression that someone was shooting at the meteoroid. This is also indicated by the features of the dispersal of meteoroid parts in Fig.1. Nonsense about good aliens and air defense missiles that destroyed the Chelyabinsk 2013 meteoroid appeared in literature and popular programs in RF. The editors of these programs do not understand that the entire West does not have effective anti-missile defenses against Russian supersonic missiles with a speed of only 2.7 km/s. And, here the speed is 7 times higher (18.3

km/s). This is not supersonic or hypersonic, but this is fast hypersonic (12.3÷30.7 km/s). The speeds of combat missiles neither in Russia nor in Iran have yet reached such speeds. A new mechanism for such rockets with efficiency 50% is proposed in this work, but the author hopes that it will not be implemented for special purposes for another 20-30 years. During this time, the elites in the United States become aware of Hegel's law of the unity and struggle of opposites (and their mutual development, not destruction).

According to NASA estimates, we get that 20% of the total energy of the meteoroid goes to radiation - 90 kt. This means that the energy of the meteoroid is used to destroy itself, i.e. the plasma tail not only wags the meteoroid (the dog), but also participates in its destruction. The mechanical model, in principle, cannot explain this phenomenon. The total energy received by air molecules due to collisions with a meteoroid during the entire flight of the meteoroid (before its destruction) does not exceed $8 \cdot 10^6$ J. Moreover, the energy received by one air molecule during a collision with a meteoroid is about 50 eV. This energy is sufficient for complete ionization and dissociation of all air molecules in the meteoroid's wake. In this case, the temperature of the electrons in the plasma tail of the meteoroid will be about 50-25 = 25 eV or 250÷300 thousand degrees. At this temperature, electrons leave the area of collision of air molecules with a meteoroid in a microsecond. Wake polarization occurs, in which a significant portion of the plasma energy in the wake of the meteoroid is retained in the form of potential Coulomb energy. Due to the polarization of the plasma in the meteoroid's wake, dynamic Coulomb surface tension is generated. This tension localizes energy in the plasma tail. This creates a cylindrically symmetrical tube of fully ionized plasma behind the meteoroid. The potential energy of a meteoroid at a small angle of entry into the Earth's gravitational field is no more than 10^{10} J. All these energies are significantly less than the kinetic energy of the meteoroid $2 \cdot 10^{15}$ J and the radiation energy recorded by NASA - $4 \cdot 10^{14}$ J. This means that the energy external to the meteoroid is not enough for such a glow, observed at the moment of its spraying. Thus, we, on the basis of the photograph in Fig.1, have proven that, according to the law of conservation of energy and the directions of explosion fragments in Fig.1, the mechanical model (Fig.2) in principle cannot explain such a spray of a meteoroid in all directions at a speed greater than the speed of the meteoroid (Fig.1).

2.5. General Analysis of Phenomena and Criticism of the Mechanical Model
We detail the problem (observed electrical phenomena) based on the most detailed work [13]. This work is a transition between the mechanical model of Grigoryan and the electrical model of Vysikaylo. In this work, Chernogor most fully collected the observed effects, but since he did not analyze the electrical mechanism in full, there are obvious errors in this work, which we will focus on:
- The appearance of noctilucent clouds at a height of 75 - 80 km after the destruction of the meteoroid was ignored. The Ignoring is due to the absence in the mechanical model of pulsating coherent processes

of electrical neutrality violation and Chernogor's misunderstanding of the architecture of the cumulative transfer of positively charged ions to the upper layers of the atmosphere along the cylindrical plasma channel (Fig.1) [4,8]. They are dropped through a huge tube, radially focusing streams of positive ions, to a height of 75 - 80 km.

- The mechanism of obtaining an additional "mysterious" impulse by a number of meteoroid fragments, in relation to the impulse of the main part of the meteoroid, is not explained. An additional "mysterious" impulse does not slow down all possible fragments, which A.F. Chernogor calls a quasi-liquid, according to the action of a shock wave according to a mechanical model (Fig.2), but to their powerful acceleration (see Fig.1). In principle, a quasi-liquid cannot behave like this! What particles of a fully ionized plasma can accelerate parts of a meteoroid moving at a speed of 18 km/s, significantly exceeding the speed of not only shock, but also detonation waves. For example, the detonation speed of pyroxylin is up to 6.8 km/s, nitroglycerin is up to 8.2 km/s, hexogen is up to 8.4 km/s, and only octogen is 9.1 km/s, but this speed is many times less than the meteoroid' speed. In plasma, only electrons have speeds greater than 18 km/s. The author proves that it is the accelerating (runaway) electrons, which form into cumulative jets, overtaking the meteoroid due to inertia, that cause all the "mysterious" phenomena recorded (Fig.1).

- Not explained (ignored) the nature of the explosion, carrying parts of the meteoroid in different directions with huge speeds, clearly exceeding the initial speed of the meteoroid as a whole (Fig.1). Within the framework of the classical mechanical model (Fig.2), it is impossible to explain such an obviously accelerated separation of parts of the meteoroid. Within the framework of classical mechanics, S.S. Grigoryan and his followers, the meteoroid is squeezed by the main shock wave in front and from the sides (Fig.2), and is not accelerated by it from behind! Such a scattering of pieces of a meteoroid, as observed in Fig.1, in principle, cannot be only because of the compression of the meteoroid by a shock wave according to the mechanical model of Fig.2.

To explain such an explosion (see Fig.1), we need a completely new physics and a new model of Coulomb initiation of fragmentation of the rear part of the meteoroid. Such a model of the subsequent explosion of small parts of the meteoroid, which amplify the cumulative jets (CJ) of electrons embedded in the meteoroid and ultimately change the trajectory of the meteoroid, was formulated by us in [4,8]. (See below);

1. In, characteristic times are indicated: the formation of turbulence (10^{-2} - 10^{-1} s), attachment of electrons to oxygen molecules and recombination with meteoric ions (10^{-2} - 10^{-1} s) [13]. However, the plasma wake (Fig.1) does not expand, which means that its is also focused, and its length is more than 30 km, i.e. characteristic relaxation times are more than 1.5 second. This clearly indicates the presence of not only dissipative (scattering) processes, but also cumulative processes that focus energy, mass, momentum, and angular momentum in the plasma wake [4,8].

2. In it is ignored the discussion of a very important problem noted in almost all serious works and monographs devoted to the meteorite-comet-asteroid problem associated with a sudden, sometimes pulsating, local increase in the brightness of the bolide. I will quote in full the text from [13,19,27]. "A very interesting and quite often recurring phenomenon is fireball flashes, consisting in a sudden increase in brightness localized in time. At present, there is no gas-dynamic model of a bolide flare... Perhaps one of the causes of flares is fragmentation, but to substantiate this hypothesis, it is necessary to build an appropriate gas-dynamic model. The question of the nature of the outbreak can only be resolved by the joint efforts of observers and specialists in mathematical modeling." Here: "A distinction is made between finely dispersed fragmentation, which probably occurs due to the action of thermal stresses in the near-surface layer of a meteoroid, and fragmentation into large fragments. The presence of the latter process is confirmed by the structure of the fallen meteorites. In a number of works, the process of finely dispersed fragmentation is singled out as the main mechanism for the removal of the mass of a meteoric body. The question of the fragmentation of a meteoroid body is beyond the scope of this book" [27].

