Modified Coulomb Forces and the Point Particles States Theory

I. N. Tukaev*

July 20, 2017

Abstract

A system of equations of motion of point particles is considered within the framework of the classical dynamics (the three Newton's laws). Equations of the system are similar to the equation by Wilhelm Eduard Weber from his theory of electrodynamics. However, while deriving equations of the system, the Coulomb law as the law for point particles which are motionless relatively one another (used by Weber for formulation of his equation) is regarded as a hypothesis unverified experimentally. An alternative hypothesis was proposed, presuming that the Coulomb law describes the interaction of the two electrically charged point particles within a determined range of their relative velocity magnitudes excluding a zero value – if the relative velocity magnitude is equal to zero, particles with like charges attract one another and those with unlike charges repulse. The results of mathematical analysis of the system of equations of motion of point particles with Coulomb forces modified in accordance with the alternative hypothesis and acting between them were used for modelling of the following physical phenomena and processes: formation and evaporation of condensate consisting of bound pairs of point particles with like charges; decay of a free neutron and a neutron in an atom's nucleus; neutron emission; emission and absorption of energy quanta by particles; interaction of particles with an atom; nuclear synthesis; formation of current sheets in the plasma; plasma ejection during the magnetic reconnection; the Lorentz force; thermo-electric phenomena; electrification; intermolecular interactions; superconductivity; solar flares; atmosphere discharges; formation and dynamics of atmospheric whirlwinds; bow shock waves created by the solar wind nearby celestial bodies of the Solar System; cometary nuclei and planetary cores; processes occurring during the passage of comets through the Earth's atmosphere. It is concluded that these phenomena and processes can be qualitatively described by the system of equations of electrically charged point particles motion within the framework of Newton's laws as it was considered in the present study.

Keywords: Newton's laws, Coulomb law, Weber's equation, Coulomb force, magnetic force, nuclear force, intermolecular force, condensation, superconductivity, comet, meteor, atmospheric whirlwind, solar wind.

*e-mail: in-t@rambler.ru

Contents

1 Physical and mathematical objects in PPST (the point particles states theory)

Physical objects:

1. particles, the point objects which are able to move relatively one another and characterised by inert masses (m) and electrical charges (q);

2. dynamic system of particles, a limited number of particles with central forces acting between them; those forces are determined by force functions, and each particle in the system has its own ordinal number;

3. **volume of particles**, the dynamic system of particles in which the motion of particles relatively one another is limited by some spatial volume.

Mathematical objects:

1. **force function**, a vector function which determines the force applied to a particle by the other particle;

2. system of equations of particle motion, a system of vector differential equations of the second order where the number of equations is equal to that of particles in the dynamic system, and every equation determines the force applied to a single particle as a sum of functions of forces applied to it from the rest of particles of the dynamic system;

3. $\vec{r}_n$ is a radius vector of the position of a particle with the ordinal number n in the dynamic systemm;

4. r_n is the magnitude of the radius vector of the position of a particle with the ordinal number n;

5. $r_n \geq 0 \quad (n = 1, ..., N)$ is the range of determination of values of magnitude of the radius vector of particle's position (where N is the number of particles in the dynamic system);

6. $\hat{r}_n = \vec{r}_n / r_n$ is a unit vector of the radius vector of the position of a particle with the ordinal number n, whereas $r_n \neq 0$;

7. $\vec{v}_n = d\vec{r}_n/dt$ is the velocity of a particle with the ordinal number n;

8. v_n is the magnitude of the velocity of a particle with the ordinal number n;

9. $v_n \geq 0 \quad (n = 1, ..., N)$ is the range of determination of values of magnitudes of particle's velocity;

10. $\hat{v}_n = \vec{v}_n / v_n$ is a unit vector of the velocity of a particle with the ordinal number n, whereas $v_n \neq 0$;

11. $d\vec{v}_n/dt = d^2\vec{r}_n/dt^2$ is an acceleration of a particle with the ordinal number n;

12. $\vec{r}_{nk} = \vec{r}_n - \vec{r}_k$ is a radius vector of the position of a particle with the ordinal number n relatively to a particle with the ordinal number k;

13. r_{nk} is the distance between particles with ordinal numbers n and k ($r_{nk} = r_{kn}$);

14. $r_{nk} > 0 \quad (n = 1, ..., N, \quad k = 1, ..., N, \quad n \neq k)$ is the range of determination of values of distances between particles in the dynamic system;

15. $\hat{r}_{nk} = \vec{r}_{nk} / r_{nk}$ is a unit vector of the radius vector of the position of a particle with the ordinal number n relatively to a particle with the ordinal number k; it determines **a unit vector of the function of force** applied to the particle n by the particle k;

16. $\vec{v}_{nk} = d\vec{r}_n/dt - d\vec{r}_k/dt$ is a velocity of a particle with the ordinal number n relatively to a particle with the ordinal number k.

17. dr_{nk}/dt is a radial relative velocity of the particles with ordinal numbers n and k ($dr_{nk}/dt = dr_{kn}/dt$);

18. v_{nk} is a magnitude of the relative velocity of the particles with ordinal numbers n and k ($v_{nk} = v_{kn}$);

19. $v_{nk} \geq 0 \quad (n = 1, ..., N, \quad k = 1, ..., N, \quad n \neq k)$ is the range of determination of values of magnitudes of particles' relative velocities in the dynamic system;

20. $d\vec{v}_{nk}/dt = d^2\vec{r}_n/dt^2 - d^2\vec{r}_k/dt^2$ is an acceleration of a particle with the ordinal number n relatively to a particle with the ordinal number k;

21. d^2r_{nk}/dt^2 is a radial relative acceleration of the particles with ordinal numbers n and k ($d^2r_{nk}/dt^2 = d^2r_{kn}/dt^2$);

22. $\mu_{nk} = m_n m_k / (m_n + m_k)$ is an reduced mass of the particles with ordinal numbers n and k;

23. Φ_{nk} is **a scalar function of interaction between the particles**, with ordinal numbers n and k ($\Phi_{nk} = \Phi_{kn}$); it determines the following parameters:

1. the sign of forces between the particles:

- if the value of the scalar function of interaction between the particles is larger than zero, the sign of forces between the particles is positive and the particles repel one another;

- if the value of the scalar function of interaction between the particles is less than zero, the sign of forces between the particles is negative and the particles attract one another;

2. the magnitude of forces between the particles:

- the magnitude of the scalar function of interaction between the particles is the magnitude of forces between the particles;

- if the magnitude of the scalar function of interaction between the particles is equal to zero, the magnitude of forces between the particles is also equal to zero.

24. $\Phi_{nk}\hat{r}_{nk}$ is the force function that determinates a force applied to the particle n by the particle k as a product of the scalar function of interaction between the particles and the unit vector of the function of force applied to the particle n by the particle k.

25. $\mu_{12} d\vec{v}_{12}/dt = \Phi_{12}\hat{r}_{12}$ is the equation of particle No. 1 motion relatively to the particle No. 2 if the number of particles in the dynamic system equals to 2.

All newly introduced terms which determinate various processes of interaction between the particles will be shown in bold when they are first used in the theory. The introduction of any other symbols in indices of mathematical objects will also be explained when they are first used. The **"volume of atoms"** term will determine the volume of particles the particles of which are bound into separate atoms.

2 Introduction

The point particles states theory (PPST) considers the system of equations similar to the equation by Wilhelm Eduard Weber in the theory of electrodynamics which was developed by Weber in the middle of 19th century and based on the three Newton's laws and a hypothesis of properties of modified Coulomb forces acting between electrically charged particles [1, 2]. Like Weber's theory, PPST is based on the three Newton's laws and a hypothesis of properties of modified Coulomb forces; however, the hypotheses in these theories are different.

The point particles states theory was developed in order to describe the dynamics of particles with modified Coulomb forces acting between them. PPST analyses the dynamics of particles and makes conclusions about their states. **The states possible**

for particles are named in PPST and determined according to particles' interaction conditions:

1. **neutral state** is the state when magnitudes of forces of interaction between the particles are equal to zero;

2. **free state** is the state when distances between particles increase to infinity, with non-zero magnitudes of forces of interaction between them;

3. **unsteady state** is the state when distances between particles decrease, with non-zero magnitudes of forces of interaction between them;

4. **bound state** is the state when distances between particles either remain unchanged or change to some finite values: the minimum distance is non-zero and the maximum one is non-infinite;

5. **bound steady state** is the state when distances between particles remain unchanged;

6. **bound unsteady state** is the state when distances between particles change to some finite values: the minimum distance is non-zero and the maximum one is non-infinite;

7. **equal states** are the states when relative velocity of particles equals to zero: magnitudes and unit vectors of particles' velocities match in any coordinate system.

As it arises from the definition of particles' states, there can be two types of bound state in PPST, the bound steady and bound unsteady one. The bound unsteady state includes the unsteady one when the distances between particles in bound unsteady state decrease.

The presented version of PPST considers particles as electrons and protons. Along with the dependence of forces, which act between the particles, on distances between the particles, the dependence of forces on the magnitude of relative velocity of the particles is introduced. Particles are considered as points, forces between them are regarded as central, the spread of interaction is believed as instant, with no intermediates (action at a distance).

Initially PPST has been developed as a theory of condensates of particles with like charges. It has been planned to consider within its framework the possibility of existence of dynamic systems formed by some volumes of condensates of particles with like charges. But at some stage of its development it was found that it can qualitatively explain some physical processes and phenomena known to science (qualitatively means that equations of the theory contain some unknown constants which values can be determined in experiments only). The frames of the theory gradually expanded and covered a wider range of research than it has been initially expected. As a result, the theory of condensates of particles with like charges was transformed into PPST, the theory of dynamic systems formed by volume of electrically charged point particles under the central forces between them which depend on distances between particles and magnitudes of their relative velocities.

Conclusions about particles' states in the theory are made on the basis of mathematical analysis of the system of equations of particle motion. The system of equations formulates using modified Coulomb forces which properties are the hypothesis of the theory. The system of equations contains only modified Coulomb forces. It doesn't mean that PPST rejects the possibility of existence of other forces acting between particles along with Coulomb's (e.g., magnetic, gravitational, nuclear, etc.). It is presumed that forces considered in the theory either supplement those that are already known or they are them. It is related to unknown constants contained in the equations of PPST, and the theory's conclusions should be considered unambiguous only after determination of their values.

The idea of development of a theory where forces depend on velocities isn't new. It has been used within the classical dynamics for explanation of common properties of electricity, magnetism and gravity over the whole 19th century. In 1800s, physicists operated with much less amount of experimental data than it is available today. Therefore, re-thinking of interaction of Coulomb charges from the point of the three Newton's laws and using the experimental data obtained in the 20th and at the beginning of the 21st century provides an opportunity of a new glance at the role of the classical dynamics in modern physical theories.

The Coulomb law as the law of interaction of motionless charges was formulated in the end of 18th century after the research of interaction of two electrically charged balls but not after the research of interaction of two ultimate particles with electrical charges. In Newton's and Coulomb's time, the immobility of both gravitational and electrical charges was interpreted as nulling of the magnitude of relative velocity of bodies which interaction has been studied, whereas the velocity of charged particles inside these bodies was ignored. But at the present time there are enough experimental facts providing to conclude that all bodies observable in the nature consist of particles which dynamic systems form these bodies, that all particles in atoms and molecules, including atoms and molecules themselves, as well as free electrons and protons, in these dynamic systems have various kinetic energies and, thus, various magnitudes of velocities relatively one another, even if the temperature of these system approaches to absolute zero. Experiments confirming the validity of Coulomb law for two electrically charged ultimate particles motionless relatively one another haven't been performed. Therefore, the Coulomb law in its contemporary formulation is the hypothesis unproven experimentally.

After Ampere had formulated his Ampere's force law, it became clear that the interaction of electrical charges depends on their velocities, and Coulomb forces started to undergo modifications. In the second half of the 19th century the most popular was the theory of interaction of electrically charged particles developed by Wilhelm Eduard Weber on the basis of modified Coulomb forces depending on distances between particles and on their first and second derivatives with respect to time [1, 2]; besides Weber presumed that the Coulomb law is valid for charged particles which are motionless relatively one another. After this theory has been criticised [3, 4, 5], there were another attempts of explanation of interactions between moving electrical charges using modified Coulomb forces; however, in the 20th century the split of forces acting between charged ultimate particles into two types, Coulomb and magnetic, yet became universally recognised. As Weber's theory, all theories which used Coulomb forces for modelling dynamic systems of ultimate particles presumed that the Coulomb law is valid for motionless particles; therefore, no alternative hypotheses have been proposed. Thus, the theoretical research of forces acting between electrically charged particles within the framework of the three Newtonian laws hasn't been completed. For meeting this gap, the alternative hypothesis was provided within the point particles states theory. Its essence is as follows:

Particles with like charges motionless relatively one another attract, particles with unlike charges motionless relatively one another repel, whereas the Coulomb law describes the interaction of two electrically charged particles in the definite range of magnitude values of their relative velocities, excluding zero value.

The first person to suggest that particles with like charges can attract was Gustav

Theodor Fechner in 1845. Investigating the interaction between current elements, he made two assumptions [4], [6]:
"1) All actions of a current-element may be considered as composed by the actions of a positive and a negative particle, of equal strength, which simultaneously traverse the same element of space in opposite directions;
2) Accepting this combination, one may represent the mutual action of two current-elements based on the assumption that like electric charges attract one another if they move in the same direction or to the same angular point, whereas unlike electric charges behave in the same way if they move in the opposite directions or when one of them approaches the angular point while the other one moves away from it".

Fechner hasn't developed the theory of electrodynamics based on these hypotheses. While working on his theory, Weber accepted only the first Fechner's assumption.

In PPST modified Coulomb forces are used for modelling of dynamic systems where changing of magnitudes of particles' relative velocities results to turning of attracting forces to repelling ones – and vice versa, repelling forces to attracting. Consideration of dynamic systems of electrons or protons interacting at these conditions demonstrates that isolated volume of electrons, as well as protons, under the temperature decrease can transform to gaseous and liquid state. Once the magnitude of relative velocity of two particles with like charges becomes less than some certain value, particles begin to attract with the possibility of formation of bound pairs. When the magnitude of their relative velocity becomes greater than this certain value, particles begin to repel one another, and if the magnitude of relative velocity of particles with like charges becomes significantly greater than this certain value, particles repel in accordance with the Coulomb law. If the magnitude of relative velocity of an electron and a proton is less than a certain value, the electron and the proton repel each other. When the magnitude of their relative velocity becomes greater than this certain value, they begin to attract. Once the magnitude of the relative velocity of the electron and the proton becomes much greater than this certain value, the electron and the proton begin to attract according to the Coulomb law.

Conditions of existence of dynamic systems in which electrons attract electrons, protons attract protons, and protons attract electrons, are determined in PPST. In other words, one can determine conditions under which a nuclear fluid is formed from attracting charged particles. In this case a neutron is represented as a bound pair of electron and proton interacting with one another in a definite range of magnitudes of their relative velocities and distances between the electron and the proton in the neutron. At that, one can determine dynamic conditions under which the following processes occur: the decay of a single neutron, the decay of a neutron in the nucleus of the atom, and the neutron emission (i.e., the escape of a single neutron from the nucleus of the atom). It is also possible to model the interaction between neutral atoms and ions, from one side, and electrons or protons from the other side, with determination of conditions under which neutral atoms or ions either attract or repel charged particles. There are also conditions of attraction and repelling between neutral atoms. In these cases, new glances arise at superconductivity, chemical bounds of atoms and molecules, interaction between Rydberg atoms, and many other phenomena from the point of the classical dynamics.

In PPST, it is possible to model conditions under which charged particles emit and absorb the quanta of energy interacting with one another at large distances; such modelling requires only the three Newton's laws, without introduction of additional particles into the theory – particles transmitters of the energy of interaction. These conditions are applied for modelling of interaction between the charged particle beam and the volume of neutral atoms (the process of particles' bremsstrahlung, the process of particles' dispersion by neutral atoms, ionisation of atoms by the particle beam, the Bragg peak of ionisation of atoms by heavy charged particle beam, explosive rupture of conductors by electric current) and processes of various types of radiation emitted by particles and atoms. PPST includes conditions of interaction of charged particles under which the correlation between gamma radiation, radio radiation and neutron beam during atmospheric and artificial electric discharges may occur. Within the PPST framework one can determine the cause of existence of the so-called "terahertz gap" (the problem of emitters and receivers of the terahertz-frequency radiation [7]).

Consideration of processes of evaporation of nuclear, electron and proton fluids in PPST provides explanation of the presence of particles with abnormally high kinetic energy in cosmic rays and particle beams appearing after flares and plasma ejections on the Sun.

Within the PPST framework, one can model processes occurring in the plasma, such as formation of current sheets, plasma ejection during the magnetic reconnection, the pinch effect, or the compression of an electrically conducting filament in the plasma by magnetic forces induced by the current itself, and self-focusing of beams of particles with like charges. In PPST, the group motion of particles with like charges along a circular trajectory creates an analogue of the Lorentz force applied to charged particles in the permanent magnetic field.

Using PPST, one can describe the process of electrification of volumes of neutral atoms and thermo-electrical phenomena such as the Seebeck effect, the Peltier effect, the Thomson effect and the thermo-current inversion in accordance with the Avenarius's law. PPST is also applicable for consideration of thermo-electrical phenomena in superconductors.

Atmospheric discharges, causes of deep-laid earthquakes and high-current discharges during explosive volcanic eruption, formation and dynamics of atmospheric whirlwind, processes on the Sun and in the solar atmosphere, interaction of protons in the solar wind with the Sun and celestial bodies of the Solar System – these are the phenomena to be considered in this study within the PPST framework.

PPST provides the opportunity of modelling of main evolution processes of dynamic systems formed with the proton and electron condensations which may be the cometary nuclei and cores of planets and stars. A separate chapter of this work focuses on the application of PPST and a theory of the **dynamic system of bound condensates** developed within its framework for the phenomenon of "Chelyabinsk meteor".

Based on the unified system of equations of charged point particles motion, PPST allows for explaining of many known phenomena and predicting of the new ones. Within the framework of this theory it is possible to model virtual dynamic systems where interaction of ultimate particles creates processes and objects similar to those which exist in the real world but are subjects of other laws.

Generally, the point particles states theory is the mathematical theory of functions with certain properties. The properties of functions are determined by the hypothesis of properties of modified Coulomb forces. At the present stage of development of PPST, the number of functions satisfying the hypothesis considered within the theory and allowing for modelling real physical processes is not defined. This work provides the mathematical analysis of the three functions of the same form with various values of constants, determining **the three types of modified Coulomb forces, such as forces between electrons, forces between the electron and the proton, and forces between protons**. Therefore, PPST is the open theory applicable for consideration of both other hypotheses and other functions.

3 Modified Coulomb forces in PPST

Based on the analysis of dynamics of charged particles in the processes occurring:

1. under the low temperatures:

- formation and condensation of bound pairs of electrons in superconductors and movement of electrons through the superconductor with no resistance [8];
– formation of so-called "electron bubbles" in liquid helium [9, 10] and in liquid hydrogen [11] when electrons accumulate in a certain volume and form around themselves an empty space, a "bubble";
- formation of so-called "snowballs" by positively charged particles in liquid helium [9] when positively charged particles accumulate in a certain volume and form around themselves a crystalline-like structure, a "snowball",

2. in nuclei of atoms:

- formation of bound pairs of protons which is confirmed by the kinematics of double-proton decay [12];
- evaporation of nuclear fluid in the liquid drop model of nucleus [13], the similarity to liquid-gas phase transition in nuclear and classical fluid,

we make five assumptions:

1. in the substance under the low temperatures, and thus, at the low values of magnitudes of relative velocities, negatively charged particles may attract, form bound pairs and stay in gaseous and liquid state. With the increase of temperature of the substance, and thus, with the increase of magnitudes of relative velocities of negatively charged particles, those negatively charged particles begin to repel one another;
2. in nuclei of atoms, positively charged particles may attract, form bound pairs and stay in gaseous and liquid state. With the increase of temperature of the nucleus, and thus, with the increase of magnitudes of relative velocities of positively charged particles, those positively charged particles begin to repel one another;
3. in the substance under the low temperatures, and thus, at the low values of magnitudes of relative velocities, positively charged particles may attract each other;
4. in the substance under the low temperatures, and thus, at the low values of magnitudes of velocities of negatively charged particles relatively neutral atoms, those negatively charged particles and neutral atoms may repel;
5. in the substance under the low temperatures, and thus, at the low values of magnitudes of velocities of positively charged particles relatively neutral atoms, those positively charged particles and neutral atoms may attract.

In other words:

1. with certain, small values of magnitudes of relative velocities:

- electrons attract each other;
- protons attract each other;
- neutral atoms repel electrons;
- neutral atoms attract protons;

2. with certain, large values of magnitudes of relative velocities:
- the dynamics of electrons and protons is described by the Coulomb law.

Based on assumptions hereinabove, **we determine as a hypothesis eight properties to be possessed by modified Coulomb forces in PPST**:

1. if the magnitude of relative velocity of two likely charged particles is less than a certain value, particles attract;

2. if the magnitude of relative velocity of two likely charged particles is equal to a certain value, the magnitude of forces between particles is equal to zero;

3. if the magnitude of relative velocity of two likely charged particles is greater than a certain value, particles repel;

4. if the magnitude of relative velocity of two likely charged particles is essentially greater than a certain value, the interaction of particles is described by the Coulomb law;

5. if the magnitude of relative velocity of two unlikely charged particles is less than a certain value, particles repel;

6. if the magnitude of relative velocity of two unlikely charged particles is equal to a certain value, the magnitude of forces between particles is equal to zero;

7. if the magnitude of relative velocity of two unlikely charged particles is greater than a certain value, particles attract;

8. if the magnitude of relative velocity of two unlikely charged particles is essentially greater than a certain value, the interaction of particles is described by the Coulomb law.