The 4D mechanisms of fragmentation, deceleration, acceleration, feedback closure of these processes (following from the virial theorem) and pulsations of the glow of a collapsing meteoroid body (bolide) are the main issues in the formulation of the problem in this article. The answers to these questions are based on the properties of the cumulating plasma in lightning [8]. Here, a completely new cumulative-dissipative plasma-beam mechanism of Coulomb initiation and maintenance of cascade fragmentation of large meteoroids is proposed, substantiated and detailed in a number of plasma-chemical reactions. The feedback mechanism is based on the coherent phenomena of de Broglie waves of electrons and ions in positively charged plasmoids in the Earth's electronegative atmosphere. As a result of these phenomena: the formation of a beam (CJ) of high-energy, "runaway" electrons, penetrating into the meteoroid from behind and the Coulomb explosion of a part of the meteoroid, the meteoroid is periodically fragmented into parts. At the first moment of introduction of the CJ of electrons into the meteoroid, apparently, its weak fragmentation occurs, since the energy concentrated only in completely ionized air is not enough. In this case, when the mechanism of acceleration of small parts of the meteoroid by the electron CJ is switched on, their faster motion than that of the main meteoroid is possible (Fig.1). Already the cumulation of the entire kinetic energy of powerful explosions of small parts that fell off behind the main meteoroid and its transformation into the energy of electrons escaping into the meteoroid closes the feedback in the process of Coulomb fragmentation and leads to catastrophic fragmentation of the meteoroid, as energy is periodically accumulated in the plasma wake behind the meteoroid. The crushed small parts are powerfully decelerated by air due to greater friction, explode and are completely ionized, while the kinetic energy of this part of the meteoroid is locally re-

leased and accumulated in the plasma wake as the internal energy of the plasmoid. This energy already corresponds to the density of the meteoroid and ~ 200 eV per meteoroid atom. According to the virial theorem, half of the potential and internal energy of the plasma wake is returned to the meteoroid, and the second is ejected into the upper layers of the atmosphere through the plasma self-focusing channel.

It turns out that smaller parts of the meteoroid can overtake and even overtake the main part of the meteoroid, since a self-forming jet "engine" can be more effective in accelerating smaller fragments than a jet "engine" accelerating the main part of the meteoroid (goose wedge effect. Here the role of the greater inertia of the main meteoroid' mass in comparison with the small parts of the meteoroid is demonstrated). In this case, a small part of the meteoroid can overtake and destroy the main part of the meteoroid. All the kinetic energy of the exploding small parts is converted into electrical energy, and then part of it into the energy of the glow of the fireball, which increases its luminosity many times over at this moment of Coulomb-explosive fragmentation initiated by Coulomb explosions of the back of the meteoroid. In this case, the energy concentrated in the mass of fragmented meteoroid particles is displayed, and not only the energy transferred to the air molecules by the meteoroid and obtained during ablation (evaporation). At the moment of explosions of the breakaway parts, a shock wave is formed, behind the meteoroid, which accompanies each time the destruction of the meteoroid by CJ of high-energy electrons. The main destruction of the meteoroid from behind arises and develops as a chain reaction as a result of explosions of small parts that have broken away from the meteoroid. The local behavior of the meteoroid and the corresponding fireball, it would seem, can be explained within the framework of only a mechanical model, taking into account the cumulative effects that manifest themselves during the simultaneous explosion of several pieces of the meteoroid and the formation of a reverse cumulative plasma jet, but the speed of the meteoroid is huge and the whole range of accompanying phenomena the introduction of a meteoroid can only be explained with the involvement of the physics of extended cylindrical cumulative-dissipative positively charged plasma structures - plasmoids that shoot by CJ of high-energy electrons into the meteoroid and by the reverse jet of positive ions to heights up to 80 km [4].

The main question of this work is how electrons (to fulfill the virial theorem) transfer ½ of the energy from exploding small fragments back to the Chelyabinsk 2013 meteoroid moving in the atmosphere at a speed of about 18 km/s. If the electron CJ penetrates into the rear of the meteoroid, then both the spray and the release of the kinetic energy of the sprayed part of the meteoroid occur here - behind the meteoroid, and not at the front of the shock wave - in front of the meteoroid, as follows from the Grigoryan's mechanical model. According to the model, only the introduction of the CJ of electrons leads to further acceleration and change in the trajectory of the meteoroid, which receives the next impulse from the explosion of the already dispersed part of the meteoroid [4]. The presence of explosions of broken off small parts behind

the meteoroid and the transformation of their energy into the energy of the CJ of electrons contributes to the further destruction of the meteoroid, changing its trajectory, and even accelerating its fall. So, according to this scheme, a self-organizing, behind a rapidly moving object, impulse plasma jet engine sparkling with radiation (Fig.1), shedding mass due to crushing of the back of the meteoroid;

- The mechanisms that ensure the fulfillment of the virial theorem or Newton's third law in a continuous medium (air) when a meteoroid penetrates at a speed of about 10 km/s - 70 km/s into the Earth's atmosphere have not been studied.
- As for the explanation in of the electrophonic effect, here Chernogor obviously forgets about the Gauss's theorem in 4D space-time [13].

I am detailing point 7. As is known, the electrophonic effect is understood as the audibility of sound by a person at great distances from a meteoroid during the passage of large cosmic bodies and long before the acoustic disturbance generated by the movement of the body has time to reach the observer. The theory of this 4D phenomenon occurring at the speed of light or close to it is considered to be not developed in detail until now [13]. The foundations of this theory are outlined in on the basis of coherent phenomena in the event of violation of electrical neutrality in the wake of a meteoroid [4,8].

According to Chernogor's erroneous ideas [13] (based mainly on a mechanical model), there are two (I and II) probable mechanisms that can qualitatively explain the electro-phonic effect observed by a number of witnesses of the appearance of the Chelyabinsk's 2013 meteoroid.

"A cosmic body, when falling in air, acquires an electric charge, under the influence of which a charge of the opposite sign flows from the surface of the earth. The latter is accompanied by an acoustic effect. According to estimates, the charge drain begins at an electric field strength on the order of a few kV/m. In the case of the Chelyabinsk meteorite, the intensity reached 0.5 - 5 MV/m" [13].

In this mechanism, Chernogor forgets that fields with a strength of 0.5 - 5 MV / m quasi-stationary arise and, according to his own calculations, only in the region of the shock wave, i.e. next to a meteoroid with a radius - R, stuck into the Earth's atmosphere. I note that these fields, obtained in Chernogor's estimates, even at a height of 20 km are 50 times higher than the breakdown ones, which is very doubtful for gas-discharge air plasma, in which even in nanosecond discharges it is possible to increase the breakdown values of the E/N parameter by only on 2 times up to ≈ 150 Td. At distances L of the order of 20 km or more from the meteoroid, even the erroneously obtained Chernogor's electric fields become negligible due to the geometric reduction factor following from the Gauss theorem, $\xi = (R/L)^2 \approx 10\text{-}6$.

From these fields, there will be no "chirring" (before the arrival of the shock wave) at distances L ~ 23 km (and more) if it is within the framework of a mechanical model that does

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not take into account long-range Coulomb potentials and characteristic dimensions of the plasmoid exceeding 30 km. "Chernogor's chirping" will be heard only near the meteoroid, at a distance of the meteoroid radius - R. At a distance R from the meteoroid, there were no listeners, fortunately for them. In Moscow, there is the institute VEI named after Lenin, where there is an installation that simulates lightning. There, the electric field strengths are of the same order (~ 3 MV / m) and its dimensions are about 10 m, but the residents of Moscow, even on the neighboring street, have no "Chernogor' chirring" in their ears.