As is demonstrated later, these eight properties of modified Coulomb forces provide necessary and sufficient conditions for developing the system of equations which describes the dynamics of charged particles in accordance with five assumptions stated at the beginning of this chapter.

We take a proton and an electron as charged particles, considering them as points. We assume the charge of electron as negative and the charge of proton as positive. In this case, the force applied to a particle by other particles should be in general a sum of two types of forces: the electron is affected by the sum of forces between electrons and forces between the electron and the proton; the proton is affected by the sum of forces between protons and forces between the electron and the proton. There are three types of Coulomb forces to be found: **forces between electrons, forces between the electron and the proton, and forces between protons**.

For all three types of forces we will consider one type of force function but with different constants determining each of these types of forces. The system of equations of motion of two particles with masses m_1 and m_2, with electric charges q_1 and q_2, with radius vectors of their positions in the arbitrary coordinate system $\vec{r}_1$ and $\vec{r}_2$ correspondingly; and with modified Coulomb forces acting between them, is represented as follows:

$$m_1 \frac{d^2\vec{r}_1}{dt^2} = \frac{q_1 q_2}{r_{12}^2} \Upsilon_{12} \hat{r}_{12}, \quad m_2 \frac{d^2\vec{r}_2}{dt^2} = \frac{q_2 q_1}{r_{21}^2} \Upsilon_{21} \hat{r}_{21}, \tag{1}$$

where:

$$\Upsilon_{12} = \Upsilon_{21}, \quad \Phi_{12} = \frac{q_1 q_2}{r_{12}^2} \Upsilon_{12}, \quad \Phi_{21} = \frac{q_2 q_1}{r_{21}^2} \Upsilon_{21}, \quad \Phi_{12} = \Phi_{21},$$

Φ_{12} is the scalar function of interaction of particles with ordinal numbers 1 and 2;
Υ_{12} is the function that modifies the Coulomb forces acting between the particles No. 1 and 2 (**the modifying function**).

On the basis of eight properties of modified Coulomb forces introduced as the hypothesis hereinabove, considering the form of the system of equations (1), we determine five properties to be possessed by modifying functions:

first:

$$0 \leq v_{12} < a_{12}, \quad \Upsilon_{12} < 0;$$

second:

$$v_{12} = a_{12}, \quad \Upsilon_{12} = 0;$$

third:

$$v_{12} > a_{12}, \quad \Upsilon_{12} > 0;$$

fourth:

$$v_{12} >> a_{12}, \quad \Upsilon_{12} \to 1,$$

fifth:

$$\Upsilon_{12} \neq \pm\infty,$$

with $a_{12} = Const$.

The number of forms of modifying functions possessing these five properties hasn't been determined at this stage of development of the theory. The selection of the form of modifying function in the actual version of PPST has been performed using the following principles:
1. correspondence of processes of particles' interaction in the theory to really observable physical processes;
2. existence of analytical solution of the two-particles problem;
3. possibility to determine the signs of forces acting between mass centres of two volumes of particles, depending on particles' relative velocities;
4. minimising of the number of unknown constants which are contained in equations of the theory.

The form of modifying function determined on the basis of these four principles and possessing five properties stated hereinabove will be used in the considered version of PPST:

$$\Upsilon_{12} = 1 - b_{12}^{\left(1 - v_{12}^2/a_{12}^2\right)}, \tag{2}$$

where:

$$a_{12} = Const, \quad b_{12} = Const, \quad a_{12} > 0, \quad b_{12} > 1.$$

Taking into account the form of modifying function (2), we rewrite the system of equations for two particles motion (1) as follows:

$$m_1 \frac{d\vec{v}_1}{dt} = \frac{q_1 q_2}{r_{12}^2} \left(1 - b_{12}^{\left(1 - v_{12}^2/a_{12}^2\right)}\right) \hat{r}_{12}, \quad m_2 \frac{d\vec{v}_2}{dt} = \frac{q_2 q_1}{r_{21}^2} \left(1 - b_{21}^{\left(1 - v_{21}^2/a_{21}^2\right)}\right) \hat{r}_{21}, \tag{3}$$

$$b_{12} = b_{21}, \quad a_{12} = a_{21}.$$

From the system (3), the equation of motion of the first particle relatively the second one to be derived:

$$\mu_{12}\frac{d\vec{v}_{12}}{dt} = \frac{q_1 q_2}{r_{12}^2}\left(1 - b_{12}^{\left(1 - v_{12}^2/a_{12}^2\right)}\right)\hat{r}_{12}. \tag{4}$$

Therefore, in the present version of the point particles states theory three modifying functions of the same form (2) will exist, with various values of constants (a_{12}, b_{12}), each of those to determine one of types of modified Coulomb forces.

4 Weber's theory of electrodynamics and PPST

The up-to-date formulation of Weber's equation [1] which describes the motion of the first particle with inert mass m_1 and electric charge q_1 relatively to the second with inert mass m_2 and electric charge q_2 is as following:

$$\mu_{12}\frac{d\vec{v}_{12}}{dt} = \frac{q_1 q_2}{r_{12}^2}\left(1 - \frac{1}{a^2}\left(\frac{dr_{12}}{dt}\right)^2 + \frac{2r_{12}}{a^2}\frac{d^2 r_{12}}{dt^2}\right)\hat{r}_{12}, \quad a = Const, \quad a > 0. \tag{5}$$

This is the equation of motion of two electrically charged point particles relatively one another, with modified Coulomb forces acting between them. The modifying function in Weber's equation look like that:

$$\Upsilon_{12} = 1 - \frac{1}{a^2}\left(\frac{dr_{12}}{dt}\right)^2 + \frac{2r_{12}}{a^2}\frac{d^2 r_{12}}{dt^2}. \tag{6}$$

As follows from (6), for modification of Coulomb forces in his theory of electrodynamics Weber used one modifying function that depends on the distance between particles, first and second derivatives of this distance with respect to time and a constant a with dimension of velocity.

Weber defined the properties of modified Coulomb forces on the basis of two, according to his own terminology, "fundamental principles" – "electrostatics" and "electrodynamics" [2].

"The principle of electrostatics" is the Coulomb law for forces interacting between two electric charges motionless relatively one another (q_1 and q_2):

$$\vec{F}_{12} = \frac{q_1 q_2}{r_{12}^2}\hat{r}_{12}.$$

"The principle of electrodynamics" is the Ampere's law for the forces of interaction between two linear elements (ds_1 and ds_2) of electric currents (i_1 and i_2):

$$\vec{F}_{12} = -k\frac{i_1 i_2}{r_{12}^2}\left(2\left(\vec{ds}_1 \cdot \vec{ds}_2\right) - \frac{3}{r_{12}^2}\left(\vec{ds}_1 \cdot \vec{r}_{12}\right)\left(\vec{ds}_2 \cdot \vec{r}_{12}\right)\right)\hat{r}_{12},$$

where k is the positive constant, and $\vec{r}_{12}$ is the radius vector of position of the mass centre of the first current element relatively to the mass centre of the second.

While determining the properties of modified Coulomb forces, Weber also proceeded from the first assumption by Gustav Theodor Fechner [4], [6]:

"All actions of a current-element may be considered as composed by the actions of a positive and a negative particle, of equal strength, which simultaneously traverse the same element of space in opposite directions".

Weber's theory could qualitatively explain all electrodynamic effects known by that time. But for the practical use of the theory the numerical value of the a constant with dimension of velocity incorporated in the modifying function had to be determined.

Comparing the point particles states theory with Weber's theory of electrodynamics, we can conclude that both theories:

1. are based on the three Newton's laws;
2. consider dynamic systems of point particles;
3. consider central forces which depend on distances between particles and relative velocities of motion of particles;
4. determine resulting forces acting between the volumes of particles at distances much longer than the maximum dimensions of volumes as forces acting between the mass centres of volumes of particles;
5. use modified Coulomb forces;
6. apply functions modifying Coulomb forces;
7. determine the properties of modifying functions proceeding from the hypothesis of properties of modified Coulomb forces;
8. formulate the hypothesis of properties of modified Coulomb forces on the basis of known physical phenomena;
9. incorporate some unknown constants into modifying functions; the numeric values of these constants can be determined experimentally only.

The main difference between the theories is that in Weber's electrodynamics the hypothesis of properties of modifying Coulomb forces is based on physical phenomena known by the middle of the 19th century, whereas in the point particles states theory it is based on physical phenomena known in the beginning of the 21st century.

Therefore, the point particles states theory is the logical continuation of Weber's theory of electrodynamics, taking into account the modern knowledge of physical processes.

5 The system of equations of motion of N particles

Using the form of modifying function determined hereinabove (2), we will derive functions which modify the Coulomb forces acting between particles in the dynamic system with the number of particles equal to N:

$$\Upsilon_{ln} = 1 - b_{ln}^{\left(1 - v_{ln}^2/a_{ln}^2\right)}, \quad l \neq n, \quad l = 1, 2, \ldots, N, \quad k = 1, 2, \ldots, N,$$

and the system of equations of motion of N particles in this dynamic system:

$$m_l \frac{d\vec{v}_l}{dt} = \sum_{n=1;\ n \neq l}^{N} \frac{q_l q_n}{r_{ln}^2} \left(1 - b_{ln}^{\left(1 - v_{ln}^2/a_{ln}^2\right)}\right) \hat{r}_{ln}, \qquad l = 1, 2, \ldots, N, \tag{7}$$

in which:

$$\vec{v}_l = \frac{d\vec{r}_l}{dt}, \quad \vec{v}_{ln} = \frac{d\vec{r}_{ln}}{dt}, \quad \vec{r}_{ln} = \vec{r}_l - \vec{r}_n, \quad v_{ln} \geq 0,$$

$$b_{ln} = Const, \quad b_{ln} = b_{nl}, \quad a_{ln} = Const, \quad a_{ln} = a_{nl}, \quad a_{ln} > 0, \quad b_{ln} > 1,$$

m_l is the inert mass of the particle No. l,
q_l is the electric charge of the particle No. l,
$\vec{r}_l$ is the radius vector of the position of the particle No. l in the coordinate system where all radius vectors of positions of all N particles are determined,
$\vec{r}_{ln}$ is the radius vector of the position of the particle No. l relatively to the particle No. n,
$\vec{v}_{ln}$ is the velocity of the particle No. l relatively to the particle No. n.

The constants b_{ln} are dimensionless. The constants a_{ln} have the dimension of velocity. Besides the masses and charges of electron and proton, the system of equations (7) also includes six constants. Each pair of constants $(a_{ln}\ , b_{ln})$ determines one of the three types of modified Coulomb forces: forces between electrons, forces between the electron and the proton, and forces between protons.

If $v_{ln} = a_{ln}$, the magnitude of forces acting between particles No. l and n is equal to zero. If $v_{ln} >> a_{ln}$, forces acting between particles No. l and n in the system of equations (7) can be approximately described by the Coulomb law. The sign of forces of acting between particles No. l and n depends on the sign of the product of their charges $(q_l q_n)$ and the sign of the modifying function which in turn depends on the value of magnitude of relative velocity of the particles:

If $v_{ln} > a_{ln}$, then:

$$\left(1 - b_{ln}^{\left(1 - v_{ln}^2 / a_{ln}^2\right)}\right) > 0.$$

If $v_{ln} < a_{ln}$, then:

$$\left(1 - b_{ln}^{\left(1 - v_{ln}^2 / a_{ln}^2\right)}\right) < 0.$$

Therefore:
1. if $q_l q_n \Upsilon_{ln} > 0$, the particles repel;
2. if $q_l q_n \Upsilon_{ln} < 0$, the particles attract.

The motion of particles determined by the system of equations (7) is subject to two laws of classical dynamics, the conservation of the sum of momenta and the conservation of the sum of moments of momenta of particles:

$$\sum_{l=1}^{N} m_l \vec{v}_l = \vec{p}_0, \quad \sum_{l=1}^{N} m_l \vec{v}_l \times \vec{r}_l = \vec{j}_0, \quad \vec{p}_0 = Const, \quad \vec{j}_0 = Const. \tag{8}$$

With the form of modifying function Υ_{ln} introduced into the theory, the system of equations (7) at $N \geq 3$ doesn't have the third analytical integral in the form of the principle of conservation of energy. The requirement of subjecting of the system of equations to the principle of conservation of energy in the form of the third analytical integral at $N \geq 3$ results to the changes of properties of modified Coulomb forces introduced into the theory as the hypothesis after which the theory either stops working (due to the absence of the possibility of mathematical analysis of derived equations) or contradicts to the reality (i.e., physical processes qualitatively described by the theory don't fit experimental observations). Therefore, in the considered version of PPST this requirement isn't made to the system of equations of motion of the particles.

For the constants b_{ln} and a_{ln} which determine the types of forces (between electrons, between the electron and the proton, and between protons) in the system of equations

(7) we introduce the following indications and definitions:
b_p is **a constant of interaction of protons**;
b_{ep} is **a constant of interaction of the electron and the proton**;
b_e is **a constant of interaction of electrons**;
a_p is **a neutral relative velocity of protons**;
a_{ep} is **a neutral relative velocity of the electron and the proton**;
a_e is **a neutral relative velocity of electrons**.

After that the system of equations (7) can be represented in more detailed form:

$$m_e \frac{d\vec{v}_{e_l}}{dt} = -\sum_{k=1}^{K} \frac{e^2}{r^2_{e_l p_k}} \left(1 - b_{ep}^{\left(1 - v^2_{e_l p_k}/a^2_{ep}\right)}\right) \hat{r}_{e_l p_k} + \sum_{n=1;\ n \neq l}^{L} \frac{e^2}{r^2_{e_l e_n}} \left(1 - b_{e}^{\left(1 - v^2_{e_l e_n}/a^2_{e}\right)}\right) \hat{r}_{e_l e_n},$$

$$m_p \frac{d\vec{v}_{p_k}}{dt} = -\sum_{l=1}^{L} \frac{e^2}{r^2_{p_k e_l}} \left(1 - b_{ep}^{\left(1 - v^2_{p_k e_l}/a^2_{ep}\right)}\right) \hat{r}_{p_k e_l} + \sum_{n=1;\ n \neq k}^{K} \frac{e^2}{r^2_{p_k p_n}} \left(1 - b_{p}^{\left(1 - v^2_{p_k p_n}/a^2_{p}\right)}\right) \hat{r}_{p_k p_n}, \quad (9)$$

$$l = 1, 2, \ldots, L, \qquad k = 1, 2, \ldots, K,$$

$$b_e > 1, \quad b_{ep} > 1, \quad b_p > 1, \quad a_e > 0, \quad a_{ep} > 0, \quad a_p > 0,$$

where:
m_e is an inert mass of the electron,
m_p is an inert mass of the proton,
e is an elementary charge in the CGS system of units,
L is the number of electrons in the dynamic system ($1, 2, \ldots, L$ is the numeration of electrons),
K is the number of protons in the dynamic system ($1, 2, \ldots, K$ is the numeration of protons),
$L + K = N$ is the number of particles in the dynamic system,
$\vec{r}_{e_l}$ and $\vec{r}_{e_n}$ are the radius vectors of position of electrons No. l and n correspondingly,
$\vec{r}_{p_k}$ and $\vec{r}_{p_n}$ are the radius vectors of position of protons No. k and n correspondingly.

The modified Coulomb forces in the system of equations (9) are determined by the three modifying functions depending on the magnitudes of relative velocities of particles:
1. the function modifying the Coulomb forces acting between protons with numbers k and n:

$$\Upsilon_{p_k p_n} = 1 - b_p^{\left(1 - \left(\vec{v}_{p_k} - \vec{v}_{p_n}\right)^2/a^2_p\right)};$$

2. the function modifying the Coulomb forces acting between the electron with number l and the proton with number k:

$$\Upsilon_{e_l p_k} = 1 - b_{ep}^{\left(1 - \left(\vec{v}_{e_l} - \vec{v}_{p_k}\right)^2/a^2_{ep}\right)};$$

3. the function modifying the Coulomb forces acting between electrons with numbers l and n:

$$\Upsilon_{e_l e_n} = 1 - b_e^{\left(1 - \left(\vec{v}_{e_l} - \vec{v}_{e_n}\right)^2/a^2_e\right)}.$$

Analytical solution of the system of equations (7) at $N \geq 3$ faces the same problem as that in the classical three-body problem: the lack in number of integrals of the system of equations enough for its solution (the Bruns's theorem [14]). Nevertheless, using definitions of the particles' states in PPST and the method of reduction of interactions of two volumes of particles to the interaction of their mass centres, the presented version of PPST enables unambiguous conclusions for certain states of two particles and conclusions on attraction or repelling of two volumes of particles at the distance which is much greater than the maximum dimension of the volumes with regard to all forces in the considered dynamic system.

6 Integrals of the system of equations of motion of two particles

We represent the system of equations (7) at $N = 2$:

$$m_1 \frac{d\vec{v}_1}{dt} = \frac{q_1 q_2}{r_{12}^2} \left(1 - b^{\left(1 - v_{12}^2/a^2\right)}\right) \hat{r}_{12}, \tag{10}$$

$$m_2 \frac{d\vec{v}_2}{dt} = \frac{q_2 q_1}{r_{21}^2} \left(1 - b^{\left(1 - v_{21}^2/a^2\right)}\right) \hat{r}_{21}, \tag{11}$$

where:
m_1 and m_2 are the masses of interacting particles, either electrons or protons or the electron and the proton,
q_1 and q_2 are the electric charges of interacting particles, correspondingly to masses of particles, either electrons or protons or the electron and the proton,
b is the constant of interaction, correspondingly to masses of particles, either electrons or protons or the electron and the proton,
a is the neutral relative velocity, correspondingly to masses of particles, either electrons or protons or the electron and the proton.

From the equations (10) and (11), we derive the equation of motion of the first particle relatively to the second:

$$\mu_{12} \frac{d\vec{v}_{12}}{dt} = \frac{q_1 q_2}{r_{12}^2} \left(1 - b^{\left(1 - v_{12}^2/a^2\right)}\right) \hat{r}_{12}. \tag{12}$$

The first integral of the equation (12) determines the moment of momentum of two particles:

$$\mu_{12} \frac{d\left(\vec{v}_{12} \times \vec{r}_{12}\right)}{dt} = 0, \qquad \mu_{12} \vec{v}_{12} \times \vec{r}_{12} = \vec{j}_0, \qquad \vec{j}_0 = Const. \tag{13}$$

We form the scalar product of (12) and $\vec{v}_{12}$:

$$\frac{\mu_{12}}{2} \frac{dv_{12}^2}{dt} = \frac{q_1 q_2}{r_{12}^2} \left(1 - b^{\left(1 - v_{12}^2/a^2\right)}\right) \frac{dr_{12}}{dt}, \tag{14}$$

or:

$$\frac{\mu_{12}}{2} \frac{b^{v_{12}^2/a^2}}{\left(b^{v_{12}^2/a^2} - b\right)} dv_{12}^2 = \frac{q_1 q_2}{r_{12}^2} dr_{12}, \qquad v_{12} \neq a. \tag{15}$$

Integration of (15) results to:

$$\frac{\mu_{12} a^2}{2} \log_b \left(\frac{b^{v_{12}^2/a^2} - b}{b^{v_0^2/a^2} - b}\right) = q_1 q_2 \left(\frac{1}{r_0} - \frac{1}{r_{12}}\right), \qquad v_0 \neq a. \tag{16}$$

r_0 is the initial distance between particles;
v_0 is the magnitude of the initial relative velocity of particles.

7 Conditions of neutral, free, unsteady and bound states of two particles

We transform (16) to the following form:

$$\left(1-b^{\left(1-v_{12}^2/a^2\right)}\right)b^{\frac{2}{\mu_{12}a^2}\left(\frac{\mu_{12}v_{12}^2}{2}+\frac{q_1q_2}{r_{12}}\right)}=\left(1-b^{\left(1-v_0^2/a^2\right)}\right)b^{\frac{2}{\mu_{12}a^2}\left(\frac{\mu_{12}v_0^2}{2}+\frac{q_1q_2}{r_0}\right)}. \qquad (17)$$

From (17) we derive two systems of inequalities:

$$v_0>a,\quad 1-b^{\left(1-v_0^2/a^2\right)}>0,\quad 1-b^{\left(1-v_{12}^2/a^2\right)}>0,\quad v_{12}>a, \qquad (18)$$

$$v_0<a,\quad 1-b^{\left(1-v_0^2/a^2\right)}<0,\quad 1-b^{\left(1-v_{12}^2/a^2\right)}<0,\quad v_{12}<a. \qquad (19)$$

The scalar function of interaction of two particles is determined by the equality:

$$\Phi_{12}=\frac{q_1q_2}{r_{12}^2}\left(1-b^{\left(1-v_{12}^2/a^2\right)}\right). \qquad (20)$$

Using (18) - (20), we make five conclusions:

It follows from the equality (20) that:

1. If $v_{12}=a$, then $\Phi_{12}=0$ - the magnitude of forces acting between the particles equals to zero. This is a neutral state of the particles when each of them moves with permanent velocity and the magnitude of their relative velocity equals to a.

It follows from the system of inequalities (18) and equality (20) that:

2. If $v_0>a$ and $q_1q_2>0$, then $\Phi_{12}>0$ - the particles always repel. If $dr_{12}/dt<0$, then the distance between the particles decreases and they are in the unsteady state. If $dr_{12}/dt\geq 0$, then the distance between the particles increases ad infinitum and they are in the free state.

3. If $v_0>a$, and $q_1q_2<0$, then $\Phi_{12}<0$ - the particles always attract. If $dr_{12}/dt<0$, then the particles are in the unsteady state. If $dr_{12}/dt\geq 0$, then the particles can be both in bound and free states.

It follows from the system of inequalities (19) and equality (20) that:

4. If $v_0<a$, and $q_1q_2>0$, then $\Phi_{12}<0$ - the particles always attract. If $dr_{12}/dt<0$, then the particles are in the unsteady state. If $dr_{12}/dt\geq 0$, then the particles can be both in bound and free states.

5. If $v_0<a$ and $q_1q_2<0$, then $\Phi_{12}>0$ - the particles always repel. If $dr_{12}/dt<0$, then the particles are in the unsteady state. If $dr_{12}/dt\geq 0$, then the particles are in the free state.

We can make one more conclusion from this chapter:

If the magnitude of relative velocity of two particles equals to some value at which the value of the magnitude of interaction forces between the particles equals to zero, then the velocities of the particles remain unchanged. Therefore, the particles are unable to overcome the zero-value threshold of magnitude of forces by themselves, without some external action. Thus, the two charged particles can't change repelling to attraction or vice versa, attraction to repelling without interaction with other particles, and can't neither to enter nor to exit the state at which the magnitude of interaction forces between the particles is equal to zero.

Therefore, for the case of interaction between the particles at $v_0 < a$, it follows from (16):

$$\frac{\mu_{12}a^2}{2}\log_b\left(b - b^{v_{12}^2/a^2}\right) + \frac{q_1q_2}{r_{12}} = \grave{C}, \tag{21}$$

$$\grave{C} = \frac{\mu_{12}a^2}{2}\log_b\left(b - b^{v_0^2/a^2}\right) + \frac{q_1q_2}{r_0}, \qquad v_0 < a,$$

and for the case of $v_0 > a$, the equation (16) results to:

$$\frac{\mu_{12}a^2}{2}\log_b\left(b^{v_{12}^2/a^2} - b\right) + \frac{q_1q_2}{r_{12}} = \acute{C}, \tag{22}$$

$$\acute{C} = \frac{\mu_{12}a^2}{2}\log_b\left(b^{v_0^2/a^2} - b\right) + \frac{q_1q_2}{r_0}, \qquad v_0 > a.$$

8 Dimensionless functions of dimensionless variables and constants for determination of the states of two particles

We introduce dimensionless functions of dimensionless variables and constants in PPST because the PPST equations contain unknown constants, a_p, a_{ep}, a_e, with dimension of velocity, and values of magnitudes of relative velocities of particles while analysing their states can be determined only with regard to those constants.

For the values of constants of interaction of particles in the considered version of PPST and in order to simplify the mathematical analysis of functions discussed in the theory, we define the equality:

$$b_p = b_{ep} = b_e = b, \tag{23}$$

and proceeding from the first principle of selecting of the form of modifying function, namely, the correspondence of theoretical processes of interaction between particles to really observable physical processes (see Chapter 3), we also define the inequality:

$$b \geq 2. \tag{24}$$

We consider (23) and (24) as one of the possible options of PPST and further on we will use only (23) and (24).

We introduce the values of five **characteristic constants of interaction between the particles**:

1. **a characteristic distance**:

$$r_h = \frac{e^2}{\mu a^2}, \tag{25}$$

2. **a characteristic kinetic energy**:

$$E_h = \frac{\mu a^2}{2}, \tag{26}$$

3. **a characteristic magnitude of moment of momentum**:

$$j_h = \mu a r_h = \frac{e^2}{a}, \tag{27}$$

4. **a characteristic magnitude of force**:

$$\Phi_h = \frac{e^2}{r_h^2} = \frac{\mu^2 a^4}{e^2}, \tag{28}$$

5. **a characteristic rotation frequency**:

$$\gamma_h = \frac{a}{2\pi r_h} = \frac{\mu a^3}{2\pi e^2}, \tag{29}$$

where:
e is the elementary electric charge in the CGS system of units.

If $a = a_p$ for the values of characteristic constants in (25-29), they will be the characteristic constants of interaction between protons, with $\mu = m_p/2$.

If $a = a_{ep}$ for the values of characteristic constants in (25-29), they will be the characteristic constants of interaction between the electron and the proton, with $\mu = m_e m_p/\left(m_e + m_p\right)$.

If $a = a_e$ for the values of characteristic constants in (25-29), they will be the characteristic constants of interaction between electrons, with $\mu = m_e/2$.

The scalar multiplication of equation (12) by $\vec{r}_{12}$ results to:

$$\frac{\mu_{12}}{2}\frac{d^2 r_{12}^2}{dt^2} - \mu_{12} v_{12}^2 = \frac{q_1 q_2}{r_{12}}\left(1 - b^{\left(1 - v_{12}^2/a^2\right)}\right). \tag{30}$$

Omitting the indices for the reduced mass of the particles (μ_{12}), for the distance between the particles and for the magnitude of relative velocity of the particles, taking into account that the bound steady state of two particles is determined by nulling of the first and second derivatives of the function of distance between them with respect to time, from (30) and (13) we get conditions of the bound steady state of the particles:

$$\mu v_s^2 = -\frac{q_1 q_2}{r_s}\left(1 - b^{\left(1 - v_s^2/a^2\right)}\right), \qquad \mu v_s r_s = j_s, \tag{31}$$

where:
v_s - is the magnitude of relative velocity of the particles in the bound steady state,
r_s - is the distance between the particles in the bound steady state,
j_s - is the magnitude of the moment of momentum of the particles $\vec{j_0}$ (13) in the bound steady state.

We determine the scalar function of interaction of particles in the bound steady state. For doing it, we make the scalar product of (12) and the unit vector of the radius vector of position of the first particle relatively to the second; in the resulting expression we substitute v_{12} with v_s and r_{12} with r_s:

$$\Phi_s = \frac{q_1 q_2}{r_s^2}\left(1 - b^{\left(1 - v_s^2/a^2\right)}\right). \tag{32}$$

Using characteristic distances (25) and neutral relative velocities of particles, we introduce a dimensionless function of the distance between the particles - R, and a dimensionless function of the relative velocity of particles - V:

$$R = \frac{r}{r_h}, \qquad V = \frac{v}{a}, \tag{33}$$

where:
r is the distance between the particles,
r_h is the characteristic distance either between protons or between electrons or between the electron and the proton,
v is the magnitude of relative velocity of the particles,
a is the neutral relative velocity of either protons or electrons or the electron and the proton.

Proceeding from (33), we derive the values of R and V for the bound steady state:

$$R_s = \frac{r_s}{r_h}, \qquad V_s = \frac{v_s}{a}. \tag{34}$$

Using (28) and (32), we determine the value of dimensionless scalar function of interaction of the particles in the bound steady state:

$$F_s = \frac{\Phi_s}{\Phi_h}. \tag{35}$$

Proceeding from (13) and (27), we determine the value of dimensionless function of magnitude of the moment of momentum of the particles:

$$J = \frac{j_0}{j_h}. \tag{36}$$

Correspondingly, from (36) we determine the value of dimensionless function of magnitude of the moment of momentum of the particles in the bound steady state:

$$J_s = \frac{j_s}{j_h}. \tag{37}$$

Using the characteristic kinetic energy (26), from (21) and (22) we determine dimensionless functions of integration constants $\grave{C}$ and $\acute{C}$:

$$\grave{E} = \frac{\grave{C}}{E_h}, \qquad \acute{E} = \frac{\acute{C}}{E_h}. \tag{38}$$

From (38) we determine the values of dimensionless functions of integration constants $\grave{C}$ and $\acute{C}$ in the bound steady states:

$$\grave{E}_s = \frac{\grave{C}_s}{E_h}, \qquad \acute{E}_s = \frac{\acute{C}_s}{E_h}, \tag{39}$$

where:

$$\grave{C}_s = \frac{\mu_{12} a^2}{2} \log_b \left(b - b^{v_s^2/a^2} \right) + \frac{q_1 q_2}{r_s}, \qquad v_s < a.$$

$$\acute{C}_s = \frac{\mu_{12} a^2}{2} \log_b \left(b^{v_s^2/a^2} - b \right) + \frac{q_1 q_2}{r_s}, \qquad v_s > a.$$

Considering determinations of characteristic constants (25-28), we transform (31) and (32):

$$\frac{r_s}{r_h} = -\frac{q_1 q_2}{e^2} \frac{a^2}{v_s^2} \left(1 - b^{\left(1 - v_s^2/a^2\right)} \right), \quad \frac{j_s}{j_h} = -\frac{q_1 q_2}{e^2} \frac{a}{v_s} \left(1 - b^{\left(1 - v_s^2/a^2\right)} \right),$$

$$\frac{\Phi_s}{\Phi_h} = \frac{q_1 q_2}{e^2} \frac{r_h^2}{r_s^2} \left(1 - b^{\left(1 - v_s^2/a^2\right)} \right). \tag{40}$$

Using (34), (35) and (37), from (40) we derive expressions of R_s, F_s and J_s functions via the V_s variable:

$$R_s = -\frac{q_1 q_2}{e^2} \frac{\left(1 - b^{\left(1 - V_s^2\right)} \right)}{V_s^2}, \tag{41}$$

$$F_s = \frac{q_1 q_2}{e^2} \frac{V_s^4}{\left(1 - b^{\left(1 - V_s^2\right)}\right)}, \tag{42}$$

$$J_s = -\frac{q_1 q_2}{e^2} \frac{\left(1 - b^{\left(1 - V_s^2\right)} \right)}{V_s}. \tag{43}$$

We transform (21) and (22) into $\grave{E}$ and $\acute{E}$ functions (38) of V and R:

$$\grave{E} = \log_b \left(b - b^{V^2} \right) + \frac{q_1 q_2}{e^2} \frac{2}{R}, \qquad 0 \le V < 1, \tag{44}$$

$$\acute{E} = \log_b \left(b^{V^2} - b \right) + \frac{q_1 q_2}{e^2} \frac{2}{R}, \qquad V > 1. \tag{45}$$

Considering conclusions of the Chapter 7 that the particles at $0 \le V < 1$ can only be bound at $q_1 q_2 > 0$, whereas at $V > 1$ they bind only at $q_1 q_2 < 0$, using (41), from (44) and (45) we find the values of $\grave{E}_s$ and $\acute{E}_s$ functions (39) for bound steady states of the particles which depend on the range of values of $q_1 q_2$ and V_s:

$$q_1 q_2 > 0, \qquad 0 \le V_s < 1, \qquad \grave{E}_s = \log_b \left(b - b^{V_s^2} \right) + \frac{2V_s^2}{\left(b^{\left(1 - V_s^2\right)} - 1\right)}, \tag{46}$$

$$q_1 q_2 < 0, \qquad V_s > 1, \qquad \acute{E}_s = \log_b \left(b^{V_s^2} - b \right) - \frac{2V_s^2}{\left(1 - b^{\left(1 - V_s^2\right)}\right)}. \tag{47}$$

Based on (33) and (36), we express the value of V^2 via dr/dt, R and J:

$$V^2 = \frac{1}{a^2} \left(\frac{dr}{dt} \right)^2 + \frac{J^2}{R^2}. \tag{48}$$

From (44) and (45) we find V^2 via R, $\grave{E}$ and $\acute{E}$:

$$V^2 = \log_b \left(b - b^{\left(\grave{E} - \frac{q_1 q_2}{e^2} \frac{2}{R}\right)} \right), \qquad 0 \le V < 1, \tag{49}$$

$$V^2 = \log_b \left(b + b^{\left(\acute{E} - \frac{q_1 q_2}{e^2} \frac{2}{R}\right)} \right), \qquad V > 1, \tag{50}$$

Using (48), (49) and (50), we write down the equations which determine the squared radial relative velocity of the particles for various ranges of values of V:

$$\frac{1}{a^2}\left(\frac{dr}{dt}\right)^2 = \log_b\left(b - b^{\left(\grave{E}-\frac{q_1q_2}{e^2}\frac{2}{R}\right)}\right) - \frac{J^2}{R^2}, \qquad 0 \le V < 1, \tag{51}$$

$$\frac{1}{a^2}\left(\frac{dr}{dt}\right)^2 = \log_b\left(b + b^{\left(\acute{E}-\frac{q_1q_2}{e^2}\frac{2}{R}\right)}\right) - \frac{J^2}{R^2}, \qquad V > 1. \tag{52}$$

9 States of two particles which magnitude of their relative velocity is less than their neutral relative velocity

In order to determine the state of particles at $v_0 < a$, we will use functions determined in the previous chapter, where $0 \le V < 1$. As follows from the conclusion 4 of the Chapter 7, at the value of V_s (34) less than 1, only likely charged particles (either two protons or two electrons) can be in the bound steady state. For this case, from (41) and with $q_1q_2 > 0$ we get the dimensionless function of the distance between likely charged particles which depends on the relative velocity of particles in the bound steady states at $0 < V_s < 1$:

$$R_s = \frac{\left(b^{\left(1-V_s^2\right)} - 1\right)}{V_s^2}. \tag{53}$$

For the function (53) we get the first limiting value:

$$V_s \to 0, \quad R_s \to +\infty,$$

and the second:

$$V_s \to 1, \quad R_s > 0.$$

Next:

$$\frac{\partial R_s}{\partial V_s} = -\frac{2}{V_s^3}\left(V_s^2 b^{\left(1-V_s^2\right)} \ln b + b^{\left(1-V_s^2\right)} - 1\right),$$

where ln is the natural logarithm. At $V_s < 1$:

$$V_s^2 b^{\left(1-V_s^2\right)} \ln b + b^{\left(1-V_s^2\right)} - 1 > 0.$$

Thus, the function R_s (53) is decreasing in the range of positive values and doesn't have neither nulls nor stationary points. The graphs of dependence of R_s on V_s are shown at Figure 1 at $b = 2$ and at Figure 2 at $b = 200$.

From (43) we get the dimensionless function of the magnitude of the moment of momentum of likely charged particles which depends on the relative velocity of particles in the bound steady states at $0 < V_s < 1$:

$$J_s = \frac{\left(b^{\left(1-V_s^2\right)} - 1\right)}{V_s}. \tag{54}$$

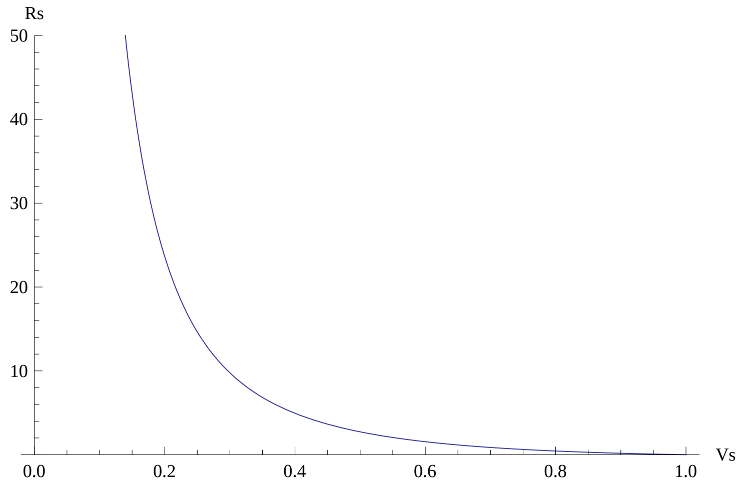

Figure 1: The graph of the function R_s (53) at $b = 2$ and with $0 < V_s < 1$.

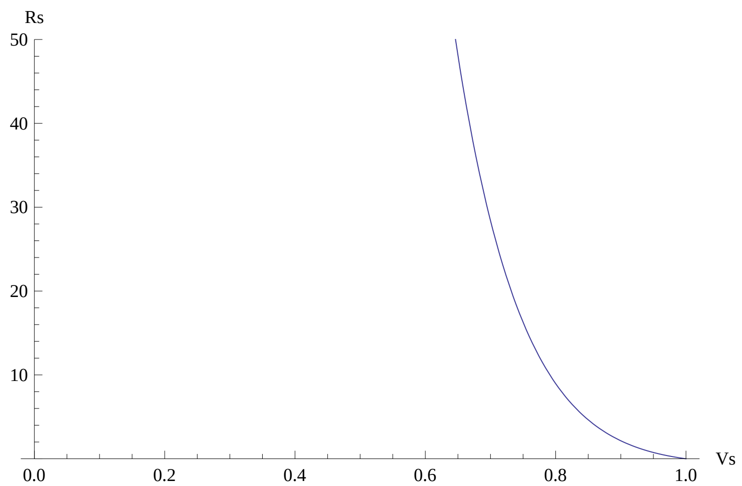

Figure 2: The graph of the function R_s (53) at $b = 200$ and with $0 < V_s < 1$.

For the function (54) we get the first limiting value:

$$V_s \to 0, \quad J_s \to +\infty,$$

and the second:

$$V_s \to 1, \quad J_s > 0.$$

Next:

$$\frac{\partial J_s}{\partial V_s} = -\frac{1}{V_s^2}\left(2V_s^2 b^{\left(1-V_s^2\right)} \ln b + b^{\left(1-V_s^2\right)} - 1\right).$$

At $V_s < 1$:

$$2V_s^2 b^{\left(1-V_s^2\right)} \ln b + b^{\left(1-V_s^2\right)} - 1 > 0.$$

Thus, the function J_s (54) is decreasing in the range of positive values and doesn't have neither nulls nor stationary points. The graphs of dependence of J_s on V_s are shown at Figure 3 at $b = 2$ and at Figure 4 at $b = 200$.

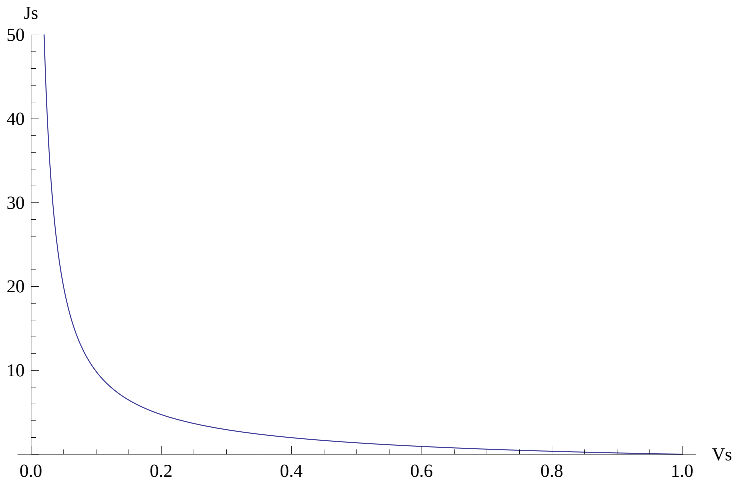

Figure 3: The graph of the function J_s (54) at $b = 2$ and with $0 < V_s < 1$.

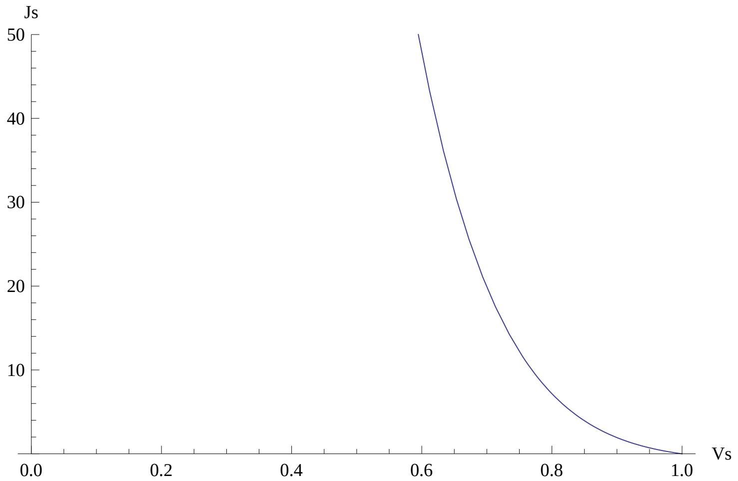

Figure 4: The graph of the function J_s (54) at $b = 200$ and with $0 < V_s < 1$.

From (46) we get the dimensionless function of the integration constant $\grave{C}$, which depends on the relative velocity of particles in the bound steady states at $0 \leq V_s < 1$:

$$\grave{E}_s = \log_b \left(b - b^{V_s^2} \right) + \frac{2V_s^2}{(b^{(1-V_s^2)} - 1)}. \tag{55}$$

For the function (55) we get the limiting value:

$$V_s = 0, \quad \grave{E}_s = \log_b (b-1), \quad b \geq 2, \quad \grave{E}_s \geq 0. \tag{56}$$

Next:

$$\frac{\partial \grave{E}_s}{\partial V_s} = \frac{2V_s}{(b^{(1-V_s^2)} - 1)^2} \left(2V_s^2 b^{(1-V_s^2)} \ln b + b^{(1-V_s^2)} - 1 \right).$$

At $V_s < 1$:

$$2V_s^2 b^{(1-V_s^2)} \ln b + b^{(1-V_s^2)} - 1 > 0.$$

Thus, the function $\grave{E}_s$ (55) is increasing in the range of positive values, it doesn't have stationary points and has a null point at $V_s = 0$ and $b = 2$. Therefore, as follows from (56), the following condition must be satisfied at $0 < V_s < 1$:

$$\grave{E}_s > \log_b (b-1). \tag{57}$$

The graphs of dependence of $\grave{E}_s$ on V_s are shown at Figure 5 at $b = 2$ and at Figure 6 at $b = 200$.

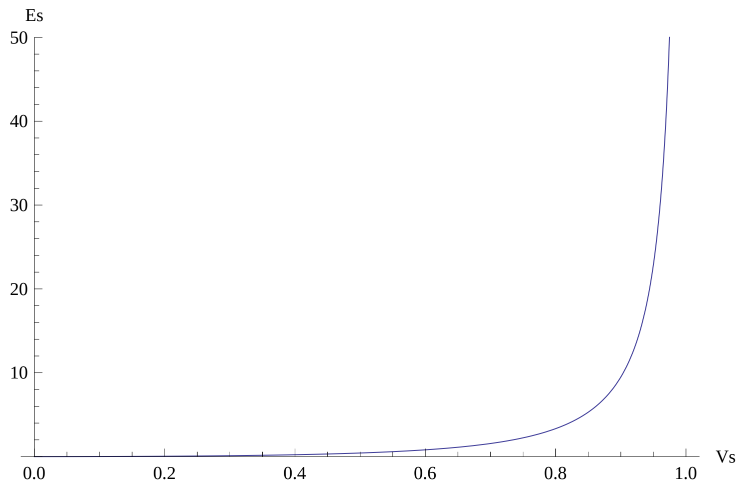

Figure 5: The graph of the function $\grave{E}_s$ (55) at $b = 2$ and with $0 < V_s < 1$.