According to "Electromagnetic waves of the sound range due to the piezoelectric effect in objects surrounding the observer, or in the person himself, are converted into sound [13]." According to Chernogor, "at f ~ 1 kHz, the electric field strength should be at least hundreds of V/m. Such fields arise on the earth's surface at the current strength in the trace $I = 5*10^4$ A" (Chernogor). Here Chernogor has a trace in which "mysterious" currents flow, which, in principle, cannot be in his initially neutral mechanistic model without taking into account the violation of electrical neutrality in the trace. Such a sharp transition from the mechanical model to the cylindrical and electrodynamic model with currents looks somewhat strange when explaining the electrophonic effect. In mechanism II, Chernogor relies on Tesla's frequency discharge and again gives the necessary condition for "chirring" - more than 100 V/m, which, in principle, is not realized according to the mechanical model at distances of more than 23 km from the meteoroid due to the same geometric reduction factor $\xi \approx 10^{-6}$. And in this case, Chernogor does not want to involve the size of the plasma tail of the order of 30 km, observed in Fig.1.

In the case of the Chelyabinsk's 2013 meteoroid, the electrophonic effect was observed at distances of more than 23 km from the meteoroid, therefore, all two possible mechanisms of the electrophonic effect proposed by L.F. Chernogor cannot explain this effect in the framework of his neutral mechanical model due to the decreasing spatial coefficient $\xi \approx 10^{-6}$. Thus, both mechanisms of the electrophonic effect, according to the mechanical model, could not take place due to the attenuation of the current transfer process generated in an acoustic shock wave of negligible energy.

All two mechanisms of the electrophonic effect proposed by Chernogor do not stand up to criticism, and Chernogor in clearly demonstrates his errors in them [13]. This always happens when the researcher does not understand the essence of the main phenomenon, therefore, all phenomena are not collected in a single picture. Part of the phenomena, therefore, has to be thrown away by Chernogor. Chernogor does not understand the phenomenon of periodic powerful crushing of a meteoroid, which is accompanied by shock waves (as if someone is shooting a meteoroid from a machine gun) and a simultaneous impulse increase in the brightness of the glow of the fireball. In he does not recall this main problem of all mechanical models [13]. Mechanical models do not take into account the phenomenon of electric

neutrality violation in the plasma tail and cannot explain the main impulsive phenomena caused by detonation (shock) waves of electron gas in the plasma in the meteoroid wake. The speed of detonation waves of electron gas exceeds the speed of a meteoroid by several times.

With the "coming" in the field of research of amateurs of their region, such as Marat Akhmetvaleev (https://uraloved.ru/foto-marata-ahmetvaleeva?ysclid=lpig4qi5dl786130180) and others, the current state of the problem of the destruction of large cosmic bodies upon entry into the Earth's atmosphere shone with bright (Fig.1). This is a completely new phenomenon falling out of the framework of the mechanical Chernogor's model of "quasi-liquid meteoroids". To describe the recorded photographically phenomena (not only the problem of the Tunguska meteoroid, but also the problem of the Chelyabinsk meteoroid of 2013), we need to use synergetics (coherent processes) in the plasma dynamics of meteoroids [4,8].

2.6. Coulomb Self-Focusing of a Plasma Trail
Behind a fast-flying (10-70 km/s) meteoroid (asteroid) or other object in the Earth's atmosphere, the air is heated and strongly ionized. At a meteoroid velocity of 20 km/s, the energy received by air molecules is about 50 eV. This is three times the ionization potential of air molecules. The more mobile (free) electrons leave the ionization region, the more the plasma is polarized and a radially self-cumulating plasmoid (Fig.1) is formed in the wake of the meteoroid (the Vysikaylo's cumulative-dissipative structure [5]. An energy of 50 eV per molecule is sufficient for complete dissociation and ionization of molecules and atoms in the wake of the meteoroid. In this case, about 20 eV remains for each electron. In this case, the air (in the trail) becomes an electropositive gas, where there is no attachment of electrons to the atoms. Electrons, as a more mobile gas, leave the plasma tail faster than positive ions. This is how a potential Coulomb radial barrier for electrons is formed (Fig.3). The radial potential blocking electrons in the radial direction increases logarithmically depending on the effective length of the cylindrical positively charged plasmoid. Outside the plasma trail, electrons lose energy and stick to oxygen molecules. This forms a cover of negative ions, which move at a significantly lower speed into the positively charged plasma trail. In this case, negative ions entering the over excited plasma layer are destroyed: electrons become free in plasma trail. These electrons are affected by the electric field formed behind the meteoroid and are accelerated by this field in the direction of the meteoroid's movement. In the area limited by this cylindrical extended a Coulomb potential radial barrier, not only all the kinetic energy received by air molecules is concentrated, but also the kinetic energy of parts of the meteoroid during its gradual and then catastrophic destruction. The highly conductive plasma column, limited by the Coulomb radial barrier, takes part in the 4D dissipation of the entire kinetic energy of the meteoroid. (The return of negative ions to the plasma tail of the meteoroid is carried out at the speed of plasma ambipolar drift). Self-focusing of highly conductive plasma structures makes it possible to extend the relaxation processes hundreds of times (1.5

seconds) and return half of the kinetic energy of the entire meteor through a cylindrical plasma channel towards in the upper layers of the atmosphere and ionosphere. This explains the influence of the meteoroid on the parameters of the ionosphere and demonstrates 4D structural implementation of the virial theorem in a pulse-periodic process.

Coulomb self-focusing of a plasma trail is a common property for all long plasma structures from ordinary electric arcs to linear lightning, plasma trails behind meteoroids and possibly for intergalactic lightning [8]. In all these cases, transverse electric fields intensely focus electrons and then

weaker electric fields, but more extended in space (30 km), form cumulative jets towards the meteoroid. Electron beams (to anode) are formed in a similar way in a gas discharge in the cathode spot or in linear lightning [3].

In a plasmoid closed by the Coulomb potential (Fig.1, 3) with complete ionization of atoms, electron-electron collisions and energy transfer to the tail of the electron velocity distribution function occur. High-energy electrons escaping from the plasmoid are responsible for electrophonic effects during the introduction of meteoroids into the Earth's atmosphere.
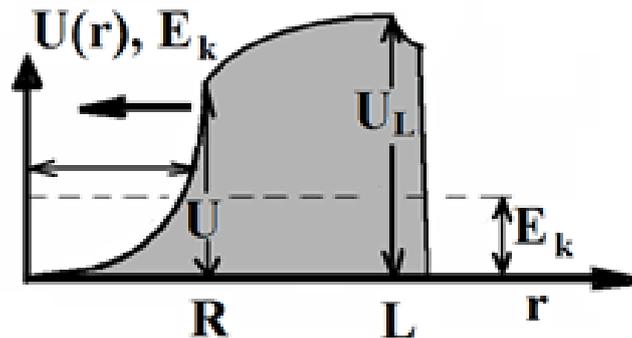

Figure 3: This is the Potential Barrier U(r) for Localized Electrons in a Cylindrical Positively Charged Plasmoid (in the Jump of the Electric Field Heating them at the +CDS Periphery) with Length L. The Characteristic Transverse Size of the Potential Well in this Case Exceeds the Radius of the Structure and can be Determined by its Length (≈ L, 3D Cylinder of Finite Dimensions: R and L << ∞) (Vysikaylo, 2013; 2014; 2023) [3,4,8]