From (42) we get the dimensionless scalar function of the interaction of particles which depends on the relative velocity of likely charged particles in the bound steady states at $0 < V_s < 1$:

$$F_s = -\frac{V_s^4}{(b^{(1-V_s^2)} - 1)}. \tag{58}$$

For the function (58) we get the first limiting value:

$$V_s \to 0, \quad F_s < 0,$$

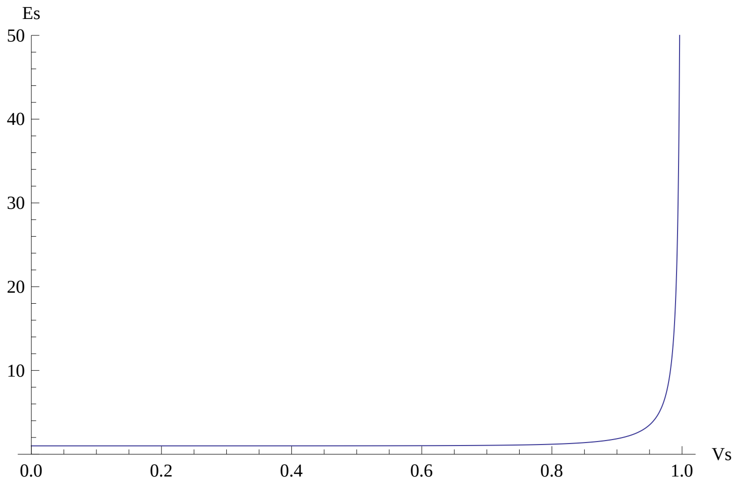

Figure 6: The graph of the function $\grave{E}_s$ (55) at $b = 200$ and with $0 < V_s < 1$.

and the second:

$$V_s \to 1, \quad F_s \to -\infty.$$

Next:

$$\frac{\partial F_s}{\partial V_s} = -\frac{2V_s^3}{\left(b^{(1-V_s^2)} - 1\right)^2} \left(V_s^2 b^{\left(1-V_s^2\right)} \ln b + 2b^{\left(1-V_s^2\right)} - 2 \right).$$

At $V_s < 1$:

$$V_s^2 b^{\left(1-V_s^2\right)} \ln b + 2b^{\left(1-V_s^2\right)} - 2 > 0.$$

Thus, the function F_s (58) at $0 < V_s < 1$ is always decreasing and negative and doesn't have neither nulls nor stationary points. The graphs of dependence of F_s on V_s are shown at Figure 7 at $b = 2$ and at Figure 8 at $b = 200$.

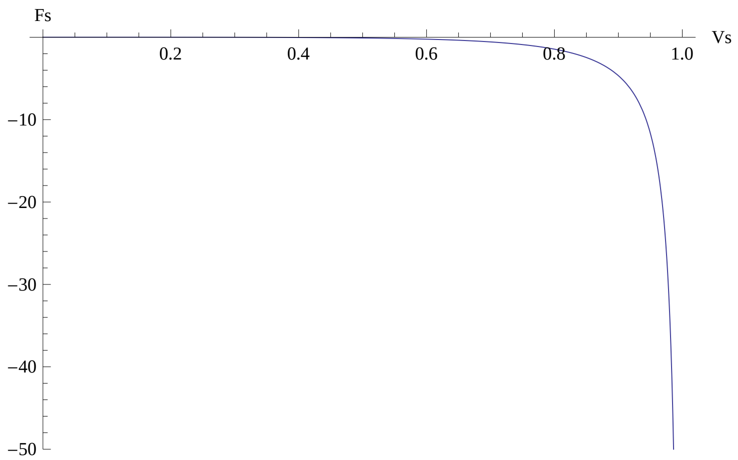

Figure 7: The graph of the function F_s (58) at $b = 2$ and with $0 < V_s < 1$.

Let us write down the function (51) of the R variable which determines the ratio of the squared value of the radial relative velocity of two particles to the squared value of their neutral relative velocity at $0 \le V < 1$:

$$\frac{1}{a^2}\left(\frac{dr}{dt}\right)^2 = \log_b \left(b - b^{\left(\grave{E} - \frac{q_1 q_2}{e^2} \frac{2}{R}\right)} \right) - \frac{J^2}{R^2}, \qquad 0 \le V < 1. \tag{59}$$

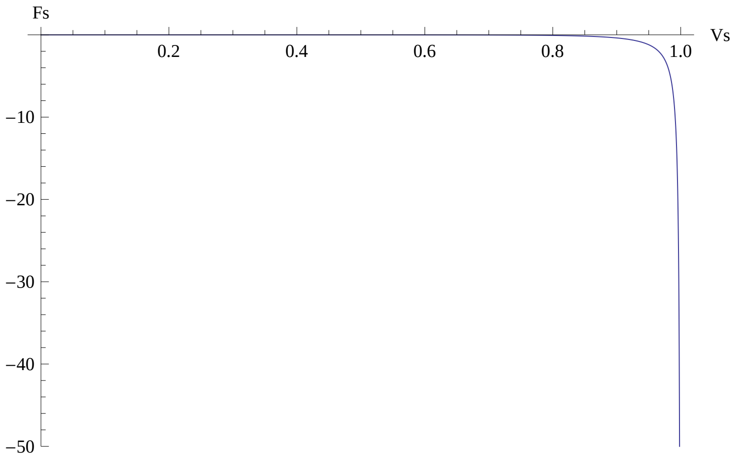

Figure 8: The graph of the function F_s (58) at $b = 200$ and with $0 < V_s < 1$.

From (59) we derive the not strict inequality for determination of values of R at which the squared value of the radial relative velocity of two particles equals to zero, and for determination of values of R at which the function (59) is positive:

$$\log_b \left(b - b^{\left(\grave{E} - \frac{q_1 q_2}{e^2} \frac{2}{R} \right)} \right) - \frac{J^2}{R^2} \geq 0, \tag{60}$$

those will be the values and ranges of values of distances at which particles can be from one another during the interaction according to (59). We convert the (60):

$$b - b^{\left(\grave{E} - \frac{q_1 q_2}{e^2} \frac{2}{R} \right)} - b^{\frac{J^2}{R^2}} \geq 0. \tag{61}$$

Based on (61), we determine and consider the function:

$$\mho_{(R)} = b - b^{\left(\grave{E} - \frac{q_1 q_2}{e^2} \frac{2}{R} \right)} - b^{\frac{J^2}{R^2}}. \tag{62}$$

From (62) we derive:

$$\log_b \left(b - b^{\left(\grave{E} - \frac{q_1 q_2}{e^2} \frac{2}{R} \right)} \right) - \frac{J^2}{R^2} = \log_b \left(1 + \mho_{(R)} b^{-\frac{J^2}{R^2}} \right). \tag{63}$$

Therefore, if $\mho_{(R)} \geq 0$, then the (60) is satisfied. We determine the function of the ratio of the squared value of the radial relative velocity of two particles to the squared value of their neutral relative velocity (59) as the function V_r, which can have both positive and negative values:

$$V_r = \log_b \left(b - b^{\left(\grave{E} - \frac{q_1 q_2}{e^2} \frac{2}{R} \right)} \right) - \frac{J^2}{R^2}, \quad 0 \leq R \leq \infty. \tag{64}$$

Then the (63) may be considered as:

$$V_r = \log_b \left(1 + \mho_{(R)} b^{-\frac{J^2}{R^2}} \right). \tag{65}$$

We write down the $\mho_{(R)}$ function (62) for the interaction of the proton and the electron at $q_1 q_2 < 0$:

$$\mho_{(R)} = b - b^{\left(\grave{E} + \frac{2}{R} \right)} - b^{\frac{J^2}{R^2}}, \quad 0 \leq R \leq \infty. \tag{66}$$

For the $\mho_{(R)}$ (66) function we get the first limiting value:

$$R = 0, \quad \mho_{(R)} < 0, \tag{67}$$

and the second:

$$R = \infty, \quad \mho_{(R)} = b - 1 - b^{\grave{E}}. \tag{68}$$

For (68) we get the three variants of the limiting value.
First:

$$R = \infty, \quad \grave{E} < \log_b (b-1), \quad \mho_{(R)} > 0. \tag{69}$$

Second:

$$R = \infty, \quad \grave{E} = \log_b (b-1), \quad \mho_{(R)} = 0. \tag{70}$$

Third:

$$R = \infty, \quad \grave{E} > \log_b (b-1), \quad \mho_{(R)} < 0. \tag{71}$$

We rewrite the $\grave{E}$ function (44) for interaction of the proton and the electron:

$$\grave{E} = \log_b \left(b - b^{V^2} \right) - \frac{2}{R}, \qquad 0 \leq V < 1, \tag{72}$$

We find the minimum possible value of the function (72):

$$R \to 0, \qquad V \to 1, \qquad \grave{E} \to -\infty. \tag{73}$$

We find the maximum possible value of the function (72):

$$R \to \infty, \qquad V = 0, \qquad \grave{E} < \log_b (b-1). \tag{74}$$

As follows from (74), for the $\mho_{(R)}$ function (66) the first variant (69) of the second limiting value (68) must be used. Thus, the limiting values of the $\mho_{(R)}$ function (66) will be the following:
First:

$$R = 0, \quad \mho_{(R)} < 0. \tag{75}$$

Second:

$$R = \infty, \quad \mho_{(R)} > 0. \tag{76}$$

From (66) we obtain the equation for determination of real positive nulls of the $\mho_{(R)}$ function (66):

$$b - b^{\left(\grave{E} + \frac{2}{R}\right)} = b^{\frac{J^2}{R^2}}. \tag{77}$$

In the left part of the equation (77) there is a strictly monotonically increasing function:

$$\frac{\partial}{\partial R} \left(b - b^{\left(\grave{E} + \frac{2}{R}\right)} \right) = \frac{2 \ln b}{R^2} b^{\left(\grave{E} + \frac{2}{R}\right)}, \tag{78}$$

whereas in the right part of it there is a strictly monotonically decreasing function:

$$\frac{\partial}{\partial R} \left(b^{\frac{J^2}{R^2}} \right) = -\frac{2J^2 \ln b}{R^3} b^{\frac{J^2}{R^2}}. \tag{79}$$

It means that the equation (77) has only one real positive root. This shows that the $\mho_{(R)}$ function (66) has the only real positive null. The first derivative of the $\mho_{(R)}$ function (66) with respect to R is greater than zero:

$$\frac{\partial \mho_{(R)}}{\partial R} = \frac{2\ln b}{R^2}\left(b^{\left(\grave{E}+\frac{2}{R}\right)} + \frac{J^2}{R} b^{\frac{J^2}{R^2}}\right). \tag{80}$$

Therefore, the $\mho_{(R)}$ function (66) increases from the range of negative values (75) to the range of positive values (76). Let us make conclusions about behaviour of the $\mho_{(R)}$ function (66):
1. With the values of R changing from zero ad infinitum, the function has only one real positive null, R_{10}, which is the real positive root of the equation (77).
2. For the range of values $R < R_{10}$ the function is negative.
3. For the range of values $R > R_{10}$ the function is positive.

Based on these conclusions, considering the V_r function (65):

$$V_r = \log_b\left(1 + \mho_{(R)} b^{-\frac{J^2}{R^2}}\right), \tag{81}$$

provided that $V_r \geq 0$, let us make conclusions about the states of the proton and electron at $0 \leq V < 1$:
1. The radial relative velocity of the proton and the electron will equal to zero at the one value of the distance between them, R_{10}. With the radial relative velocity equal to zero, the proton and the electron will not stay in the bound steady state since at $0 \leq V < 1$ the proton and the electron repel and thus, at $dr/dt = 0$ the radial relative acceleration of the particles d^2r/dt^2 is greater than zero.
2. If $dr/dt > 0$ then the distance between particles increases and can't be equal to R_{10} at which $dr/dt = 0$. Therefore, at $dr/dt > 0$ the particles are in the free state.
3. If $dr/dt = 0$ then $R = R_{10}$, $d^2r/dt^2 > 0$, and the distance between particles increases. Therefore, at $dr/dt = 0$ the particles are in the free state.
4. If $dr/dt < 0$ then the distance between particles decreases and the particles are in the unsteady state. After dr/dt goes above the zero value at $R = R_{10}$ and dr/dt becomes greater than zero, the R value begins to increase. Thus, the particles' state turns from unsteady to free.

Let us take the inequality (61):

$$b - b^{\left(\grave{E}-\frac{q_1 q_2}{e^2}\frac{2}{R}\right)} - b^{\frac{J^2}{R^2}} \geq 0,$$

and convert it as follows:

$$b^{\frac{q_1 q_2}{e^2}\frac{2}{R}}\left(b - b^{\frac{J^2}{R^2}}\right) - b^{\grave{E}} \geq 0. \tag{82}$$

Based on (82), we determine and consider the function:

$$\mho_{(R)} = b^{\frac{q_1 q_2}{e^2}\frac{2}{R}}\left(b - b^{\frac{J^2}{R^2}}\right) - b^{\grave{E}}. \tag{83}$$

We obtain from (83):

$$\log_b\left(b - b^{\left(\grave{E}-\frac{q_1 q_2}{e^2}\frac{2}{R}\right)}\right) - \frac{J^2}{R^2} = \log_b\left(1 + \mho_{(R)} b^{-\frac{J^2}{R^2}-\frac{q_1 q_2}{e^2}\frac{2}{R}}\right). \tag{84}$$

Therefore, if $\mho_{(R)} \geq 0$ then the (60) is satisfied. Based on (84), we can express the V_r function (64) via the $\mho_{(R)}$ function (83) as:

$$V_r = \log_b \left(1 + \mho_{(R)} b^{-\frac{J^2}{R^2} - \frac{q_1 q_2}{e^2} \frac{2}{R}} \right). \tag{85}$$

We write down the $\mho_{(R)}$ function (83) for interaction between either two protons or two electrons, thus, at $q_1 q_2 > 0$:

$$\mho_{(R)} = b^{\frac{2}{R}} \left(b - b^{\frac{J^2}{R^2}} \right) - b^{\grave{E}}, \quad 0 \leq R \leq \infty. \tag{86}$$

For the $\mho_{(R)}$ function (86) we find the first limiting value:

$$R = 0, \quad \mho_{(R)} < 0, \tag{87}$$

and the second:

$$R = \infty, \quad \mho_{(R)} = b - 1 - b^{\grave{E}}. \tag{88}$$

For (88) we get the three variants of the limiting value.
First:

$$R = \infty, \quad \grave{E} < \log_b (b-1), \quad \mho_{(R)} > 0. \tag{89}$$

Second:

$$R = \infty, \quad \grave{E} = \log_b (b-1), \quad \mho_{(R)} = 0. \tag{90}$$

Third:

$$R = \infty, \quad \grave{E} > \log_b (b-1), \quad \mho_{(R)} < 0. \tag{91}$$

We rewrite the $\grave{E}$ function (44) for interaction between either two protons or two electrons:

$$\grave{E} = \log_b \left(b - b^{V^2} \right) + \frac{2}{R}, \qquad 0 \leq V < 1, \tag{92}$$

We find the minimum possible value of the function (92):

$$R \to \infty, \qquad V \to 1, \qquad \grave{E} \to -\infty. \tag{93}$$

We find the maximum possible value of the function (92):

$$R \to 0, \qquad V = 0, \qquad \grave{E} \to +\infty. \tag{94}$$

It follows from (93) and (94) that the $\mho_{(R)}$ function (86) is to be considered for the three variants of the second limiting value (89, 90, 91). We find the partial derivative of the $\mho_{(R)}$ function (86) with respect to R:

$$\frac{\partial \mho_{(R)}}{\partial R} = \frac{2 \ln b}{R^2} b^{\frac{2}{R}} \left(b^{\frac{J^2}{R^2}} \left(1 + \frac{J^2}{R} \right) - b \right). \tag{95}$$

The (95) provides the equation which real positive roots are the stationary points of the $\mho_{(R)}$ function:

$$1 + \frac{J^2}{R} = b^{\left(1 - \frac{J^2}{R^2}\right)}. \tag{96}$$

In the left part of the equation (96) there is a strictly monotonically decreasing function:

$$\frac{\partial}{\partial R}\left(1+\frac{J^2}{R}\right)=-\frac{J^2}{R^2}, \tag{97}$$

whereas in the right part of it there is a strictly monotonically increasing function:

$$\frac{\partial}{\partial R}\left(b^{\left(1-\frac{J^2}{R^2}\right)}\right)=\frac{2J^2\ln b}{R^3}b^{\left(1-\frac{J^2}{R^2}\right)}. \tag{98}$$

It means that the equation (96) has only one real positive root which value will determine the one stationary value of the $\mho_{(R)}$ function. If we determine in (96):

$$J=\frac{\left(b^{\left(1-x^2\right)}-1\right)}{x}, \quad 0<x<1, \tag{99}$$

then the real positive root of the equation (96) will be the following:

$$R_x=\frac{\left(b^{\left(1-x^2\right)}-1\right)}{x^2}, \quad 0<x<1. \tag{100}$$

Functions (100) and (99) are similar to those of (53) and (54) correspondingly which behaviour was considered hereinabove for the bound steady states of the likely charged particles at $0<V_s<1$. The values of J (99) and R_x (100) are unambiguously determined by the x variable within the whole positive number line excluding the values at which $x=0$. Therefore, R_x will be the only stationary point of the $\mho_{(R)}$ function (86). We determine the value of the second derivative of the $\mho_{(R)}$ function (86) in the stationary point of R_x:

$$\frac{\partial^2\mho_{(R)}}{\partial R^2}_{(R=R_x)}=-\frac{2J^2\ln b}{R_x^6}b^{\left(\frac{2}{R_x}+\frac{J^2}{R_x^2}\right)}\left(R_x^2+2R_x\ln b+2J^2\ln b\right). \tag{101}$$

Thus, the second derivative of the $\mho_{(R)}$ function (86) in the point of R_x (100) is less than zero. Therefore, the stationary point of the $\mho_{(R)}$ function (86) is its maximum point.

Let us consider the $\mho_{(R)}$ function (86) for the first variant (89) of the second limiting value (88):

$$R=0, \quad \mho_{(R)}<0, \tag{102}$$

$$R=\infty, \quad \grave{E}<\log_b\left(b-1\right), \quad \mho_{(R)}>0. \tag{103}$$

Based on (102) and (103), we conclude:
The $\mho_{(R)}$ function (86) at $\grave{E}<\log_b\left(b-1\right)$ will increase from the range of negative values to the range of positive values, the maximum of the function will lay within the range of positive values, and as the maximum point is passed, the function will decrease within the range of positive values.

Therefore, the $\mho_{(R)}$ function (86) at $\grave{E}<\log_b\left(b-1\right)$ will have the one real positive null.

Let us consider the $\mho_{(R)}$ function (86) for the second variant (90) of the second limiting value (88):

$$R=0, \quad \mho_{(R)}<0, \tag{104}$$

$$R = \infty, \quad \grave{E} = \log_b (b-1), \quad \mho_{(R)} = 0. \tag{105}$$

The $\mho_{(R)}$ function (86) has the global maximum, thus, its value in the maximum point will be greater than the values of its limits. Therefore, based on (105), we can determine:

$$\mho_{(R_x)} > 0. \tag{106}$$

It follows from the (106) that the maximum value of the $\mho_{(R)}$ function (86) at $\grave{E} = \log_b (b-1)$ and at J and R_x, determined in (99) and (100) correspondingly will be greater than zero. Based on it, we conclude:
The $\mho_{(R)}$ function (86) at $\grave{E} = \log_b (b-1)$ will increase from the range of negative values to the range of positive values, the maximum of the function will lay within the range of positive values, and as the maximum point is passed, the function will decrease within the range of positive values down to zero. It means that the $\mho_{(R)}$ function (86) at $\grave{E} = \log_b (b-1)$ and at $R \neq \infty$ will have the one real positive null.

Let us consider the $\mho_{(R)}$ function (86) for the third variant (91) of the second limiting value (88):

$$R = 0, \quad \mho_{(R)} < 0, \tag{107}$$

$$R = \infty, \quad \grave{E} > \log_b (b-1), \quad \mho_{(R)} < 0. \tag{108}$$

We write down the value of the $\mho_{(R)}$ function (86) in the maximum point of R_x as follows:

$$\mho_{(R_x)} = b^{\log_b \left(b - b^{\frac{J^2}{R_x^2}} \right) + \frac{2}{R_x}} - b^{\grave{E}}, \quad R_x > J. \tag{109}$$

The power of the positive term in the right part of (109) is expressed by the function:

$$f_{(R_x)} = \log_b \left(b - b^{\frac{J^2}{R_x^2}} \right) + \frac{2}{R_x}. \tag{110}$$

The power of the negative term in the right part of (109) can be expressed by the function (44) which value is constant as follows:

$$\grave{E} = \log_b \left(b - b^{\frac{1}{a^2}\left(\frac{dr_0}{dt}\right)^2 + \frac{J^2}{R_0^2}} \right) + \frac{2}{R_0}, \quad \frac{1}{a^2}\left(\frac{dr_0}{dt}\right)^2 + \frac{J^2}{R_0^2} < 1, \quad R_0 > J. \tag{111}$$

It follows from (109), (110) and (111) that the $\mho_{(R)}$ function (86) at $\grave{E} > \log_b (b-1)$ will always have the point $R_0 = R_x$ at which its value either is equal to zero at $dr_0/dt = 0$ or is greater than zero at $dr_0/dt \neq 0$. In other words, if the following conditions are satisfied:

$$\grave{E} > \log_b (b-1), \quad J = \frac{b^{1-x^2} - 1}{x}, \quad 0 < x < 1, \tag{112}$$

then the following condition is satisfied too:

$$\grave{E} \leq \log_b \left(b - b^{x^2} \right) + \frac{2x^2}{b^{1-x^2} - 1}. \tag{113}$$

Based on the analysis of the behaviour of the $\mho_{(R)}$ function (86) and taking into account (107) and (108), we make the following conclusions:

The $\mho_{(R)}$ function (86) at $\grave{E} > \log_b(b-1)$ increases within the range of negative values the maximum of the function either equals to zero or lays within the range of positive values, and as the maximum point is passed, the function decreases within the range of negative values.