2.7. Coulomb Mechanism of Meteoroid (Asteroid) Fragmentation

A cumulative jet (CJ) of high-energy electrons behaving coherently, like electromagnetic radiation in a laser, accumulates (focuses) the energy stored throughout the plasmoid – in a huge storage capacitor of electrical and kinetic energies (Fig.4a). The polarized cylindrical plasmoid grows linearly with the speed of a meteoroid. The flow of high-energy electrons catching up with the meteoroid periodically explodes the meteoroid with a electrons (Coulomb forces) and accelerates its parts, including in the direction of the meteoroid (Fig.4b). We estimated the parameters of the

high-energy electron beam for lightning (~2 km) in, and for the plasma tail of the Chelyabinsk's meteoroid (its length is ~30 km) in [3,4,8]. According to the Coulomb mechanism proposed by us [4,8] and according to the virial theorem: half of the entire kinetic energy of a meteoroid goes to its destruction and acceleration of its parts by a beam of fast electrons, and the other half goes to discharge positive ions into the upper layers of the atmosphere (up to heights of 70-80 km). In [4,8], we explained all the phenomena observed by eyewitnesses during the complete destruction of the Chelyabinsk's meteoroid at an altitude of 23 km.
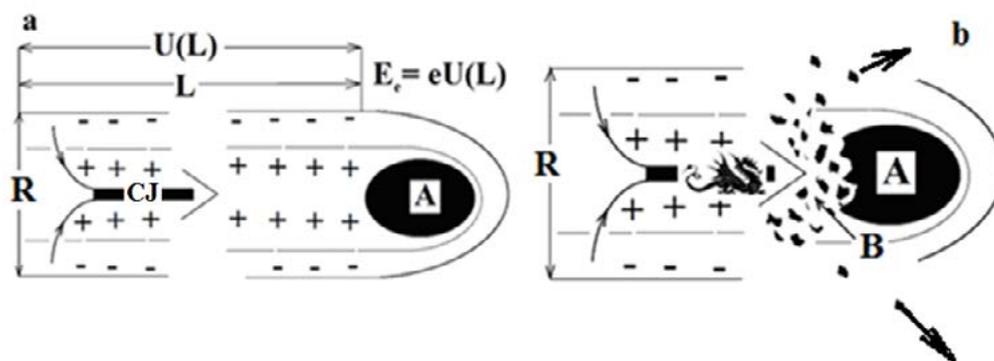

Figure 4: Two-Dimensional Scheme: a) A Vysikaylo's Railgun with a Space Charge Operating on Coulomb (Polarization) Forces (Vysikaylo,2013; Vysikaylo,2023) [3,4,8], and Not on Lorentz's Forces (As in the Artsimovich's Railgun). "+" and "-" - Represent the Separation of the Space Charge (Polarization) of the Plasma Behind a Rapidly Moving Object - A in the Medium. Behind Body A, a Cumulative Jet (CJ) of Electrons is Formed in a Positively Charged Plasma Column, Converting the Potential Energy of Polarization (The Kinetic Energy of the Meteoroid) into Energy CJ; b)

A New Cumulative-Plasma Mechanism of Fractal Fragmentation of Meteoroids, Initiated by Coulomb Explosions. This Mechanism was Proposed by the Author in (Vysikaylo, 2013; Vysikaylo, 2023) [4,8]. A is a Fast Moving Object in an Electronegative Medium. B - Exploding Fragments that form a Jet Engine Behind Object A and Simultaneously Destroy it from Behind, Thereby Supplying the Engine with a New High-Energy "Fuel" with an Energy of 200 eV Per Atom of Already Solid Fuel (At a Meteoroid Speed ~20 km/s)

2.7.1. Theoretical Description Vysikaylo's Cumulative-Dissipative Structures with Violation of Electrical Neutrality

Currently, there are several mathematical models that explain the emergence of long-range dynamic order in a system of dissipative structures formed in a medium by a huge number of particles activated to form structures with long-range dynamic order. We know the diffusion dissipative Kolmogorov-Turing-Prigozhin structures. Their research goes back to the works of Fisher (1930) Kolmogorov (1937), Turing (1952), Prigozhin (1968) and others. Turing's work became a classic, his ideas formed the basis of the modern theory of nonlinear systems, the theory of self-organization and synergetics. He considered the system:

$$\partial n_1/\partial t = P(n_1, n_2) + D_1 \partial^2 (n_1)/(\partial r)^2$$
$$\partial n_2/\partial t = Q(n_1, n_2) + D_2 \partial^2 (n_2)/(\partial r)^2$$

The Turing's model takes into account the interaction of two diffusion processes (with coefficients D_1 and D_2) and nonlinear reactions (P and Q) occurring with concentrations of interacting chemical elements (with particle number density n_1 and n_2) of a continuous medium. The concentration profiles obtained by numerical or analytical modeling in this model are diffusion or Bessel.

A.N. Kolmogorov, I.G. Petrovsky and N.S. Piskunov in 1937 within the framework of this model analytically studied the diffusion equation associated with an increase in the amount of microbial matter and obtained the value of the propagation velocity of the diffusion front:

$$V = 2(D\,v)^{1/2}$$

Where D is the diffusion coefficient, v is the characteristic frequency of the growth. In 1967, Dykhne and Velikhov (independently of Kolmogorov and K°) obtained a similar expression for plasma ionization waves using the dimensional method. Later, they were pointed out the work of Kolmogorov and their error in 2 times.

However, in nature there are not only diffusion processes of dissipation. In nature, the processes of convective cumulation (focusing) have long been discovered. The gravitational cumulation processes were studied by Newton, Kepler, Euler (1767), Lagrange (1772), Besant (1858), Rayleigh (1917), Guderley (1942, compression shock wave), Zababakhin (1965) and others. We are most interested in the studies of unlimited cumulation processes in the works of E.I. Zababakhin. These works are summarized by V.A. Simonenko in the monograph "Phenomena of unlimited cumulation" 1988 [28]. In the conclusion of this book, the

authors (V.A. Simonenko) say that "despite the instability of cumulation in continuous media, it remains a very useful idealization, allowing for precise solutions and indicating how to approach it in practice, without, however, relying on self-focusing" [28].

And now, a little more than 36 years have passed, and we are successfully solving the problems of self-focusing (cumulation) of de Broglie waves of electrons in quantum resonators in the most "subtle experiments", both at the level of nanometer sizes, and in the mesoworld of huge plasma trails behind meteoroids penetrating the Earth's atmosphere, as in this work and in [1-8,19]. Atomism and the associated size limit indicated in Zababakhin's works are already coming to the forefront and even appear to have been passed in nuclear physics [19]. However, the definition given by Ya.B. Zeldovich to the concept of cumulation for continuous media remains a very useful and fairly general definition of this phenomenon, observed from the femto-world of atomic nuclei to the world of stars and galaxies.

"Cumulation, i.e. concentration in a small volume of force, energy or other physical quantity, is the most important phenomenon of nature," asserted Ya. B. Zeldovich in his preface to the book "Phenomena of Unlimited Cumulation" [28]. The definition of cumulation given by Ya. B. Zeldovich is the most successful, clear and at the same time quite complete definition of the phenomenon of self-focusing in natural, physical, social, political, economic and other phenomena [29].

2.7.2. Architecture and Super Properties of the Vysikaylo's Cumulative Dissipative Structures

Cumulative-dissipative structures have long been observed in nature (Fig.5). However, these phenomena belonged to the paradox without explanation, although the main provisions of the theory were laid down in the works of Euler, Lagrange, Roche and other researchers of gravitational structures (Fig.6) for gravitational potentials. Moreover, Kepler's problem has long been solved in the general case for Coulomb and gravitational potentials.

We will analyze the architecture of cumulation processes and dissipation processes in Vysikaylo' CDS based on Fig.5. To do this, we will fill the Roche' cavity of the Sun and Jupiter (Fig. 6) with ordinary dust and hit the Roche' cavity to the left of the Sun with a large hand. The dust will move towards Jupiter's Roche' cavity and after passing through the Sun region will be focused by equipotentials to the cumulation point L1. This means that the points discovered by Euler (1767) are not libration (Lagrange) points, but are essentially Euler's cumulation points [5]. A constriction is formed at the cumulation point, after which dust flows from the Roche's

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cavity of the Sun can expand into the Roche's cavity of Jupiter.

The formation of Vysikaylo's bicyclones, discovered in 2012, can also be explained in terms of the Euler-Vysikaylo's model (Fig.6) [1,2]. To do this, you need to simultaneously at the same time hit the dust with large palms from opposite sides. In this case, the dust from the Roche' cavity of the Sun will penetrate into the Rosh' cavity of Jupiter, and the dust from the Rosh' cavity of Jupiter will tend to get into the Rosh' cavity of the Sun. This problem of frontal collision of dust flows from the Roche' cavity of the Sun and Jupiter at the cumulation point L_1 is solved in 4D space-time by generating rotation in opposite directions of oppositely directed [1,2]. Such bicyclones with constrictions in L_1 are complete analogues of Cooper pairs discovered in the nanoworld, therefore such bicyclones are called quasi-Cooper cyclones. Based on this

approach, I have explained all the effects observed during the development of tropical cyclones. Namely, the idea of co-organization of Cooper pairs led to the discovery of quasi-Cooper cyclones or Vysikaylo's bicyclones in meso and macro-worlds. On this basis, the co-organization of cyclonic and anticyclonic flows into one structure, a bicyclone, was discovered. Dual currents enhance each other's rotation and transform any kinetic and potential energies into rotation, dividing these energies equally between cyclonic and anticyclonic motions. The idea of such a co-organization of dual convective (rather than diffusion) flows made it possible to discover the structural turbulence of Vysikaylo and to explain and describe analytically all the observed phenomena during the formation of tropical cyclones [1,2] (these phenomena observed in nature are collected in the works of Erokhin and Artekha).
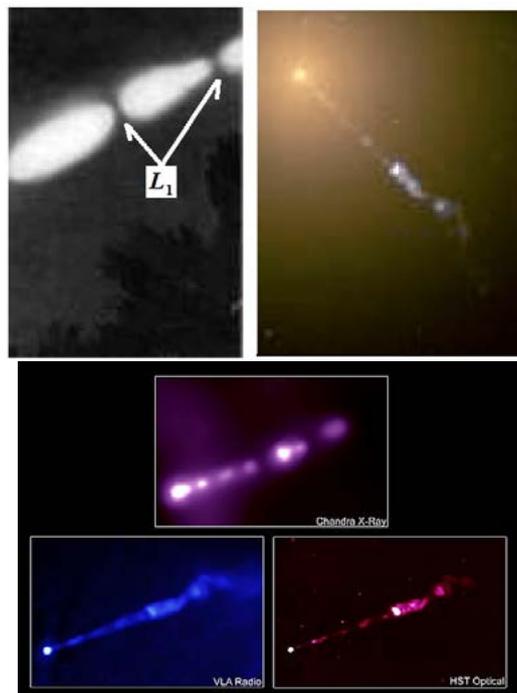

Figure 5: This is a Demonstration of Dynamic Surface Tension, which Accumulates Energy in Plasmoids: a) Beaded Lightning in the Earth's Electronegative Atmosphere. L_1 - Points of Libration - Cumulation (Vysikaylo, 2014) [5]. b) The Central Region of the M 87 Galaxy with an Active Nucleus. Jet Size ~ 1.5 kpc. Hubble Telescope (NASA). We Observe Jet Stratification and Formation of Cumulation Regions
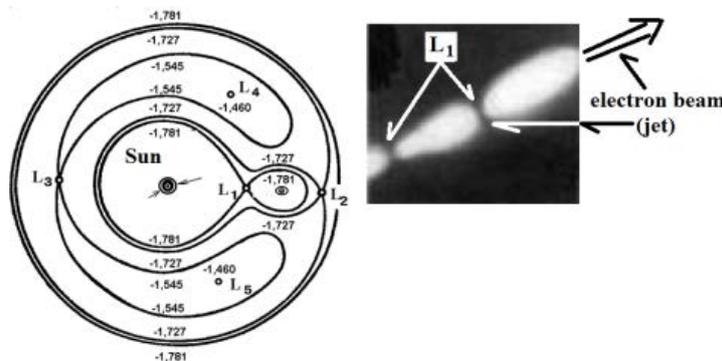

Figure 6: This is a 2D Cross-Sectional Diagram of Equipotential Surface Profiles (3D Roche' Cavities) Surrounding: a) The Gravitating System of Two Attractors (Sun and Jupiter), Taking into Account the Centrifugal Potential in the Euler Problem of Linear Cumulation Points L_{1-3} and Triangular Lagrange Libration Points $L_{4,5}$., b) This is the Formation of Vysikaylo's Cumulation Points in a Beaded Lightning Between the Luminous Positively Charged Cumulative-Dissipative Vysikaylo's Structures

Similar phenomena of structural cumulation are observed at the libration point L_1 when ordinary stars are consumed by quantum stars in stellar pairs (Vysikaylo, 2013) [2] (the phenomena and paradoxes that arise are described in the paper (Bisikalo and Friedman, 2008) [30]. The main achievement within the framework of the Vysikaylo's structural turbulence model was the description of the eye (eye) of a tropical cyclone, which is not described in the Rossby's models and other, as Vlasov said, inferior models. The second discovered property of structural turbulence or bicyclones is an increase in the cumulation of such a structure with an increase in rotation and an increase in rotation during cumulation.

2.7.3. Positively Charged Systems and Cumulation and Libration Points for Electrons Between Them

Euler was the first to think about the interference of gravity and centrifugal potentials when analyzing the motions of a small body in the region of two rotating attractors. Euler's idea about the cumulation points L_1 (it is clear to Newton), and $L_{2,3}$ (exit from the point L_1 to the line) and his discovery of three linear libration points L_{1-3}, as a result of the splitting of the libration point L_1 due to the centrifugal potential and Lagrange's idea about the exit of the analysis into the plane of rotation of Jupiter around the Sun and the discovery by him of 2 more triangular points $L_{4,5}$, allowed me to discover the points of libration and cumulation for electrons in the region of positively charged Coulomb attractors.

My entry into 4D space-time to describe phenomena in the region of two interacting attractors allowed me to understand that the gradients of any potentials (gravitational, Coulomb and pressure) carry out a similar structural cumulation of energy-mass-pulse flows. This understanding allowed me to classify the points discovered by Euler in 1767 as cumulation points, and the points discovered by Lagrange as libration points [5]. At the same time, cumulation lines and planes were discovered and described in [5].