Therefore, the $\mho_{(R)}$ function (86) at $\grave{E} > \log_b(b-1)$ either has the one null in the maximum point at which $dr/dt = 0$ or two nulls if its maximum value is greater than zero.

Let us make some conclusions about the behaviour of the $\mho_{(R)}$ function (86):
1. At $\grave{E} \leq \log_b(b-1)$ and at $0 \leq R < \infty$ the function has the one real positive null R_{20}; besides, within the range of values $R < R_{20}$ the function is negative whereas within the range of values $R > R_{20}$ the function is positive.
2. At $\grave{E} > \log_b(b-1)$ and with the values of R changing from zero ad infinitum the function either has the one real positive null R_x (100) or two real positive nulls R_{01} and R_{02}; besides, $R_{01} < R_x < R_{02}$.
3. If at $\grave{E} > \log_b(b-1)$ the value of the function in the maximum point is equal to zero, the function has the one real positive null R_x; besides, the function is negative both within the range of values $R < R_x$ and $R > R_x$.
4. If at $\grave{E} > \log_b(b-1)$ the value of the function in the maximum point is greater than zero, the function has two real positive nulls R_{01} and R_{02}; besides, the condition $R_{01} < R_x < R_{02}$ is satisfied. The function is negative within the range of values $R < R_{01}$. The function is positive within the range of values $R_{01} < R < R_{02}$. The function is negative within the range of values $R > R_{02}$.

Based on these conclusions and considering the V_r function (85) at $q_1 q_2 > 0$:

$$V_r = \log_b\left(1 + \mho_{(R)} b^{-\frac{J^2}{R^2} - \frac{2}{R}}\right), \tag{114}$$

with $V_r \geq 0$, we conclude about the state of two likely charged particles, either two protons or two electrons, at $0 \leq V < 1$:
1. With $\grave{E} \leq \log_b(b-1)$), the radial relative velocity of particles equals to zero at the one value of the distance between them, R_{20}; besides, at the moment when the value of the radial relative velocity equals to zero, the particles will not be in the bound steady state since, as it was demonstrated above (57), the value of the $\grave{E}_s$ function (55) for the bound steady states at $J_s \neq 0$ will be greater than $\log_b(b-1)$.
2. If at $\grave{E} \leq \log_b(b-1)$ the radial relative velocity of particles is greater than zero ($dr/dt > 0$) then the distance between the particles is not equal to R_{20} and increases, thus, it can't have the value of R_{20} at which $dr/dt = 0$. Therefore, at $dr/dt > 0$ the particles are in the free state.
3. If at $\grave{E} \leq \log_b(b-1)$ the radial relative velocity of particles equals to zero ($dr/dt = 0$) then the distance between the particles is equal to R_{20} but since the particles at that will not be in the bound steady state and will not be at the distance between one another in the range of values $R < R_{20}$, the radial relative acceleration of particles will be greater than zero ($dr^2/dt^2 > 0$), and thus, the distance between particles will increase. Therefore, the particles will be in the free state.
4. If at $\grave{E} \leq \log_b(b-1)$ the radial relative velocity of particles is less than zero ($dr/dt < 0$) then the distance between the particles isn't equal to R_{20} and decreases, thus, the particles are in the unsteady state. As dr/dt passes the zero value at $R = R_{20}$, dr/dt becomes greater than zero and the value of R begins to increase and the unsteady state of particles

turns into the free.
5. If at $\grave{E} > \log_b(b-1)$ the radial relative velocity of particles is equal to zero at the same distance between them if the values of $\grave{E}$ and J are as follows:

$$\grave{E} = \log_b\left(b - b^{x^2}\right) + \frac{2x^2}{b^{1-x^2}-1}, \quad 0 < x < 1, \tag{115}$$

$$J = \frac{b^{1-x^2}-1}{x}, \quad 0 < x < 1. \tag{116}$$

In this case the value of the distance between the particles can be equal to R_x only. Thus, the particles will be in the bound steady state with the following values of parameters of interaction:

$$\grave{E}_s = \log_b\left(b - b^{V_s^2}\right) + \frac{2V_s^2}{b^{1-V_s^2}-1}, \quad 0 < V_s < 1, \tag{117}$$

$$J_s = \frac{b^{1-V_s^2}-1}{V_s}, \quad 0 < V_s < 1. \tag{118}$$

$$R_s = \frac{b^{1-V_s^2}-1}{V_s^2}, \quad 0 < V_s < 1. \tag{119}$$

6. If the following conditions are satisfied:

$$J = \frac{b^{1-x^2}-1}{x}, \quad \log_b(b-1) < \grave{E} < \log_b\left(b - b^{x^2}\right) + \frac{2x^2}{b^{1-x^2}-1}, \quad 0 < x < 1, \tag{120}$$

then the radial relative velocity of particles is equal to zero at the two values of distance between them, R_{01} and R_{02}. Thus, the particles under the conditions of (120) will be in the bound unsteady state while the distance between them will change in the range of $R_{01} \le R \le R_{02}$; at that, the following condition will be satisfied:

$$R_{01} < \frac{b^{1-x^2}-1}{x^2} < R_{02}, \quad 0 < x < 1.$$

Based on conclusions about the states of two likely charged particles, either two protons or two electrons at $0 \le V < 1$, we may conclude the following:
1. With:

$$0 < V < 1, \quad J \neq 0, \quad \grave{E} \le \log_b(b-1), \quad \frac{dr}{dt} \ge 0, \tag{121}$$

the two likely charged particles are in the free state.
2. With:

$$0 < V < 1, \quad J \neq 0, \quad \grave{E} > \log_b(b-1), \tag{122}$$

the two likely charged particles are in the bound state.

Proceeding from (122), we substitute the $\grave{C}$ value in the $\grave{E}$ value with its determination via the initial conditions of the motion of particles (21), with $q_1 q_2 > 0$ we obtain the conditions of the bound state of two likely charged particles depending either on the initial conditions of the motion:

$$\log_b\left(\frac{b - b^{V_0^2}}{b-1}\right) + \frac{2}{R_0} > 0, \quad J \neq 0, \quad V_0 = \frac{v_0}{a}, \quad 0 < V_0 < 1, \quad R_0 = \frac{r_0}{r_h}, \tag{123}$$

or on V and R variables:

$$\log_b\left(\frac{b-b^{V^2}}{b-1}\right)+\frac{2}{R}>0, \quad J\neq 0, \quad 0<V<1. \tag{124}$$

Proceeding from (121), we substitute the $\grave{C}$ value in the $\grave{E}$ value with its determination via the initial conditions of the motion of particles (21), with $q_1q_2>0$ we obtain the conditions of the free state of two likely charged particles depending either on the initial conditions of the motion:

$$\log_b\left(\frac{b-b^{V_0^2}}{b-1}\right)+\frac{2}{R_0}\leq 0, \quad J\neq 0, \quad 0<V_0<1, \quad \frac{dr_0}{dt}\geq 0, \tag{125}$$

or on V and R variables:

$$\log_b\left(\frac{b-b^{V^2}}{b-1}\right)+\frac{2}{R}\leq 0, \quad J\neq 0, \quad 0<V<1, \quad \frac{dr}{dt}\geq 0. \tag{126}$$

Proceeding from (123), we substitute the dimensionless functions of variables and constants with their values and obtain the conditions of the bound state of two electrons:

$$\frac{m_e a_e^2}{4}\log_b\left(\frac{b-b^{v_0^2/a_e^2}}{b-1}\right)+\frac{e^2}{r_0}>0, \quad j_0\neq 0, \quad 0<v_0<a_e, \tag{127}$$

and the conditions of the bound state of two protons:

$$\frac{m_p a_p^2}{4}\log_b\left(\frac{b-b^{v_0^2/a_p^2}}{b-1}\right)+\frac{e^2}{r_0}>0, \quad j_0\neq 0, \quad 0<v_0<a_p, \tag{128}$$

depending on the initial conditions of the motion.

The boundary values of the initial conditions of the motion of the free state with the bound state will be determined from the equality:

$$\log_b\left(\frac{b-b^{V_0^2}}{b-1}\right)=-\frac{2}{R_0}, \quad J\neq 0, \quad 0<V_0<1, \tag{129}$$

for the interaction between two electrons:

$$\frac{m_e a_e^2}{4}\log_b\left(\frac{b-b^{v_0^2/a_e^2}}{b-1}\right)=-\frac{e^2}{r_0}, \quad j_0\neq 0, \quad 0<v_0<a_e, \tag{130}$$

and for the interaction between two protons:

$$\frac{m_p a_p^2}{4}\log_b\left(\frac{b-b^{v_0^2/a_p^2}}{b-1}\right)=-\frac{e^2}{r_0}, \quad j_0\neq 0, \quad 0<v_0<a_p. \tag{131}$$

From (129) we get the dimensionless function of boundary values of R_0 of free and bound states which depends on the boundary values of relative velocities of likely charged particles V_0 at $0<V_0<1$:

$$R_0=\frac{2}{\log_b(b-1)-\log_b\left(b-b^{V_0^2}\right)}. \tag{132}$$

For the function (132) we get the first limiting value:

$$V_0 \to 0, \quad R_0 \to \infty,$$

and the second:

$$V_0 \to 1, \quad R_0 \to 0.$$

Next:

$$\frac{\partial R_0}{\partial V_0} = -\frac{4V_0 \ln b}{\left(b^{\left(1-V_0^2\right)} - 1\right)\left(\log_b (b-1) - \log_b \left(b - b^{V_0^2}\right)\right)^2}.$$

At $V_0 < 1$:

$$\frac{\partial R_0}{\partial V_0} < 0.$$

Thus, the function R_0 (132) at $0 < V_0 < 1$ is decreasing and always positive and doesn't have neither nulls nor stationary points.

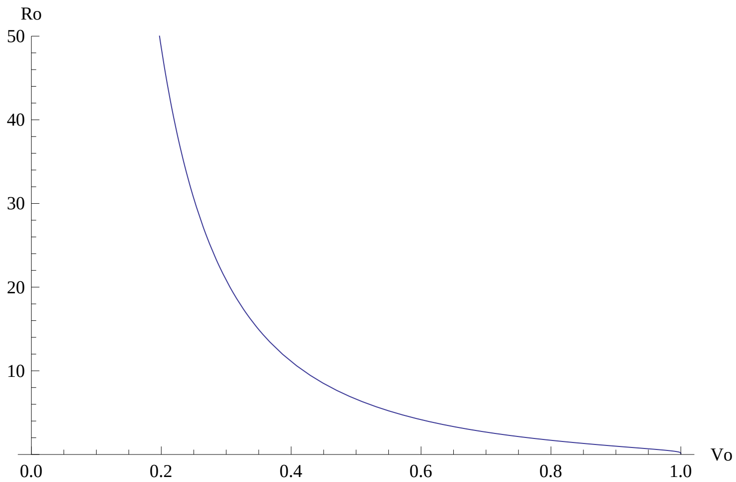

Figure 9: The graph of the function R_0 (132) at $b = 2$ and with $0 < V_0 < 1$.

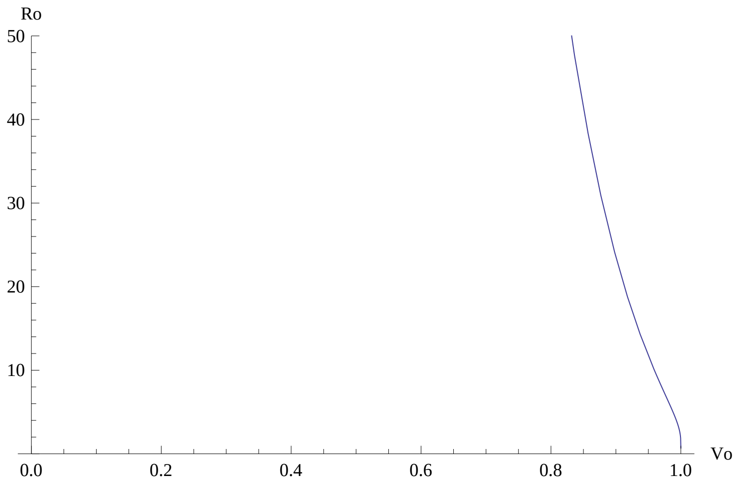

Figure 10: The graph of the function R_0 (132) at $b = 200$ and with $0 < V_0 < 1$.

The graphs of dependence of R_0 on V_0 are shown at Figure 9 at $b = 2$ and at Figure 10 at $b = 200$. If we consider the V values instead of V_0 values and R values instead of R_0 values for the graphs at Figures 9 and 10, then the range of R and V values located to the right from the R_0 function graph, including the R_0 and V_0 values, will determine the free states of particles at $dr/dt \geq 0$. And the range of values to the left from the graph will determine both the bound steady and the bound unsteady states of likely charged particles.

The greater is the magnitude of the attracting force between the particles in the bound state, the greater is the force to be applied for breaking the bond between them and turning their bound state into the free. Proceeding from this, based on the analysis of the R_s (53) and F_s (58) functions, one can conclude that the bound steady state which would be most sustainable to turning into the free state is the bound steady state of two likely charged particles when the magnitude of relative velocity of the particles approaches the value of the neutral relative velocity of these particles from the zero side and the distance between them approaches zero.

10 States of two particles which magnitude of their relative velocity is greater than their neutral relative velocity

As follows from the Chapter 7, the bound state at $v_0 > a$ can be if only $q_1 q_2 < 0$. And thus, this condition can exist for interaction between the electron and the proton only at $V > 1$. For this case we proceed from (41) as $q_1 q_2 < 0$ and obtain the dimensionless function of the distance between the electron and the proton which depends on the relative velocity of particles in the bound steady states as $V_s > 1$:

$$R_s = \frac{\left(1 - b^{\left(1-V_s^2\right)}\right)}{V_s^2}. \tag{133}$$

For the function (133) we get the first limiting value:

$$V_s \to 1, \quad R_s > 0,$$

and the second:

$$V_s >> 1, \quad R_s \to \frac{1}{V_s^2}.$$

Next:

$$\frac{\partial R_s}{\partial V_s} = \frac{2}{V_s^3}\left(V_s^2 b^{\left(1-V_s^2\right)} \ln b + b^{\left(1-V_s^2\right)} - 1\right). \tag{134}$$

From (134) we derive the equation which real positive roots are the stationary points of the R_s function at $V_s > 1$:

$$V_s^2 b^{\left(1-V_s^2\right)} \ln b + b^{\left(1-V_s^2\right)} - 1 = 0. \tag{135}$$

Let us consider the function formed from (135):

$$\mho_{(V_s)} = V_s^2 b^{\left(1-V_s^2\right)} \ln b + b^{\left(1-V_s^2\right)} - 1. \tag{136}$$

For the function (136) we get the first limiting value:

$$V_s \to 1, \quad \mho_{(V_s)} > 0,$$

and the second:

$$V_s >> 1, \quad \mho_{(V_s)} < 0.$$

We find the partial derivative of $\mho_{(V_s)}$ with respect to V_s:

$$\frac{\partial \mho_{(V_s)}}{\partial V_s} = -2V_s^3 b^{\left(1-V_s^2\right)} \ln^2 b. \tag{137}$$

Thus, the $\mho_{(V_s)}$ function (136) is strictly monotonic and decreasing from positive values to negative. Therefore, the equation (135) has only one real positive root. We find the second derivative of R_s with respect to V_s:

$$\frac{\partial^2 R_s}{\partial V_s^2} = -\frac{6}{V_s^4}\left(V_s^2 b^{\left(1-V_s^2\right)} \ln b + b^{\left(1-V_s^2\right)} - 1\right) - 4b^{\left(1-V_s^2\right)} \ln^2 b. \tag{138}$$

With V_s equal to the real positive root of the equation (135), the second derivative of R_s is less than zero:

$$\frac{\partial^2 R_s}{\partial V_s^2} = -4b^{\left(1-V_s^2\right)} \ln^2 b. \tag{139}$$

Therefore, the value of V_s at which the equation (135) is equal to zero will be that at which the R_s function (133) has the maximum of its positive value since the limiting values of the R_s function are greater than zero and it doesn't have nulls. The graphs of dependence of R_s on V_s are shown at Figure 11 at $b = 2$ and at Figure 12 at $b = 200$.

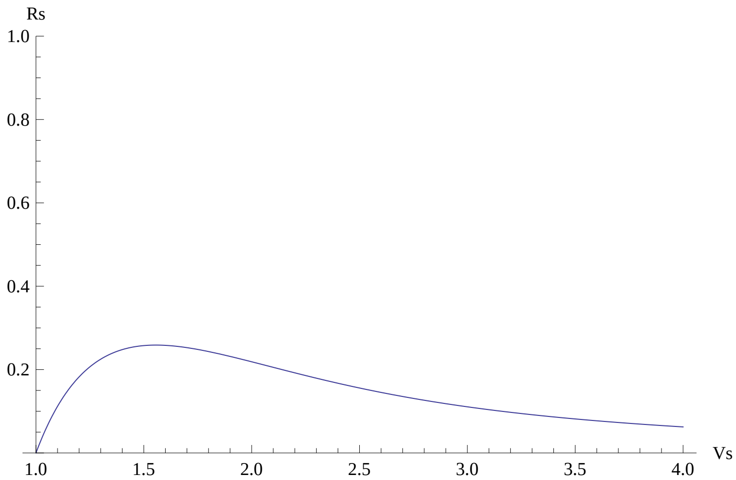

Figure 11: The graph of the function R_s (133) at $b = 2$ and with $V_s > 1$.

From (43) we get the dimensionless function of the magnitude of the moment of momentum of unlikely charged particles (the electron and the proton) which depends on the relative velocity of particles in the bound steady states at $V_s > 1$:

$$J_s = \frac{\left(1 - b^{\left(1-V_s^2\right)}\right)}{V_s}. \tag{140}$$

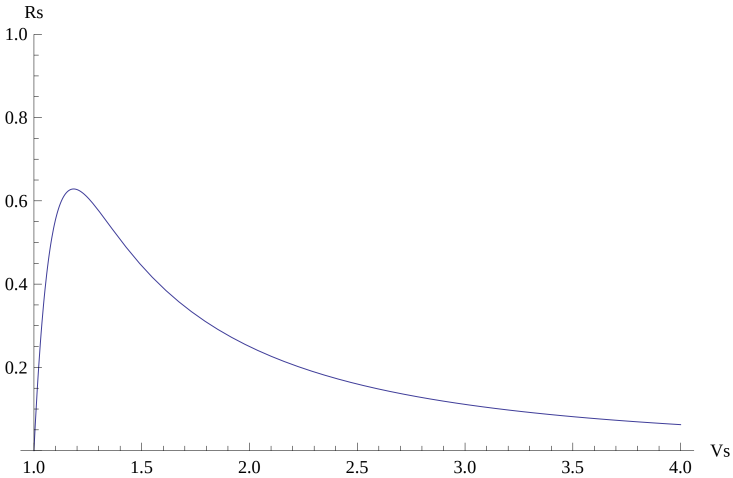

Figure 12: The graph of the function R_s (133) at $b = 200$ and with $V_s > 1$.

For the function (140) we get the first limiting value:

$$V_s \to 1, \quad J_s > 0,$$

and the second:

$$V_s >> 1, \quad J_s \to \frac{1}{V_s}.$$

Next:

$$\frac{\partial J_s}{\partial V_s} = \frac{1}{V_s^2} \left(2V_s^2 b^{\left(1-V_s^2\right)} \ln b + b^{\left(1-V_s^2\right)} - 1 \right). \tag{141}$$

From (141) we derive the equation which real positive roots are the stationary points of the J_s function at $V_s > 1$:

$$2V_s^2 b^{\left(1-V_s^2\right)} \ln b + b^{\left(1-V_s^2\right)} - 1 = 0. \tag{142}$$

From (142) we form the following function:

$$\mho_{(V_s)} = 2V_s^2 b^{\left(1-V_s^2\right)} \ln b + b^{\left(1-V_s^2\right)} - 1. \tag{143}$$

For the function (143) we get the first limiting value:

$$V_s \to 1, \quad \mho_{(V_s)} > 0,$$

and the second:

$$V_s >> 1, \quad \mho_{(V_s)} < 0.$$

We find the partial derivative of $\mho_{(V_s)}$ with respect to V_s:

$$\frac{\partial \mho_{(V_s)}}{\partial V_s} = 2V_s b^{\left(1-V_s^2\right)} \left(1 - 2V_s^2 \ln b\right) \ln b. \tag{144}$$

By definition of V_s for (142) and b, in the considered version of PPST (23) we have the following:

$$V_s > 1, \quad b \geq 2, \quad 2 \ln b > 1. \tag{145}$$

Therefore:

$$\frac{\partial \mho_{(V_s)}}{\partial V_s} < 0.$$

Thus, the $\mho_{(V_s)}$ function is strictly monotonic and decreasing from positive values to negative. As follows from it, the equation (142) has only one real positive root. We find the second derivative of J_s with respect to V_s:

$$\frac{\partial^2 J_s}{\partial V_s^2} = -\frac{2}{V_s^3}\left(2V_s^2 b^{\left(1-V_s^2\right)} \ln b + b^{\left(1-V_s^2\right)} - 1\right) + \frac{2\ln b}{V_s} b^{\left(1-V_s^2\right)}\left(1 - 2V_s^2 \ln b\right). \tag{146}$$

Applying (142) and (145) to (146), we obtain the value of the second derivative of J_s with respect to V_s in the stationary point which is the real positive root of the equation (142):

$$\frac{\partial^2 J_s}{\partial V_s^2} < 0.$$

Therefore, the J_s function (140) at the value of V_s equal to the real positive root of the equation (142) will have the maximum of its positive value since the limiting values of the J_s function are greater than zero and it doesn't have nulls. The graphs of dependence of J_s on V_s are shown at Figure 13 at $b = 2$ and at Figure 14 at $b = 200$.