Such a generalization of the works of Euler, Lagrange, Roche and other researchers of the system of gravitating attractors allowed me to explain the experiments of Stark (1903) - the reverse movement of the cathode spot in a transverse magnetic field, the presence of a Faraday dark space between a positively charged cathode spot and a positive plasma column in gas discharges, striations, impulse propagation of lightning in the experiments of Schonland (1937) (jets are also formed in the same way, Fig.3-6) and other paradoxes in gas-discharge plasma in laboratories, ionosphere, heliosphere and galaxies. The work ended with the formulation of the Generalized Mathematical Transposition Method (GMTM) – the transfer of mathematical models from the well-studied natural sciences to the less-studied areas. GMTM allows you to transfer the knowledge gained in the study of gravitating systems into knowledge that allows you to describe electrodynamic systems with violation of electrical neutrality and vice versa. This made it possible to discover a completely new method for verifying general knowledge in the natural sciences and making discoveries analytically. This method should also be applied in describing

hydrodynamic and quantum-mechanical phenomena. So within the framework of synergetics - the science of the joint (synergetic) action of a huge number of elements, a section on cumulative-dissipative processes appeared.

2.7.4. Vysikaylo's Perturbation Theory for Describing Phenomena in Plasma with Current

Above, we substantiated and, based on experiments with lightning and plasma structures in gas-discharge plasma, qualitatively explained all the phenomena observed during the penetration of the Chelyabinsk 2013 meteoroid into the Earth's atmosphere. Since when air molecules collide with a meteoroid, the energy is sufficient for the dissociation and single ionization of all atoms, the plasma in the meteoroid's wake can be considered an electropositive gas of positive ions and electrons. To describe such a plasma with a current in a gas completely dissociated into atoms presents certain difficulties due to the complete absence of experimentally measured rate constants of the processes and transfer from the parameter E/N or electron temperature. Such data are available for air, and the most detailed studies have been carried out for discharge plasma in nitrogen. On this basis, we will formulate a general mathematical model for describing transition layers in an inhomogeneous plasma with current. To take into account the inertia and rotation of the flows of electrons and positive ions in the plasma wake behind the meteoroid, the equation of momentum transfer of charged particles should also be taken into account in the model. In this case, according to Vysikaylo's perturbation theory, within the framework (zero approximation) of the smallness of the current of positive ions compared to the electron current from the system of Poisson's equations for the electric field and the transfer of positive ions and electrons, it is possible to obtain from the equation for ions one 4D equation for the transfer of parameter profiles plasma [6,24-26]:

$$\partial n_e/\partial t - \partial[(\boldsymbol{l}_{E0}/\mu_e)\boldsymbol{\nabla}](\mu_e\, n_e)/\partial t + (\boldsymbol{j}/e)\boldsymbol{\nabla}(\mu_{+0}/\mu_{e0}) \cdot$$
$$- \boldsymbol{\nabla}\{(\mu_{+0}\boldsymbol{E}_0/\mu_{e0})(\boldsymbol{l}_{E0}\cdot\boldsymbol{\nabla})(\mu_{e0}\, n_e)\} = I_{+0} - R_{+0}, \quad (1)$$

Here in the zeroth approximation of our perturbation theory, the drift velocity of electrons and ions is described by the relations: $\boldsymbol{V}_{e0} = \mu_{e0}\boldsymbol{E}_0$, $\boldsymbol{V}_{+0} = \mu_{+0}\boldsymbol{E}_0$, here are the mobility of electrons – μ_{e0} and ions – μ_{+0}, respectively, $\boldsymbol{l}_{E0} = \boldsymbol{E}_0/(4\pi e n_e)$ vectorized characteristic size of electric field strength change. Since the plasma in the trail is completely ionized, the length of the violation of electrical neutrality is small and a sharp jump is formed along the entire boundary of the luminous plasma trail (Vysikaylo's shock wave of the electric field) (Vysikaylo, 2024) [6,24-26].

4D Vysikaylo' equation (1) is derived from $\partial\, n_+/\partial t + \mathrm{div}(n_+ \boldsymbol{V}_i) = I_+ - R_+$, by modifying the ion concentration n_i by $n_e - (\boldsymbol{l}_{E0}\boldsymbol{\nabla})(n_e\, \mu_{e0})/\mu_{e0}$. The terms with $\boldsymbol{l}_{E0}$ in (1) arises due to taking into account the violation of electroneutrality (from Poisson's equation for the electric field). The second term with mixed derivatives with respect to time and spatial coordinates has no analogues in hydrodynamics, and the fourth term is analogous to diffusion. In hydrodynamics, the

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transition from convective to diffusion transfer is observed during the formation of shock waves discovered by Mach. The presence in (1) of a term due to the violation of electrical neutrality allows us to assert that the presence of electric field shock waves in the plasma should be expected. These shock waves form the dynamic surface tension of plasmoids with sizes from 10 cm to 1.5 kpc (Fig.5, 6). Shock waves of the electric field in gas-discharge were discovered and visualized by Vysikaylo and co-authors in 1985-1987 [6]. The presence of 2 and 4 terms in (1) with a mixed derivative will allow us to describe stationary and traveling shock waves of the electric field - strata (parameter E/N) both in ordinary gas-discharge plasma and in the ionosphere and heliosphere, where global currents flow [6].

The third term in (1) takes into account the ambipolar drift of the plasma due to the different dependences of the mobility of electrons and positive ions on the parameter E/N (Vysikaylo, 2021) [6]. In a discharge in high purity nitrogen, the value of the ambipolar drift reaches a value of 70 m/s in the positive plasma column. It is directed from the region with small values of the E/N parameter to large values. This ambipolar drift leads to plasma cumulation to cumulation centers or lines [4]. In the air, the ambipolar drift can significantly exceed 100 m/s. This ambipolar drift of plasma in the air can lead to self-focusing of the plasma trail behind the meteoroid.

As we noted, to take into account the inertia and rotation of charged plasma particles in the first approximation according to Vysikaylo's perturbation theory, it is necessary to take into account the momentum transfer equation (Vysikaylo, 2021) [6]. Where do we get the expression for the velocities of charged particles in the form:

$$V_{+,e} = V_{+,e0} + V_{+,e1} \qquad (2)$$

Here $V_{+,e0} = F_{+,e} / \nu_{+,e0} = \mu_{+,e} E_0$; $V_{+,e}$ $= (- \partial V_{+,e0}/\partial t - (V_{+,e0} \cdot \nabla) V_{+,e0} + (\nabla p_{+,e0})/n_{+,e})/\nu_{+,e0}$;

$(V_{+,e0} \cdot \nabla) V_{+,e0} = \nabla(V_{+,e0})^2/2 + (\nabla \times V_{+,e0}) \times V_{+,e0}$.

Taking into account the terms with $\nabla(V_{+,e0})^2/2$ in the first approximation according to the Vysikailo perturbation theory leads to a modification of the effective ambipolar diffusion in (1). In this case, taking into account the inertial pressure - $\nabla(V_{+,e0})^2/2$ of positive ions leads to ambipolar diffusion of a column of positively charged plasma, and taking into account the inertial pressure of electrons - $\nabla(V_{+,e0})^2/2$ leads to ambipolar anti-diffusion of plasma.

Taking into account the rotation of charged plasma particles - $(\nabla \times V_{+,e0}) \times V_{+,e0}$ leads to a number of particularly interesting phenomena in the presence of plasma cumulation towards a certain central axis of the plasmoid (for example, Fig. 1). Since electrons and positively charged ions move in opposite directions, they also rotate in opposite directions. This is how cylindrically symmetrical plasma filaments are formed, rotating relative to each other, or bi-cyclonic flows of

electrons and positive ions in such plasmoids. In bi-cyclonic systems, opposing flows enhance each other's rotation, while the total rotational moment of the bi-system remains close to zero (as, for example, in tropical bi-cyclones [1,2].

According to (2) in ambipolar flows in (1) it is possible to take into account the pressure gradients of positive ions and electrons - $p_{+,e0}$. This will lead to renormalization of ambipolar plasma diffusions.

Taking into account the nonstationarity of the term – $(\partial V_{+,e0}/\partial t)/\nu_{+,e0} = \mu_{+,e}(\partial E_0/\partial t)/\nu_{+,e0}$ in (2) will lead to renormalization of the term with the mixed derivative in (1) .

In the case of an isotropic medium, the mobility in different directions remains constant and the terms $(\nabla \times V_{+,e0}) \times V_{+,e0}$ in the first approximation according to Vysikaylo's perturbation theory (Vysikaylo, 2023) [8] can be represented as $\mu_{+,e}(\nabla \times E_0) \times E_0$. So, in a first approximation according to our perturbation theory, a magnetic field appears.

Thus, the theoretical description of the ambipolar behavior of charged particles in a current-carrying plasma represents a complex 4D problem.

Behind the meteoroid in the plasma trail, due to the departure of high-energy electrons escaping from the trail, a Coulomb force arises, acting on positive ions away from the meteoroid and on electrons towards the meteoroid (Fig.4). The presence of a radial Coulomb barrier for electron flows from the plasma cylinder (Fig.3) leads to a dual ambipolar ejection of charged particles: positive ions and accompanying electrons into the upper layers of the atmosphere and an electron beam into the meteoroid. This is how the entire plasma structure (with dimensions from 30 to 80 km) works, structurally spraying the meteoroid substance (including water vapor present in the meteoroid) into the upper layers of the atmosphere in the form of positive ions. Evidence of the cylindrical cumulation of plasma in the wake (of this mechanism) is, among other things, the registration of noctilucent clouds at altitudes of 75 km.

3. Discussion of Results

Usually, the analysis of the electrical properties of the plasma in the tail of meteoroids is carried out on the basis of Grigoryan's mechanical model and ends, at best, with the following conclusions: «At the initial moment, the volume electron densities in the trail have been shown to be equal to approximately 10^{17}–10^{22} m^{-3}, respectively, and the plasma specific conductivity to be equal to $\sim 10^3$ Ohm^{-1} m^{-1}. The role of the dusty plasma component was insignificant» [23].

We have shown in the section "General analysis of phenomena and criticism of the mechanical model" that a number of basic phenomena cannot be explained in principle within the framework of the mechanical model (even with the use of not complete electrical models [13]. Moreover, the question of the fulfillment of the virial theorem is not raised at all in such works). Nevertheless, already within the framework of the mechanical model, at high meteoroid velocities ($V_m \gg V_s$ is the

speed of sound), we observe the formation of a cylindrically symmetrical bag that holds the disturbances within a conical structure (Fig. 2).

According to experimental observations of lightning and other electrical phenomena, such as intergalactic lightning (Fig. 1, 3-6), the characteristic transverse dimensions of cylindrically symmetric plasma structures remain virtually unchanged. This gives us grounds to assume the existence of self-cumulation processes of such plasma structures. This assumption was qualitatively investigated in the section "Coulomb mechanism of meteoroid (asteroid) fragmentation".

In this section we argue that the cylindrically symmetric plasma structure (hose behind the meteoroid (Fig. 1)) is formed by the processes of ambipolar drift (the third term in (1)). According to our theoretical and experimental studies, this type of ambipolar drift (caused by different dependences of the electron and positive ion mobilities) is directed from small values of the parameter E/N to the region of large values of this parameter. In the case of a limited (droplet model) plasma positively charged structure, the ambipolar drift is directed toward the self-forming boundary of the plasmoid (Fig. 7). Thus, plasma disturbances are directed toward the boundaries of the plasmoid and such solutions are stitched together by the formation of Vysikaylo's shock wave of the electric field with a characteristic size lE [6,24-26].
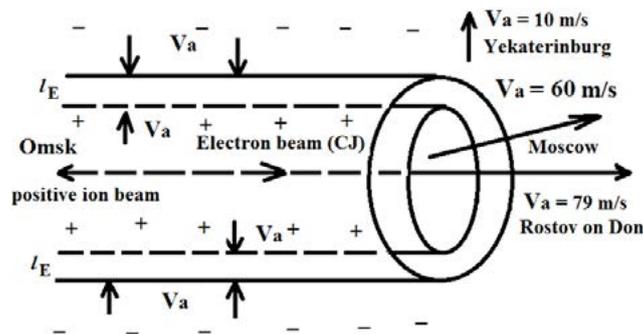

Figure 7. 3D schemes: formation of the Vysikaylo's laser-gun by ambipolar drifts directed towards the boundaries of the plasma structure and the propagation of plasma disturbances in the ionosphere at the speed of ambipolar drift V_a (these are analogs of Mach's shock waves) of plasma disturbances after the destruction of the meteoroid according to the Vysikaylo's fragmentation scheme

Figure. 7 shows the formation scheme of a partially open in the direction of the meteoroid motion (partially closed from the sides) cumulative-dissipative polarized Vysikaylo structure. All the kinetic energy of the meteoroid and ionized air molecules is converted into the energy of a cylindrical electric capacitor (Fig. 7). When the capacitor energy reaches a critical value, it is broken down by an electron beam directed after the meteoroid (CJ). The introduction of a beam of high-energy electrons into the meteoroid leads to a Coulomb explosion and fragmentation of the meteoroid from behind according to the Vysikaylo model (Fig. 4b). Limitation of the radial propagation of the plasma disturbance occurs due to converging waves of ambipolar drift (the third term in (1)), directed to the boundaries of the self-forming cylindrically symmetric plasmoid. This occurs in complete analogy with the formation scheme of ordinary linear lightning and other Vysikaylo's positively charged cumulative-dissipative structures (+CDS) [1,3,4,6,8,24-26,31]. At the boundary of the plasmoid, a Vysikaylo's shock wave of the electric field is formed, compressing +CDS.

After the final Coulomb fragmentation of the meteoroid (to ions and electrons) according to the Vysikaylo's scheme (Fig. 4b), as shown by the experimental data presented to RIA News 03/21/2013, the electron beam pulse continues its movement in the form of plasma ambipolar waves with different velocities V_a, depending on their direction of movement. Such a dependence of the propagation speed of disturbances clearly indicates the ambipolar nature of

the momentum transfer in the direction of the meteoroid movement. This once again proves the electrical nature of the effect of +CDS (Fig. 4,7) on the entire ionosphere and atmosphere of the Earth. According to the diagram (Fig. 4b, 7), the virial theorem may be fulfilled earlier than the meteoroid collides with the Earth's surface. This occurs when the Vysikaylo's +CDS is broken through by a cumulative electron jet in a pulse-periodic mode, which corresponds to the meteoroid being periodically shot (destruction) by its tail.