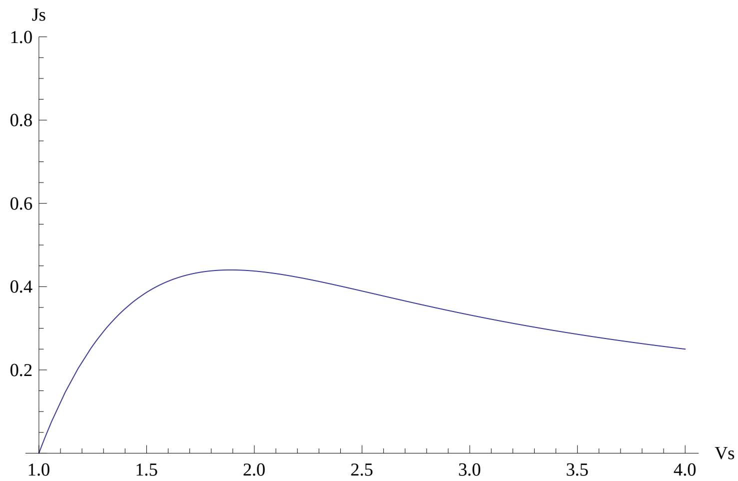

Figure 13: The graph of the function J_s (140) at $b = 2$ and with $V_s > 1$.

From (47) we get the dimensionless function of the integration constant $\acute{C}$ which depends on the relative velocity of unlikely charged particles in the bound steady states at $V_s > 1$:

$$\acute{E}_s = \log_b\left(b^{V_s^2} - b\right) - \frac{2V_s^2}{\left(1 - b^{\left(1-V_s^2\right)}\right)}. \tag{147}$$

We convert (147) as follows:

$$\acute{E}_s = \log_b\left(1 - b^{\left(1-V_s^2\right)}\right) - V_s^2 \frac{1 + b^{\left(1-V_s^2\right)}}{\left(1 - b^{\left(1-V_s^2\right)}\right)}. \tag{148}$$

At $V_s > 1$:

$$0 < 1 - b^{\left(1-V_s^2\right)} < 1.$$

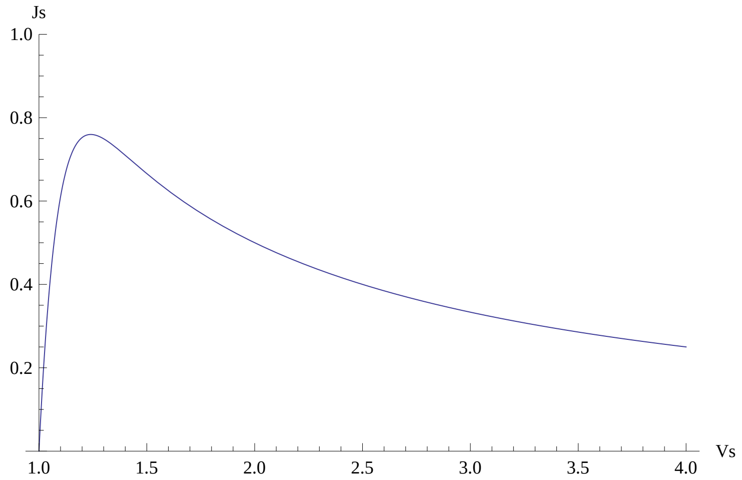

Figure 14: The graph of the function J_s (140) at $b = 200$ and with $V_s > 1$.

Thus:

$$\acute{E}_s < 0. \tag{149}$$

For the function (147) we get the first limiting value:

$$V_s \to 1, \quad \acute{E}_s \to -\infty,$$

and the second:

$$V_s >> 1, \quad \acute{E}_s \to -V_s^2.$$

Next:

$$\frac{\partial \acute{E}_s}{\partial V_s} = \frac{2V_s}{\left(1 - b^{(1-V_s^2)}\right)^2} \left(2V_s^2 b^{\left(1-V_s^2\right)} \ln b + b^{\left(1-V_s^2\right)} - 1\right). \tag{150}$$

From (150) we derive the equation which real positive roots are the stationary points of the $\acute{E}_s$ function at $V_s > 1$:

$$2V_s^2 b^{\left(1-V_s^2\right)} \ln b + b^{\left(1-V_s^2\right)} - 1 = 0. \tag{151}$$

The equation (151) is identical to (142). Therefore, the $\acute{E}_s$ function (147) at the value of V_s equal to the real positive root of the equation (151) will have the one stationary point. The second derivative of $\acute{E}_s$ with respect to V_s as well as that of J_s (140) with respect to V_s at the conditions determined for (151) and (145) will be negative. Thus, the $\acute{E}_s$ function (147) at the value of V_s equal to the real positive root of the equation (151) will have the maximum of its negative value since $\acute{E}_s < 0$. The graphs of dependence of $\acute{E}_s$ on V_s are shown at Figure 15 at $b = 2$ and at Figure 16 at $b = 200$.

From (42) we get the dimensionless scalar function of interaction of particles which depends on the relative velocity of unlikely charged particles in the bound steady states at $V_s > 1$:

$$F_s = -\frac{V_s^4}{\left(1 - b^{(1-V_s^2)}\right)}. \tag{152}$$

For the function (152) we get the first limiting value:

$$V_s \to 1, \quad F_s \to -\infty,$$

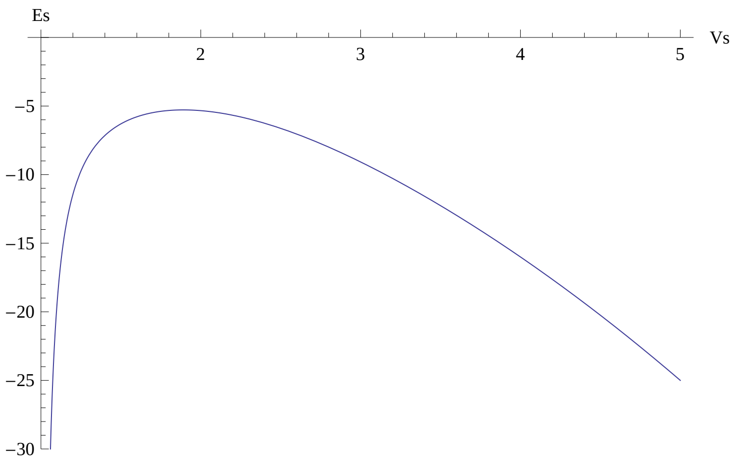

Figure 15: The graph of the function $\acute{E}_s$ (147) at $b = 2$ and with $V_s > 1$.

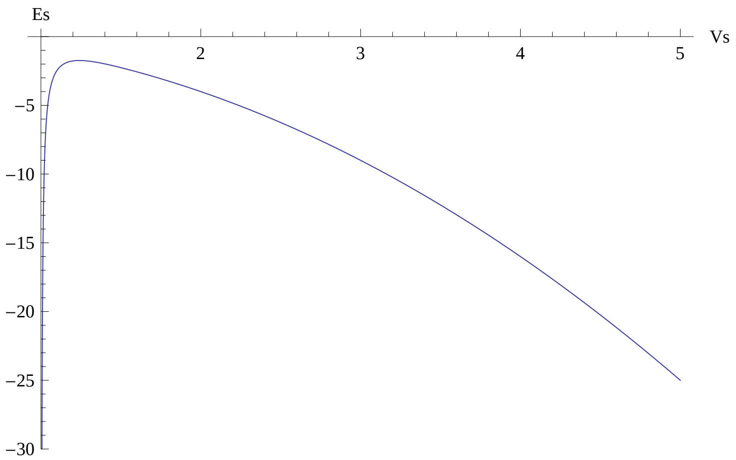

Figure 16: The graph of the function $\acute{E}_s$ (147) at $b = 200$ and with $V_s > 1$.

and the second:

$$V_s >> 1, \quad F_s \to -V_s^4.$$

Next:

$$\frac{\partial F_s}{\partial V_s} = \frac{2V_s^3}{(1-b^{(1-V_s^2)})^2} \left(V_s^2 b^{\left(1-V_s^2\right)} \ln b + 2b^{\left(1-V_s^2\right)} - 2 \right). \tag{153}$$

From (153) we derive the equation which real positive roots are the stationary points of the F_s function (152) at $V_s > 1$:

$$V_s^2 b^{\left(1-V_s^2\right)} \ln b + 2b^{\left(1-V_s^2\right)} - 2 = 0. \tag{154}$$

Let us consider the function formed from (154):

$$\mho_{(V_s)} = V_s^2 b^{\left(1-V_s^2\right)} \ln b + 2b^{\left(1-V_s^2\right)} - 2. \tag{155}$$

For the function (155) we get the first limiting value:

$$V_s \to 1, \quad \mho_{(V_s)} > 0,$$

and the second:

$$V_s >> 1, \quad \mho_{(V_s)} < 0.$$

We find the partial derivative of $\mho_{(V_s)}$ with respect to V_s:

$$\frac{\partial \mho_{(V_s)}}{\partial V_s} = -2V_s b^{\left(1-V_s^2\right)} \left(1 + V_s^2 \ln b\right) \ln b. \tag{156}$$

Thus, the $\mho_{(V_s)}$ function is strictly monotonic and decreasing from positive values to negative. As follows from it, the equation (154) has only one real positive root which value determines the one stationary point of the F_s function (152). The second derivative of F_s with respect to V_s at the point determined by the real positive root of the equation (154) will look as follows:

$$\frac{\partial^2 F_s}{\partial V_s^2} = -\frac{4V_s^4 b^{\left(1-V_s^2\right)} \ln b}{(1-b^{(1-V_s^2)})^2} \left(1 + V_s^2 \ln b\right). \tag{157}$$

It is negative and therefore, the F_s function (152) at the point determined by the real positive root of the equation (154) has the maximum of its negative value since the limiting values of F_s are less than zero and F_s itself doesn't have nulls. The graphs of dependence of F_s on V_s are shown at Figure 17 at $b = 2$ and at Figure 18 at $b = 200$.

Let us write down the function (52) at $q_1 q_2 > 0$ which determines the ratio of the squared value of the radial relative velocity of two likely charged particles (either two protons or two electrons) to the squared value of their neutral relative velocity at $V > 1$:

$$\frac{1}{a^2} \left(\frac{dr}{dt}\right)^2 = \log_b \left(b + b^{\left(\acute{E} - \frac{2}{R}\right)}\right) - \frac{J^2}{R^2}, \qquad V > 1. \tag{158}$$

From (158) we derive the not strict inequality for determination of values of R at which the squared value of the radial relative velocity of two particles equals to zero, and for determination of values of R at which the function (158) is positive:

$$\log_b \left(b + b^{\left(\acute{E} - \frac{2}{R}\right)}\right) - \frac{J^2}{R^2} \geq 0, \tag{159}$$

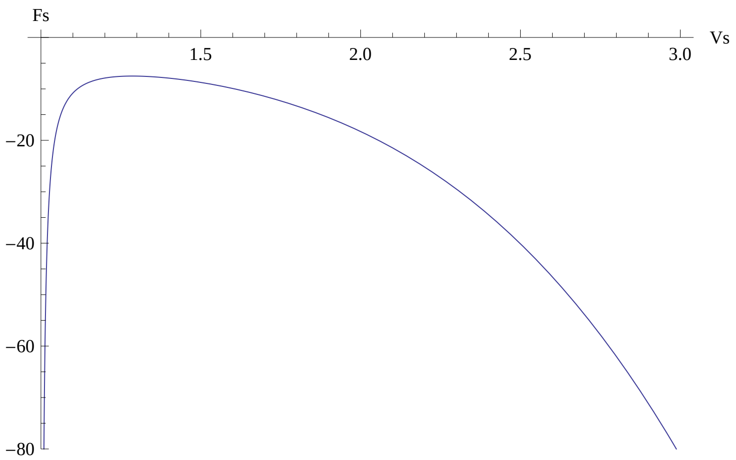

Figure 17: The graph of the function F_s (152) at $b = 2$ and with $V_s > 1$.

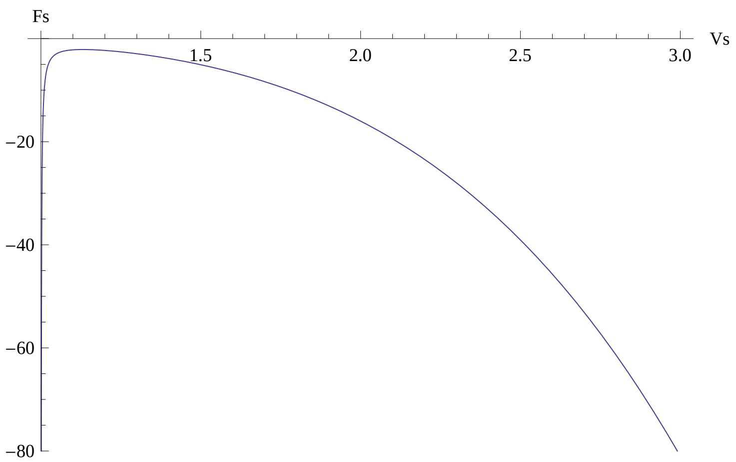

Figure 18: The graph of the function F_s (152) at $b = 200$ and with $V_s > 1$.

those will be the values and ranges of values of distances at which particles can be from one another during the interaction according to (158).
We convert the (159):

$$b + b^{\left(\acute{E} - \frac{2}{R}\right)} - b^{\frac{J^2}{R^2}} \geq 0. \tag{160}$$

Based on (160), we determine and consider the function:

$$\mho_{(R)} = b + b^{\left(\acute{E} - \frac{2}{R}\right)} - b^{\frac{J^2}{R^2}}. \tag{161}$$

From (161) we derive:

$$\log_b \left(b + b^{\left(\acute{E} - \frac{2}{R}\right)} \right) - \frac{J^2}{R^2} = \log_b \left(1 + \mho_{(R)} b^{-\frac{J^2}{R^2}} \right). \tag{162}$$

Therefore, if $\mho_{(R)} \geq 0$, then the (159) is satisfied. We determine the function of the ratio of the squared value of the radial relative velocity of two likely charged particles to the squared value of their neutral relative velocity (158) as the function V_r which can have both positive and negative values:

$$V_r = \log_b \left(b + b^{\left(\acute{E} - \frac{2}{R}\right)} \right) - \frac{J^2}{R^2}, \quad 0 \leq R \leq \infty. \tag{163}$$

Then the (162) can be considered as:

$$V_r = \log_b \left(1 + \mho_{(R)} b^{-\frac{J^2}{R^2}} \right), \tag{164}$$

and the function (161) can be determined as follows:

$$\mho_{(R)} = b + b^{\left(\acute{E} - \frac{2}{R}\right)} - b^{\frac{J^2}{R^2}}, \quad 0 \leq R \leq \infty. \tag{165}$$

For the $\mho_{(R)}$ function (165) we find the first limiting value:

$$R = 0, \quad \mho_{(R)} < 0, \tag{166}$$

and the second:

$$R = \infty, \quad \mho_{(R)} > 0. \tag{167}$$

From (165) we obtain the equation for determination of real positive nulls of the $\mho_{(R)}$ function (165):

$$b + b^{\left(\acute{E} - \frac{2}{R}\right)} = b^{\frac{J^2}{R^2}}. \tag{168}$$

In the left part of the equation (168) there is a strictly monotonically increasing function:

$$\frac{\partial}{\partial R} \left(b + b^{\left(\acute{E} - \frac{2}{R}\right)} \right) = \frac{2 \ln b}{R^2} b^{\left(\acute{E} - \frac{2}{R}\right)}, \tag{169}$$

whereas in the right part of it there is a strictly monotonically decreasing function:

$$\frac{\partial}{\partial R} \left(b^{\frac{J^2}{R^2}} \right) = -\frac{2J^2 \ln b}{R^3} b^{\frac{J^2}{R^2}}. \tag{170}$$

It means that the equation (168) has only one real positive root. As follows from it, the $\mho_{(R)}$ function (165) has the only real positive null. The first derivative of the $\mho_{(R)}$ function (165) with respect to R is greater than zero:

$$\frac{\partial \mho_{(R)}}{\partial R} = \frac{2 \ln b}{R^2} \left(b^{\left(\acute{E} - \frac{2}{R}\right)} + \frac{J^2}{R} b^{\frac{J^2}{R^2}} \right). \tag{171}$$

Therefore, the $\mho_{(R)}$ function (165) increases from the range of negative values (166) to the range of positive values (167). Let us make conclusions about behaviour of the $\mho_{(R)}$ function (165):
1. with the values of R changing from zero ad infinitum, the function has only one real positive null, R_{10}, which is the real positive root of the equation (168);
2. for the range of values $R < R_{10}$ the function is negative;
3. for the range of values $R > R_{10}$ the function is positive.

Based on these conclusions, considering the V_r function (164):

$$V_r = \log_b \left(1 + \mho_{(R)} b^{-\frac{J^2}{R^2}} \right), \tag{172}$$

provided that $V_r \geq 0$, let us make conclusions about the states of two likely charged particles, either two protons or two electrons, at $V > 1$:
1. The radial relative velocity of particles will equal to zero at the one value of the distance between them, R_{10}. With the radial relative velocity equal to zero, likely charged particles will not stay in the bound steady state since at $V > 1$ likely charged particles repel and thus, at $dr/dt = 0$ the radial relative acceleration of the particles d^2r/dt^2 is greater than zero.
2. If $dr/dt > 0$ then the distance between particles increases and can't be equal to R_{10} at which $dr/dt = 0$. Therefore, at $dr/dt > 0$ the particles are in the free state.
3. If $dr/dt = 0$ then $R = R_{10}$, $d^2r/dt^2 > 0$, and the distance between particles will increase, and thus, the particles are in the free state.
4. If $dr/dt < 0$ then the distance between particles decreases and the particles are in the unsteady state. After dr/dt traverses the zero value at $R = R_{10}$ and dr/dt becomes greater than zero, the R value begins to increase and the particles' state turns from unsteady to free.

We write down the function (52) at $q_1 q_2 < 0$ which determines the ratio of the squared value of the radial relative velocity of two unlikely charged particles (the proton and the electron) to the squared value of their neutral relative velocity at $V > 1$:

$$\frac{1}{a^2} \left(\frac{dr}{dt} \right)^2 = \log_b \left(b + b^{\left(\acute{E} + \frac{2}{R}\right)} \right) - \frac{J^2}{R^2}, \quad V > 1. \tag{173}$$

From (173) we derive the not strict inequality for determination of values of R at which the value of the squared radial relative velocity of two unlikely charged particles equals to zero, and for determination of values of R at which the function (173) is positive:

$$\log_b \left(b + b^{\left(\acute{E} + \frac{2}{R}\right)} \right) - \frac{J^2}{R^2} \geq 0, \tag{174}$$

those will be the values and ranges of values of distances at which particles can be from one another during the interaction according to (173). We convert the (174):

$$b + b^{\left(\acute{E} + \frac{2}{R}\right)} - b^{\frac{J^2}{R^2}} \geq 0. \tag{175}$$

Next, we obtain from (175):

$$b^{\acute{E}} - \left(b^{\frac{J^2}{R^2}} - b\right) b^{-\frac{2}{R}} \geq 0. \tag{176}$$

Based on (176), we determine and consider the function:

$$\mho_{(R)} = b^{\acute{E}} - \left(b^{\frac{J^2}{R^2}} - b\right) b^{-\frac{2}{R}}. \tag{177}$$

From (177) we derive:

$$\log_b \left(b + b^{\left(\acute{E}+\frac{2}{R}\right)}\right) - \frac{J^2}{R^2} = \log_b \left(1 + \mho_{(R)} b^{\left(\frac{2}{R}-\frac{J^2}{R^2}\right)}\right). \tag{178}$$

Therefore, if $\mho_{(R)} \geq 0$, then the (174) is satisfied. We determine the function of the ratio of the squared value of the radial relative velocity of two unlikely charged particles to the squared value of their neutral relative velocity (173) as the function V_r which can have both positive and negative values:

$$V_r = \log_b \left(b + b^{\left(\acute{E}+\frac{2}{R}\right)}\right) - \frac{J^2}{R^2}, \quad V > 1, \quad 0 \leq R \leq \infty. \tag{179}$$

Then the (178) may be considered as:

$$V_r = \log_b \left(1 + \mho_{(R)} b^{\left(\frac{2}{R}-\frac{J^2}{R^2}\right)}\right), \tag{180}$$

and the function (177) can be determined as follows:

$$\mho_{(R)} = b^{\acute{E}} - \left(b^{\frac{J^2}{R^2}} - b\right) b^{-\frac{2}{R}}, \quad 0 \leq R \leq \infty. \tag{181}$$

For the $\mho_{(R)}$ function (181) we find the first limiting value:

$$R = 0, \quad \mho_{(R)} < 0, \tag{182}$$

and the second:

$$R = \infty, \quad \mho_{(R)} = b^{\acute{E}} + b - 1 > 0. \tag{183}$$

We find the first derivative of the $\mho_{(R)}$ function with respect to R:

$$\frac{\partial \mho_{(R)}}{\partial R} = \frac{2 \ln b}{R^2} b^{-\frac{2}{R}} \left(b - \left(1 - \frac{J^2}{R}\right) b^{\frac{J^2}{R^2}}\right). \tag{184}$$

The (184) gives the equation which real positive roots are the stationary points of the $\mho_{(R)}$ function:

$$b - \left(1 - \frac{J^2}{R}\right) b^{\frac{J^2}{R^2}} = 0. \tag{185}$$

From (185) we form the function which real positive nulls will be the stationary points of the $\mho_{(R)}$ function (181):

$$\mho_{k(R)} = b - \left(1 - \frac{J^2}{R}\right) b^{\frac{J^2}{R^2}}. \tag{186}$$

Let us find the limiting values of the $\mho_{k(R)}$ function:

$$R = 0, \quad \mho_{k(R)} > 0. \tag{187}$$

$$R = \infty, \quad \mho_{k(R)} > 0. \tag{188}$$

We differentiate the $\mho_{k(R)}$ function with respect to R:

$$\frac{\partial \mho_{k(R)}}{\partial R} = -\frac{J^2}{R^4} b^{\frac{J^2}{R^2}} \left(R^2 - 2R\ln b + 2J^2 \ln b\right). \tag{189}$$

From (189) we derive the equation which real positive roots are the stationary points of the $\mho_{k(R)}$ function:

$$R^2 - 2R\ln b + 2J^2 \ln b = 0. \tag{190}$$

Solving the equation (190), we get:

$$R_{1,2} = \ln b \left(1 \mp \left(1 - \frac{2J^2}{\ln b}\right)^{1/2}\right), \quad J^2 \le \frac{\ln b}{2}. \tag{191}$$

As follows from (191), if:

$$J^2 > \frac{\ln b}{2}, \tag{192}$$

then:

$$R^2 - 2R\ln b + 2J^2 \ln b > 0. \tag{193}$$

And thus, we derive from (189):

$$\frac{\partial \mho_{k(R)}}{\partial R} < 0. \tag{194}$$

Then the $\mho_{k(R)}$ function (186) will decrease in the positive range, will not have stationary points and will not have real positive nulls since its limiting ranges (187) and (188) are positive. Therefore, the following conditions will be satisfied:

$$J > \left(\frac{\ln b}{2}\right)^{1/2}, \quad \mho_{k(R)} > 0. \tag{195}$$

Next, as follows from (191):

$$J^2 = \frac{\ln b}{2}, \quad R_{1,2} = \ln b. \tag{196}$$

At the conditions of (196):

$$b \ge 2, \quad 2\ln b > 1, \quad \mho_{k(R)} = b - \frac{1}{2} b^{\frac{1}{2\ln b}} > 0. \tag{197}$$

Therefore, the $\mho_{k(R)}$ function at the conditions of (196) has the one stationary point at which its value is positive and doesn't have real positive nulls since its limiting values (187) and (188), as well as its value in the stationary point, are positive. It follows from (195), (196) and (197) correspondingly that the first derivative of $\mho_{(R)}$ function (184) with respect to R at the conditions of (195), (196) and (197) is greater than zero and the $\mho_{(R)}$ function at these conditions doesn't have stationary points and increases from the range of negative values to the range of positive values. Therefore, the $\mho_{(R)}$ function (181) at

$J^2 \geq \ln b/2$ has only one real positive null. If the values of R are greater than this null, the $\mho_{(R)}$ function is positive. If the values of R are less than this null, the $\mho_{(R)}$ function is negative.

Let us find the values of the second derivative of the $\mho_{k(R)}$ function with respect to R at the stationary points, i.e., at the conditions of (191):

$$\left.\frac{\partial^2 \mho_{k(R)}}{\partial R^2}\right|_{(R=R_{1,2})} = -\frac{2J^2}{R_{1,2}^4} b^{\frac{J^2}{R_{1,2}^2}} \left(R_{1,2} - \ln b\right). \tag{198}$$

As follows from (198), at $R_{1,2} < \ln b$ the value of the second derivative of the $\mho_{k(R)}$ function in the stationary point is greater than zero. Thus, we can determine from (191) that in the R_1 stationary point:

$$R_1 = \ln b \left(1 - \left(1 - \frac{2J^2}{\ln b}\right)^{1/2}\right), \tag{199}$$

the $\mho_{k(R)}$ function has its local minimum.
As it also follows from (198), at $R_{1,2} > \ln b$ the value of the second derivative of the $\mho_{k(R)}$ function in the stationary point is less than zero. We can determine from (191) that in the R_2 stationary point:

$$R_2 = \ln b \left(1 + \left(1 - \frac{2J^2}{\ln b}\right)^{1/2}\right), \tag{200}$$

the $\mho_{k(R)}$ function has its local maximum.
Assuming that the values of the $\mho_{k(R)}$ function in the limiting points are positive (187, 188), in the stationary point of the minimum value (199) the $\mho_{k(R)}$ function has its local minimum whereas in the stationary point of the maximum value (200) it has its local maximum, and that the function doesn't have any other stationary point, we conclude:
1. The value of the $\mho_{k(R)}$ function in the local maximum point is greater than zero.
2. If the value of the $\mho_{k(R)}$ function in the local minimum point is greater than zero, the $\mho_{k(R)}$ function doesn't have real positive nulls.
3. If the value of the $\mho_{k(R)}$ function in the local minimum point equals to zero, the $\mho_{k(R)}$ function has one real positive null.
4. If the value of the $\mho_{k(R)}$ function in the local minimum point is less than zero, the $\mho_{k(R)}$ function has two real positive nulls.

As follows from the conclusion 3 and (199), there is a single value of J which we determine as J_c, at which the $\mho_{k(R)}$ function has one real positive null. If we determine this null based on (199) as:

$$R_c = \ln b \left(1 - \left(1 - \frac{2J_c^2}{\ln b}\right)^{1/2}\right), \tag{201}$$

then the value of J_c will be determined from the equation (185), substituting in it the R with the R_c value:

$$\left(1 - \frac{J_c^2}{R_c}\right) b^{\frac{J_c^2}{R_c^2}} - b = 0. \tag{202}$$

If we determine:

$$J_c = \frac{\left(1 - b^{\left(1-V_c^2\right)}\right)}{V_c}, \quad V_c > 1, \tag{203}$$

then the real positive root of the equation (202) will be as follows:

$$R_c = \frac{\left(1 - b^{\left(1-V_c^2\right)}\right)}{V_c^2}, \quad V_c > 1. \tag{204}$$

The value of V_c is determined from the equation derived from (201) by introducing into it the R_c (204) and J_c (203) expressed via V_c:

$$2V_c^2 b^{\left(1-V_c^2\right)} \ln b + b^{\left(1-V_c^2\right)} - 1 = 0. \tag{205}$$

The equation (205) is identical to the equation (142) which determines the value of V_s at which the dimensionless function of the magnitude of moment of momentum of unlikely charged particles, the electron and the proton, depending on the relative velocity of the particles in the bound steady states has its maximum. As follows from the analysis of the equation (142), at $b \geq 2$ and $V_c > 1$ the equation (205) has only one real positive root. At $b = 2$, $V_c = 1.8905056...$ Thus, the maximum of the J_s function (140) will match the J_c value.

We substitute R with $R_{1(J)}$ (199) in the $\mho_{k(R)}$ function (186) which will be determined by the J variable:

$$\mho_{k(J)} = b - \left(1 - \frac{J^2}{R_{1(J)}}\right) b^{\frac{J^2}{R_{1(J)}^2}}. \tag{206}$$

From (203) and (205) we derive:

$$J_c = \frac{2V_c \ln b}{2V_c^2 \ln b + 1}. \tag{207}$$

As follows from (196) and (197), the value of J at which the $\mho_{k(R)}$ function has one stationary point $R = \ln b$ is determined by the equality:

$$J = \left(\frac{\ln b}{2}\right)^{(1/2)}. \tag{208}$$

As it was shown hereinabove (195), the values of J at which the $\mho_{k(R)}$ function doesn't have stationary points are determined by the inequality:

$$J > \left(\frac{\ln b}{2}\right)^{(1/2)}. \tag{209}$$

From (207) and (208) we derive the strict inequality:

$$\frac{2V_c \ln b}{2V_c^2 \ln b + 1} < \left(\frac{\ln b}{2}\right)^{(1/2)}.$$

Thus:

$$J_c < \left(\frac{\ln b}{2}\right)^{(1/2)}. \tag{210}$$

Proceeding from (208) and (210), we determine the first limiting value of the $\mho_{k(J)}$ function (206) at which and above which the $\mho_{k(J)}$ function has stationary points:

$$J = J_c, \quad R_{1(J_c)} = R_c, \quad \mho_{k(J_c)} = 0. \tag{211}$$

From (195), (196) and (197) we find the second limiting value above which $\mho_{k(J)}$ doesn't have stationary points:

$$J = \left(\frac{\ln b}{2}\right)^{(1/2)}, \quad R_{1(J)} = \ln b, \quad \mho_{k(J)} = b - \frac{1}{2} b^{\frac{1}{2\ln b}} > 0. \tag{212}$$

We determine the derivative of the $\mho_{k(J)}$ function with respect to J at the $R_{1(J)}$ (199) point:

$$\frac{\partial \mho_{k(J)}}{\partial J} = \frac{2J}{R^3_{1(J)}} b^{\frac{J^2}{R^2_{1(J)}}} \left(R_{1(J)} - J^2\right) \ln b. \tag{213}$$

As follows from (199), $R_{1(J)} > J^2$, thus:

$$\frac{\partial \mho_{k(J)}}{\partial J} > 0.$$

Therefore, the $\mho_{k(J)}$ function at the range of values of J:

$$J_c \leq J \leq \left(\frac{\ln b}{2}\right)^{(1/2)},$$

doesn't have stationary points, increases from zero to positive values and thus, it doesn't have nulls at $J > J_c$. Therefore, $\mho_{k(R)}$ at $J_c < J \leq \left(\frac{\ln b}{2}\right)^{(1/2)}$ has the local minimum of the positive value and, according to the conclusion 2, it doesn't have real positive nulls. As follows from it, the $\mho_{(R)}$ function at $J > J_c$ doesn't have stationary points and has one real positive null.

Let us consider the equation (185) from which the $\mho_{k(R)}$ function has been formed:

$$b - \left(1 - \frac{J^2}{R}\right) b^{\frac{J^2}{R^2}} = 0. \tag{214}$$

As it was demonstrated hereinabove, the $\mho_{k(R)}$ function at $J > J_c$ doesn't have real positive nulls. Thus, as the equation (214) has two real positive roots, they can only exist at $J < J_c$. With $J = J_c$ the equation (214) has one real positive root, R_c. As follows from the analysis of the J_s function (140), at $J_s < J_c$ the same value of J_s can be expressed via two different values of V_s. One of them is greater than V_c, another one is less than V_c. Therefore, at $J < J_c$ we can determine the double equality:

$$J = \frac{\left(1 - b^{\left(1 - x^2_{min}\right)}\right)}{x_{min}} = \frac{\left(1 - b^{\left(1 - x^2_{max}\right)}\right)}{x_{max}}, \quad 1 < x_{min} < V_c, \quad x_{max} > V_c, \tag{215}$$

where the V_c value is determined as the real positive root of the equation (205). As follows from (215), the two real positive roots of the equation (214), R_{min} and R_{max} ($R_{min} < R_{max}$) will be determined via the x_{max} and x_{min} values as:

$$R_{min} = \frac{\left(1 - b^{\left(1 - x^2_{max}\right)}\right)}{x^2_{max}}, \quad x_{max} > V_c, \tag{216}$$

$$R_{max} = \frac{\left(1 - b^{\left(1-x_{min}^2\right)}\right)}{x_{min}^2}, \quad 1 < x_{min} < V_c, \tag{217}$$

where x_{min} and x_{max} are the different functions of J according to (215). With the value of $J < J_c$ determined in (215), the $\mho_{(R)}$ function will have two stationary points, one of them is R_{min} (216) and another one is R_{max} (217). With $J = J_c$ the $\mho_{(R)}$ function will have one stationary point R_c. At $J > J_c$ the $\mho_{(R)}$ function will not have any stationary points. Let us find the second derivative of the $\mho_{(R)}$ function with respect to R in the stationary points at $J < J_c$:

$$\frac{\partial^2 \mho_{(R)}}{\partial R^2}_{(R=R_x)} = \frac{2J^2 \ln b}{R_x^6} \left(-R_x^2 + 2R_x \ln b - 2J^2 \ln b\right) b^{\left(\frac{J^2}{R_x^2} - \frac{2}{R_x}\right)}, \tag{218}$$

where R_x can possess the values of either R_{min} (216) or R_{max} (217). The function:

$$f_{(x)} = -R_x^2 + 2R_x \ln b - 2J^2 \ln b, \tag{219}$$

determines in (218) the sign of the second derivative of $\mho_{(R)}$ with respect to R in the stationary points. If we introduce the following into (219):

$$R_x = \frac{\left(1 - b^{\left(1-x^2\right)}\right)}{x^2}, \quad J = \frac{\left(1 - b^{\left(1-x^2\right)}\right)}{x}, \quad x > 1, \tag{220}$$

where x will determine the values of either x_{max} or x_{min} from (216) and (217), then (219) can be converted into the following form:

$$\frac{x^4 f_{(x)}}{1 - b^{(1-x^2)}} = 2x^2 b^{\left(1-x^2\right)} \ln b + b^{\left(1-x^2\right)} - 1. \tag{221}$$

The function formed from the right part of (221):

$$f_{1(x)} = 2x^2 b^{\left(1-x^2\right)} \ln b + b^{\left(1-x^2\right)} - 1,$$

is identical to the function (143) considered hereinabove and has the following properties:
1. at $b \geq 2$ the function has one real positive null, $x = V_c$;
2. at $x < V_c$ the value of the function is positive;
3. at $x > V_c$ the value of the function is negative.

As follows from these properties, from (216), (217) and (218), the value of the second derivative of the $\mho_{(R)}$ function with respect to R in the R_{min} point is negative whereas in the R_{max} point it's positive. Therefore:
1. in the R_{min} point the $\mho_{(R)}$ function has its local maximum;
2. in the R_{max} point the $\mho_{(R)}$ function has its local minimum.

We rewrite the $\mho_{(R)}$ function (181) as follows:

$$\mho_{(R)} = b^{\acute{E}} - b^{\log_b\left(b^{\frac{J^2}{R^2}} - b\right) - \frac{2}{R}}, \quad R < J. \tag{222}$$

As follows from (222), if:

$$\acute{E} = \log_b \left(b^{\frac{J^2}{R^2}} - b\right) - \frac{2}{R}, \tag{223}$$

then the value of the $\mho_{(R)}$ function will equal to zero. If in (223) $J = J_c$ (203) and $R = R_c$ (204), then the value of $\acute{E}$ at which the value of $\mho_{(R)}$ equals to zero will be determined as:

$$\acute{E}_c = \log_b \left(b^{V_c^2} - b \right) - \frac{2V_c^2}{1 - b^{1-V_c^2}}. \tag{224}$$

Therefore, the $\acute{E}_c$ value matches the maximum value of the $\acute{E}_s$ function (147) for the bound steady states of the proton and the electron.

The values of the first and the second derivatives of the $\mho_{(R)}$ function with respect to R at the R_c point and with $J = J_c$ are equal to zero; the value of the third derivative of the $\mho_{(R)}$ function with respect to R at the R_c point and with $J = J_c$ will be determined by the equality:

$$\frac{\partial^3 \mho_{(R)}}{\partial R^3}_{(R=R_c)} = -\frac{4J_c^2 \ln b}{R_c^6} b^{\left(\frac{J_c^2}{R_c} - \frac{2}{R_c}\right)} \left(R_c - \ln b\right), \tag{225}$$

it is not equal to zero since $R_c \neq \ln b$. As follows from it, the $\mho_{(R)}$ function has an inflection point R_c at $J = J_c$. We can conclude from (224) that at $\acute{E} = \acute{E}_c$ and $J = J_c$ the $\mho_{(R)}$ has the inflection point R_c at which the value of $\mho_{(R)}$ equals to zero. As follows from (222), if $J = J_c$ and $\acute{E} < \acute{E}_c$, then the $\mho_{(R)}$ function has the inflection point R_c at which the value of $\mho_{(R)}$ is less than zero since in this case the (222) results to the following:

$$b^{\acute{E}} < b^{\log_b \left(b^{\frac{J_c^2}{R_c^2}} - b \right) - \frac{2}{R_c}}. \tag{226}$$

If $J = J_c$ and $\acute{E} > \acute{E}_c$ then the $\mho_{(R)}$ function has the inflection point R_c at which the value of $\mho_{(R)}$ is greater than zero since in this case the (222) results to the following:

$$b^{\acute{E}} > b^{\log_b \left(b^{\frac{J_c^2}{R_c^2}} - b \right) - \frac{2}{R_c}}. \tag{227}$$

The (227) demonstrates that at $\acute{E} > \acute{E}_c$ the values of the local maximum and the local minimum of the $\mho_{(R)}$ function will be greater than zero. It is determined by the following: first, the $\acute{E}_s$ function (147) has the maximum at $V_s = V_c$:

$$\acute{E}_c = \log_b \left(b^{\frac{J_c^2}{R_c^2}} - b \right) - \frac{2}{R_c} = \log_b \left(b^{V_c^2} - b \right) - \frac{2V_c^2}{1 - b^{1-V_c^2}}, \tag{228}$$

second, at $J > J_c$ the $\mho_{(R)}$ function doesn't have stationary points, third, the value of the power of the negative term in the right part of (222) in the local maximum point of the $\mho_{(R)}$ function will be as follows:

$$\log_b \left(b^{x_{max}^2} - b \right) - \frac{2x_{max}^2}{1 - b^{1-x_{max}^2}}, \quad x_{max} > V_c, \tag{229}$$

whereas in the local minimum point it will be:

$$\log_b \left(b^{x_{min}^2} - b \right) - \frac{2x_{min}^2}{1 - b^{1-x_{min}^2}}, \quad 1 < x_{min} < V_c. \tag{230}$$

Thus, the following inequalities will be satisfied:

$$\acute{E} > \acute{E}_c, \quad b^{\acute{E}} > b^{\log_b\left(b^{\frac{J^2}{R^2_{max}}} - b\right) - \frac{2}{R_{max}}}, \quad b^{\acute{E}} > b^{\log_b\left(b^{\frac{J^2}{R^2_{min}}} - b\right) - \frac{2}{R_{min}}}.$$

Therefore, at $\acute{E} > \acute{E}_c$ the $\mho_{(R)}$ function will have one real positive null.

As follows from (229) and (230), the strict inequality should be satisfied:

$$\log_b\left(b^{x^2_{max}} - b\right) - \frac{2x^2_{max}}{1 - b^{1-x^2_{max}}} < \log_b\left(b^{x^2_{min}} - b\right) - \frac{2x^2_{min}}{1 - b^{1-x^2_{min}}}, \tag{231}$$

since the value of the $\mho_{(R)}$ function (222) in the local maximum point is always greater than that in the local minimum point.

The analysis of the $\mho_{(R)}$ (181) and $\mho_{k(R)}$ (186) functions performed hereinabove provides the following conclusions on the behaviour of the $\mho_{(R)}$ function:

1. With $R \to 0$, $\mho_{(R)} < 0$.
2. With $R \to \infty$, $\mho_{(R)} > 0$.
3. With $J > J_c$ the $\mho_{(R)}$ function has one real positive null, R_{10}. Within the range of values $0 < R < R_{10}$, the $\mho_{(R)}$ function is negative. Within the range of values $R > R_{10}$ the $\mho_{(R)}$ function is positive.
4. With $\acute{E} > \acute{E}_c$ the $\mho_{(R)}$ function has one real positive null, R_{20}. Within the range of values $0 < R < R_{20}$, the $\mho_{(R)}$ function is negative. Within the range of values $R > R_{20}$, the $\mho_{(R)}$ function is positive.
5. With $J = J_c$ and $\acute{E} = \acute{E}_c$ the $\mho_{(R)}$ function has one real positive null, R_c. R_c is the inflection point of the $\mho_{(R)}$ function. Within the range of values $0 < R < R_c$, the $\mho_{(R)}$ function is negative. Within the range of values $R > R_c$, the $\mho_{(R)}$ function is positive.
6. With $J < J_c$ the $\mho_{(R)}$ function has two stationary points, one of them R_{min} (216) which determines its local maximum, and another one R_{max} (217) which determines its local minimum.
7. With $J < J_c$ the value of the $\mho_{(R)}$ function in its local maximum point, R_{min} (216), is determined as follows:

$$\mho_{(R_{min})} = b^{\acute{E}} - b^{\log_b\left(b^{x^2_{max}} - b\right) - \frac{2x^2_{max}}{1 - b^{1-x^2_{max}}}}. \tag{232}$$

8. If:

$$J < J_c, \quad \acute{E} < \log_b\left(b^{x^2_{max}} - b\right) - \frac{2x^2_{max}}{1 - b^{1-x^2_{max}}}, \tag{233}$$

the $\mho_{(R)}$ function has one real positive null, R_{50}, since if the $\mho_{(R)}$ function is negative in the local maximum point then it is negative in its local minimum point. Within the range of values $0 < R < R_{50}$ the $\mho_{(R)}$ function is negative. Within the range of values $R > R_{50}$, the $\mho_{(R)}$ function is positive.