3.1. Vysikaylo's Incongruent Shock Wave

Fig. 7 shows a diagram of the implementation of a cylindrically symmetric shock wave of the electric field surrounding the plasma in the tail of a meteoroid (asteroid). According to the diagram, the shock wave separates the plasma with negative ions and the plasma where these ions are destroyed in collisions with excited particles and thus turned into atoms, positive ions and free electrons, capable of being accelerated by the electric field in +CDS (in a positively charged electric cord) more quickly than negative ions.

The presence of plasmas with different contents of negative ions at the boundary of the shock wave allows us to classify such shock waves as incongruent jumps of plasma parameters. In Fig. 7, we detailed how the Le Chatelier – Brown's principle is implemented in such jumps: the medium is polarized, forms a capacitor, which, when destroyed, fragments the disturber of the equilibrium of the medium

and throws off its remains in the form of positive ions in the direction opposite to the direction of its movement (Fig. 7).

4. Conclusion

The Chelyabinsk meteoroid of 2013 showed the fragility of our civilization, which is not yet able to understand, comprehend and apply in practice all the phenomena recorded on video cameras by amateurs in their region. "Classical" science was unable to explain all the observed effects. The press suggested that we are being protected by some higher intelligence that is shooting at the Chelyabinsk meteoroid.

Having analyzed these visualized phenomena, I come to the understanding that these: photographs (Fig. 1); data presented by NASA on all the parameters of the explosion (in particular, the transition of a significant part of all the kinetic energy of the meteoroid into electromagnetic radiation); data on the spread of plasma disturbances at the speed of ambipolar drift, presented by RIA News 03/21/2013 and all the videos and eyewitness accounts of the event collected on the Internet, are undoubtedly worthy of the highest awards and praise, since they completely overturn the "classical" mechanical ideas about many natural phenomena (Fig. 1,5). All these data allow me to assert that I have formulated for the first time a model of fragmentation of meteoroids and small asteroids (to electrons and positive ions), which explains the reverse energy flow (in the form of a beam of high-energy electrons) of half the kinetic energy of the entire meteoroid to its destruction.

These data transfer the phenomena of the invasion of asteroids and meteoroids from the class of phenomena in "quasi-liquids" to the class of cumulative-dissipative synergetic (coherent) bright plasma electrical phenomena with dimensions up to 30 km and a diameter of more than 18 m. These electrical phenomena occur with solid bodies in plasma with long-range electrical potentials. These phenomena are similar to the phenomena in linear lightning and intergalactic lightning [8,13]. In the works we first proposed a model of the Coulomb explosion of a meteoroid, based on the model for ordinary linear lightning [4,8]. The formation of plasma structures (+CDS – plasmoids) is caused by radial self-focusing (cumulation) of the positive charge by negative ions and electrons returning to +CDS. The theoretical results we obtained for describing linear lightning were compared with all experimental observations of Schonland (1934-1937) of the pulse-periodic advance of linear lightning near the Earth's surface. Good agreement between the results made it possible to apply our modified model to describe the phenomenon of fragmentation of meteoroids and asteroids [4,8,9]. On this basis, in the works we first proposed a model of the Coulomb explosion of a meteoroid and detailed such fundamental principles as the Le Chatelier-Brown principle and the virial theorem, formulated in 1870 by Clausius for gravitating systems, Fock for quantum systems and here by us for plasma tails behind meteoroids and asteroids [4,8].

Indeed, in the works we explained the processes of radial cumulation of all flows of energy, mass and momentum to the center of a positively charged plasma structure behind a meteoroid [4,8]. The ejection of free high-energy electrons and the constant growth of the positively charged region behind a moving meteoroid (Fig. 4a) is the generator of an electric field that affects the formation of a beam of high-energy electrons penetrating into the meteoroid and a flow of positive ions rushing in the opposite direction. Since the charge of electrons is equal to the charge of positive ions, the forces and work of the electric field on the flows of electrons and positive ions are equal. As a result, the virial theorem is realized in the form of two quasi-neutral counter flows to the meteoroid and from it. Therefore, half of the entire kinetic energy of the meteoroid in the form of a beam of high-energy electrons catches up in it and fragments it into positive ions and electrons. Shock and detonation waves have a speed of less than 10 km/s and cannot ensure the fulfillment of the virial theorem for the process of a meteoroid entering the Earth's atmosphere. Our pulse-periodic mechanism that destroys meteoroids solves the problem of fulfilling the virial theorem for any meteoroid speeds - from 10 km/s to 70 km/s and more even before their collision with the Earth's surface.

The analogue of a fully reflecting mirror in the case of a plasmoid (Fig. 1) is the end of the tail of a positively charged plasmoid (at a distance of 30 km from the meteoroid). The analogue of a transparent mirror is the meteoroid itself, the movement and destruction of which generates a new element of a positively charged plasmoid (Fig. 4b). Within the framework of only the mechanical model Chernogor could not explain the whole spectrum of amazing phenomena that occurred during the penetration of the Chelyabinsk meteoroid in 2013 into the electronegative atmosphere of the Earth in the photo in Fig. 1 [13]. All these processes can be explained only on the basis of the theory of cumulative-dissipative plasma structures of Vysikaylo, with the involvement of cyclic plasma-chemical processes [4,8]. These processes are significantly enhanced by mechanical processes with explosions and spraying of small fragments up to ions (after the next fragmentation of the meteoroid) and are accompanied, in turn, by the separation of charges due to the difference in the masses of electrons and positively charged ions (Fig. 4,7). The results obtained by us in the works are useful for completely new discoveries, explanations of paradoxes and development of completely unexpected new technologies - flight on its own plasma tail or external combustion engine [4,8].

The whole spectrum of theoretical research and experimental observations of phenomena before (electrophone effects), during the formation of +CDS (destruction of the meteoroid by a beam of fast electrons) and after complete fragmentation (propagation of plasma disturbances with ambipolar drift speeds) of the Chelyabinsk meteoroid clearly indicates the importance of the processes of formation, vital activity and propagation of the Vysikaylo's shock waves of electric field, and not only Mach's shock waves [24-26]. Based on the de Broglie hypothesis: "particles behave like waves", we have shown that de Broglie waves of electrons in plasmoids can

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behave like electromagnetic waves in quantum generators (lasers) - form longitudinal opposite energy flows from the plasmoid resonator in the presence of an external electric field. Our studies prove the validity of further development of Louis de Broglie's hypothesis: "particles behave like waves" and can form their flows similarly to electromagnetic waves in a conventional laser (in the plasma tail of an asteroid or meteoroid). At the same time, in the formation of Vysikaylo plasma cumulative-dissipative structures that shoot de Broglie waves of electrons at asteroids and meteoroids penetrating the Earth's atmosphere, the role of incongruent shock waves of the Vysikaylo's electric field is significant.

The mechanism proposed by us, which explains all the observed phenomena during the propagation of electric arcs, lightning and the introduction of the Chelyabinsk's 2013 meteorite into the Earth's atmosphere, proves that de Broglie electron wave lasers with a resonator length from 10 cm to 30 km and a diameter of about 18 m are realized in nature and can be described theoretically [3,4,8]. This gives us the basis for using this mechanism to explain the co-organization of opposite proton jets from black holes and electrons in black holes. These laser-like jets are already being observed in Hubble-type telescopes and have lengths up to 1.5 kpc (Fig.5) [3,4,8,21]. Therefore, our cumulative-reactive mechanism is able to explain the increased velocities of active neutron stars.

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