9. With $J < J_c$, the value of the $\mho_{(R)}$ function in its local minimum point, R_{max} (217), is determined as follows:

$$\mho_{(R_{max})} = b^{\acute{E}} - b^{\log_b\left(b^{x^2_{min}} - b\right) - \frac{2x^2_{min}}{1 - b^{1-x^2_{min}}}}. \tag{234}$$

10. If:

$$J < J_c, \quad \acute{E} > \log_b\left(b^{x^2_{min}} - b\right) - \frac{2x^2_{min}}{1 - b^{1-x^2_{min}}}, \tag{235}$$

the $\mho_{(R)}$ function has one real positive null, R_{60}, since if the $\mho_{(R)}$ function is positive in the local minimum point then it is positive in its local maximum point. Within the range of values $0 < R < R_{60}$, the $\mho_{(R)}$ function is negative. Within the range of values $R > R_{60}$, the $\mho_{(R)}$ function is positive.

11. If:

$$J < J_c, \quad \log_b\left(b^{x^2_{max}} - b\right) - \frac{2x^2_{max}}{1 - b^{1-x^2_{max}}} < \acute{E} < \log_b\left(b^{x^2_{min}} - b\right) - \frac{2x^2_{min}}{1 - b^{1-x^2_{min}}}, \tag{236}$$

the $\mho_{(R)}$ function has three real positive nulls since if the $\mho_{(R)}$ function is positive in the local maximum point and negative in its local minimum point, then it traverses the zero value thrice. The nulls of the $\mho_{(R)}$ function will be in the following points: R_{01}, R_{02}, and R_{03}; the ranges of their values are determined by the inequalities: $R_{01} < R_{min} < R_{02} < R_{max} < R_{03}$. Within the range of values $0 < R < R_{01}$, the $\mho_{(R)}$ function is negative. Within the range of values $R_{01} < R < R_{02}$, the $\mho_{(R)}$ function is positive. Within the range of values $R_{02} < R < R_{03}$, the $\mho_{(R)}$ function is negative. Within the range of values $R > R_{03}$, the $\mho_{(R)}$ function is positive.

12. If:

$$J < J_c, \quad \acute{E} = \log_b\left(b^{x^2_{max}} - b\right) - \frac{2x^2_{max}}{1 - b^{1-x^2_{max}}}, \tag{237}$$

the $\mho_{(R)}$ function has two real positive nulls since if the $\mho_{(R)}$ function has the null in its local maximum point, it will traverse the zero value once again as it passes the local minimum point. The nulls of the $\mho_{(R)}$ function will be in the following points: R_{min} and R_{04}; the ranges of their values are determined by the inequalities: $R_{min} < R_{max} < R_{04}$. Within the range of values $0 < R < R_{min}$, the $\mho_{(R)}$ function is negative. Within the range of values $R_{min} < R < R_{04}$, the $\mho_{(R)}$ function is negative. Within the range of values $R > R_{04}$, the $\mho_{(R)}$ function is positive.

13. If:

$$J < J_c, \quad \acute{E} = \log_b\left(b^{x^2_{min}} - b\right) - \frac{2x^2_{min}}{1 - b^{1-x^2_{min}}}, \tag{238}$$

the $\mho_{(R)}$ function has two real positive nulls since if the $\mho_{(R)}$ function has the null in its local minimum point, it should traverse the zero value in order to pass the local maximum point. The nulls of the $\mho_{(R)}$ function will be in the following points: R_{05} and R_{max}; the ranges of their values are determined by the inequalities: $R_{05} < R_{min} < R_{max}$. Within the range of values $0 < R < R_{05}$, the $\mho_{(R)}$ function is negative. Within the range of values $R_{05} < R < R_{max}$, the $\mho_{(R)}$ function is positive. Within the range of values $R > R_{max}$, the $\mho_{(R)}$ function is positive.

Conclusions 1–13 provided for the $\mho_{(R)}$ function are also valid for the V_r function (180):

$$V_r = \log_b\left(1 + \mho_{(R)} b^{\left(\frac{2}{R} - \frac{J^2}{R^2}\right)}\right).$$

Based on these conclusions and on the fact that particles interacting in accordance to (173) can be on such distance from one another at which the $\mho_{(R)}$ function and, correspondingly,

the V_r function have either zero or positive values, we determine the states in which the electron and the proton can be at $V > 1$, depending on initial conditions of the motion. The initial state of the electron and the proton at $V > 1$ will depend, first, on dimensionless integration constants $\acute{E}$ and J; second, on the value of dimensionless constant $R_0 = r_0/r_h$ (where r_0 is the initial distance between the particles (16)) which in turn determines the value of the squared initial radial relative velocity of the particles, $(dr_0/dt)^2$ (173); third, on the values of dr_0/dt and d^2r_0/dt^2. The initial state will not always match the final state. The initial state will determine the final one:
1. As follows from conclusion 3 for the $\mho_{(R)}$ function, with $J > J_c$ the V_r function (180) has one real positive null, R_{10}. Within the range of values $0 < R < R_{10}$, the V_r function is negative. Within the range of values $R > R_{10}$, the V_r function is positive.
If:
$$J > J_c, \quad \frac{dr_0}{dt} > 0, \tag{239}$$
then $R > R_{10}$, and the distance between particles will increase. Thus, the radial relative velocity of the particles will not be equal to zero since in this case the value of the distance between particles will not traverse the value of the null point of the V_r function. Therefore, the proton and the electron at the initial conditions of motion (239) are in the free state.
If:
$$J > J_c, \quad \frac{dr_0}{dt} = 0, \tag{240}$$
then $R_0 = R_{10}$, at that the particles will not be in the bound steady state since this state is possible at $J \leq J_c$ only. Thus, the distance between particles will increase since in this case $d^2r_0/dt^2 > 0$. Therefore, the proton and the electron at the initial conditions of motion (240) are in the free state.
If:
$$J > J_c, \quad \frac{dr_0}{dt} < 0, \tag{241}$$
then $R > R_{10}$, and the distance between particles will decrease, and thus, the particles are in the unsteady state. Once dr/dt traverses the zero value at $R = R_{10}$, dr/dt becomes greater than zero and the R value will increase, the unsteady state of particles will turn to free.
2. As follows from conclusion 4 for the $\mho_{(R)}$ function, with $\acute{E} > \acute{E}_c$ the V_r function (180) has one real positive null, R_{20}. Within the range of values $0 < R < R_{20}$, the V_r function is negative. Within the range of values $R > R_{20}$, the V_r function is positive.
If:
$$\acute{E} > \acute{E}_c, \quad \frac{dr_0}{dt} > 0, \tag{242}$$
then $R > R_{20}$, and the distance between particles will increase. Thus, the radial relative velocity of the particles will not be equal to zero since in this case the value of the distance between particles will not traverse the value of the null point of the V_r function. Therefore, the proton and the electron at the initial conditions of motion (242) are in the free state.
If:
$$\acute{E} > \acute{E}_c, \quad \frac{dr_0}{dt} = 0, \tag{243}$$
then $R_0 = R_{20}$; at that the particles will not be in the bound steady state since this state is possible at $\acute{E} \leq \acute{E}_c$ only. Thus, the distance between particles will increase since in this case $d^2r_0/dt^2 > 0$. Therefore, the proton and the electron at the initial conditions of

motion (243) are in the free state.
If:

$$\acute{E} > \acute{E}_c, \quad \frac{dr_0}{dt} < 0, \tag{244}$$

then $R > R_{20}$, and the distance between particles will decrease, and thus, the particles are in the unsteady state. Once dr/dt traverses the zero value at $R = R_{20}$, dr/dt becomes greater than zero and the R value will increase, the unsteady state of particles will turn to free.

3. As follows from conclusion 5 for the $\mho_{(R)}$ function, with $J = J_c$ and $\acute{E} = \acute{E}_c$ the V_r function (180) has one real positive null, R_c. R_c is the inflection point of the V_r function. Within the range of values $0 < R < R_c$ the V_r function is negative. Within the range of values $R > R_c$ the V_r function is positive.
If:

$$J = J_c, \quad \acute{E} = \acute{E}_c, \quad R = R_c, \tag{245}$$

then $dr/dt = 0$ and $d^2r/dt^2 = 0$. Therefore, the proton and the electron at the conditions (245) are in the bound steady state.
If:

$$J = J_c, \quad \acute{E} = \acute{E}_c, \quad dr/dt > 0, \tag{246}$$

then $R > R_c$, and the distance between particles will increase. The radial relative velocity of the particles will not be equal to zero since in this case the value of the distance between particles will not traverse the value of the null point of the V_r function. Therefore, the proton and the electron at the initial conditions of motion (246) are in the free state.
If:

$$J = J_c, \quad \acute{E} = \acute{E}_c, \quad dr/dt < 0, \tag{247}$$

then $R > R_c$, and the distance between particles will decrease. Therefore, at the initial conditions (247) the proton and the electron in their initial state will be in the unsteady state. Once the value of the distance between the particles becomes equal to R_c, dr/dt and d^2r/dt^2 become equal to zero, the distance between particles will stop changing, and the particles will turn into the bound steady state and will remain in it. Therefore, at the conditions of initial motion (247) the unsteady state will be initial for the proton and the electron, whereas the bound steady state will be their final one.

4. As follows from conclusion 8 for the $\mho_{(R)}$ function, if:

$$J < J_c, \quad \acute{E} < \log_b\left(b^{x_{max}^2} - b\right) - \frac{2x_{max}^2}{1 - b^{1-x_{max}^2}}, \tag{248}$$

then the V_r function (180) has one real positive null, R_{50}. Within the range of values $0 < R < R_{50}$ the V_r function is negative. Within the range of values $R > R_{50}$ the V_r function is positive.
If:

$$J < J_c, \quad \acute{E} < \log_b\left(b^{x_{max}^2} - b\right) - \frac{2x_{max}^2}{1 - b^{1-x_{max}^2}}, \quad \frac{dr_0}{dt} > 0, \tag{249}$$

then $R > R_{50}$, and the distance between particles will increase. Thus, the radial relative velocity of the particles will not be equal to zero since in this case the value of the distance between particles will not traverse the value of the null point of the V_r function. Therefore,

the proton and the electron at the initial conditions of motion (249) are in the free state.
If:

$$J < J_c, \quad \acute{E} < \log_b \left(b^{x_{max}^2} - b\right) - \frac{2x_{max}^2}{1 - b^{1-x_{max}^2}}, \quad \frac{dr_0}{dt} = 0, \tag{250}$$

then $R_0 = R_{50}$; at that the particles will not be in the bound steady state since this state will possible either at:

$$J = \frac{1 - b^{1-x_{min}^2}}{x_{min}}, \quad R = \frac{1 - b^{1-x_{min}^2}}{x_{min}^2}, \quad \acute{E} = \log_b \left(b^{x_{min}^2} - b\right) - \frac{2x_{min}^2}{1 - b^{1-x_{min}^2}}, \tag{251}$$

or at:

$$J = \frac{1 - b^{1-x_{max}^2}}{x_{max}}, \quad R = \frac{1 - b^{1-x_{max}^2}}{x_{max}^2}, \quad \acute{E} = \log_b \left(b^{x_{max}^2} - b\right) - \frac{2x_{max}^2}{1 - b^{1-x_{max}^2}}. \tag{252}$$

Therefore, as follows from (251) and (252), there will be no bound steady states neither at:

$$\acute{E} > \log_b \left(b^{x_{min}^2} - b\right) - \frac{2x_{min}^2}{1 - b^{1-x_{min}^2}}, \tag{253}$$

nor at:

$$\acute{E} < \log_b \left(b^{x_{max}^2} - b\right) - \frac{2x_{max}^2}{1 - b^{1-x_{max}^2}}, \tag{254}$$

nor at:

$$\log_b \left(b^{x_{max}^2} - b\right) - \frac{2x_{max}^2}{1 - b^{1-x_{max}^2}} < \acute{E} < \log_b \left(b^{x_{min}^2} - b\right) - \frac{2x_{min}^2}{1 - b^{1-x_{min}^2}}. \tag{255}$$

Thus, the distance between particles at the conditions of (250) will increase since in this case $d^2r_0/dt^2 > 0$. Therefore, the proton and the electron at the initial conditions of motion (250) are in the free state.
If:

$$J < J_c, \quad \acute{E} < \log_b \left(b^{x_{max}^2} - b\right) - \frac{2x_{max}^2}{1 - b^{1-x_{max}^2}}, \quad \frac{dr_0}{dt} < 0, \tag{256}$$

then $R > R_{50}$, and the distance between particles will decrease. Therefore, at the initial conditions (256) the proton and the electron will be in the unsteady state. Once dr/dt traverses the zero value at $R = R_{50}$, dr/dt becomes greater than zero and the R value will increase, the unsteady state of particles will turn to free.
5. As follows from conclusion 10 for the $\mho_{(R)}$ function, if:

$$J < J_c, \quad \acute{E} > \log_b \left(b^{x_{min}^2} - b\right) - \frac{2x_{min}^2}{1 - b^{1-x_{min}^2}}, \tag{257}$$

the V_r function (180) has one real positive null, R_{60}. Within the range of values $0 < R < R_{60}$, the V_r function is negative. Within the range of values $R > R_{60}$, the V_r function is positive.
If:

$$J < J_c, \quad \acute{E} > \log_b \left(b^{x_{min}^2} - b\right) - \frac{2x_{min}^2}{1 - b^{1-x_{min}^2}}, \quad \frac{dr_0}{dt} > 0, \tag{258}$$

then $R > R_{60}$, and the distance between particles will increase. Thus, the radial relative velocity of the particles will not be equal to zero since in this case the value of the distance

between particles will not traverse the value of the null point of the V_r function. Therefore, the proton and the electron at the initial conditions of motion (258) are in the free state.
If:

$$J < J_c, \quad \acute{E} > \log_b \left(b^{x_{min}^2} - b \right) - \frac{2x_{min}^2}{1 - b^{1-x_{min}^2}}, \quad \frac{dr_0}{dt} = 0, \tag{259}$$

then $R_0 = R_{50}$; at that the particles will not be in the bound steady state. Thus, the distance between particles will increase since in this case $d^2r_0/dt^2 > 0$. Therefore, the proton and the electron at the initial conditions of motion (259) are in the free state.
If:

$$J < J_c, \quad \acute{E} > \log_b \left(b^{x_{min}^2} - b \right) - \frac{2x_{min}^2}{1 - b^{1-x_{min}^2}}, \quad \frac{dr_0}{dt} < 0, \tag{260}$$

then $R > R_{60}$, and the distance between particles will decrease. Therefore, at the initial conditions of motion (260) the proton and the electron will be in the unsteady state. Once dr/dt traverses the zero value at $R = R_{60}$, dr/dt becomes greater than zero and the R value will increase, the unsteady state of particles will turn to free.
6. As follows from conclusion 11 for the $\mho_{(R)}$ function, if with $J < J_c$:

$$\log_b \left(b^{x_{max}^2} - b \right) - \frac{2x_{max}^2}{1 - b^{1-x_{max}^2}} < \acute{E} < \log_b \left(b^{x_{min}^2} - b \right) - \frac{2x_{min}^2}{1 - b^{1-x_{min}^2}}, \tag{261}$$

the V_r function (180) has three real positive nulls. The zero values of the V_r will be in the points R_{01}, R_{02}, R_{03}, which ranges of values will be determined by the following inequalities: $R_{01} < R_{min} < R_{02} < R_{max} < R_{03}$. Within the range of values $0 < R < R_{01}$, the V_r function is negative. Within the range of values $R_{01} < R < R_{02}$, the V_r function is positive. Within the range of values $R_{02} < R < R_{03}$, the V_r function is negative. Within the range of values $R > R_{03}$, the V_r function is positive.
If:

$$J < J_c, \quad R_{01} \leq R \leq R_{02},$$
$$\log_b \left(b^{x_{max}^2} - b \right) - \frac{2x_{max}^2}{1 - b^{1-x_{max}^2}} < \acute{E} < \log_b \left(b^{x_{min}^2} - b \right) - \frac{2x_{min}^2}{1 - b^{1-x_{min}^2}}, \tag{262}$$

then the proton and the electron are in the bound unsteady state, at that the distance between them is changing within the range of $R_{01} \leq R \leq R_{02}$. If $R = R_{01}$, then $dr/dt = 0$ and $d^2r/dt^2 > 0$. If $R = R_{02}$, then $dr/dt = 0$ and $d^2r/dt^2 < 0$.
If:

$$J < J_c, \quad R \geq R_{03}, \quad dr_0/dt \geq 0,$$
$$\log_b \left(b^{x_{max}^2} - b \right) - \frac{2x_{max}^2}{1 - b^{1-x_{max}^2}} < \acute{E} < \log_b \left(b^{x_{min}^2} - b \right) - \frac{2x_{min}^2}{1 - b^{1-x_{min}^2}}, \tag{263}$$

then the proton and the electron are in the free state.
If:

$$J < J_c, \quad R > R_{03}, \quad dr_0/dt < 0,$$
$$\log_b \left(b^{x_{max}^2} - b \right) - \frac{2x_{max}^2}{1 - b^{1-x_{max}^2}} < \acute{E} < \log_b \left(b^{x_{min}^2} - b \right) - \frac{2x_{min}^2}{1 - b^{1-x_{min}^2}}, \tag{264}$$

then the initial state of the proton and the electron will be unsteady whereas the final one will be free.
7. As follows from conclusion 12 for the $\mho_{(R)}$ function, if with $J < J_c$:

$$\acute{E} = \log_b \left(b^{x_{max}^2} - b \right) - \frac{2x_{max}^2}{1 - b^{1-x_{max}^2}}, \tag{265}$$

the V_r function (180) has two real positive nulls. The zero values of V_r will be in the points R_{min} and R_{04} which ranges of values will be determined by the inequalities: $R_{min} < R_{max} < R_{04}$. Within the range of values $0 < R < R_{min}$, the V_r function is negative. Within the range of values $R_{min} < R < R_{04}$, the V_r function is negative. Within the range of values $R > R_{04}$, the V_r function is positive.
If:

$$J < J_c, \quad \acute{E} = \log_b \left(b^{x_{max}^2} - b \right) - \frac{2x_{max}^2}{1 - b^{1-x_{max}^2}}, \quad R = R_{min}, \tag{266}$$

then the proton and the electron are in the bound steady state.
If:

$$J < J_c, \quad \acute{E} = \log_b \left(b^{x_{max}^2} - b \right) - \frac{2x_{max}^2}{1 - b^{1-x_{max}^2}}, \quad R \geq R_{04}, \quad dr_0/dt \geq 0, \tag{267}$$

then proton and the electron are in the free state.
If:

$$J < J_c, \quad \acute{E} = \log_b \left(b^{x_{max}^2} - b \right) - \frac{2x_{max}^2}{1 - b^{1-x_{max}^2}}, \quad R > R_{04}, \quad dr_0/dt < 0, \tag{268}$$

then the initial state of the proton and the electron will be unsteady whereas the final one will be free.
8. As follows from conclusion 13 for the $\mho_{(R)}$ function, if with $J < J_c$:

$$\acute{E} = \log_b \left(b^{x_{min}^2} - b \right) - \frac{2x_{min}^2}{1 - b^{1-x_{min}^2}}, \tag{269}$$

the V_r function (180) has two real positive nulls. The zero values of V_r will be in the points R_{05} and R_{max} which ranges of values will be determined by the inequalities: $R_{05} < R_{min} < R_{max}$. Within the range of values $0 < R < R_{05}$, the V_r function is negative. Within the range of values $R_{05} < R < R_{max}$, the V_r function is positive. Within the range of values $R > R_{max}$, the V_r function is positive.
If:

$$J < J_c, \quad \acute{E} = \log_b \left(b^{x_{min}^2} - b \right) - \frac{2x_{min}^2}{1 - b^{1-x_{min}^2}}, \quad R = R_{max}, \tag{270}$$

then the proton and the electron are in the bound steady state.
If:

$$J < J_c, \quad \acute{E} = \log_b \left(b^{x_{min}^2} - b \right) - \frac{2x_{min}^2}{1 - b^{1-x_{min}^2}}, \quad R > R_{max}, \quad dr_0/dt > 0, \tag{271}$$

then the proton and the electron are in the free state.
If:

$$J < J_c, \quad \acute{E} = \log_b \left(b^{x_{min}^2} - b \right) - \frac{2x_{min}^2}{1 - b^{1-x_{min}^2}}, \quad R > R_{max}, \quad dr_0/dt < 0, \tag{272}$$

then the initial state of the proton and the electron will be unsteady. Once the value of R becomes equal to R_{max}, the values of both dr/dt and d^2r/dt^2 will equal to zero, the particles will turn to the bound steady state and will remain in it.
If:

$$J < J_c, \quad \acute{E} = \log_b \left(b^{x_{min}^2} - b \right) - \frac{2x_{min}^2}{1 - b^{1-x_{min}^2}}, \quad R_{05} < R < R_{max}, \quad dr_0/dt < 0, \tag{273}$$

then the initial state of the proton and the electron will be unsteady. Once the value of R becomes equal to R_{05}, the values of dr/dt will equal to zero and the value of d^2r/dt^2 will become greater than zero, and R will begin to increase, the particles will turn to the bound unsteady state. Once the value of R becomes equal to R_{max}, the particles will turn to the bound steady state and will remain in it.
If:

$$J < J_c, \quad \acute{E} = \log_b \left(b^{x_{min}^2} - b \right) - \frac{2x_{min}^2}{1 - b^{1-x_{min}^2}}, \quad R = R_{05}, \tag{274}$$

then the initial state of the proton and the electron will be bound unsteady; at that the distance between particles will increase. Once the value of R becomes equal to R_{max}, the particles will turn to the bound steady state and will remain in it.
If:

$$J < J_c, \quad \acute{E} = \log_b \left(b^{x_{min}^2} - b \right) - \frac{2x_{min}^2}{1 - b^{1-x_{min}^2}}, \quad R_{05} < R < R_{max}, \quad dr_0/dt > 0, \tag{275}$$

then the initial state of the proton and the electron will be the bound unsteady; at that the distance between particles will increase. Once the value of R becomes equal to R_{max}, the particles will turn to the bound steady state and will remain in it.
9. As follows from determination of the sign of the $\mho_{(R)}$ function (181) for the various ranges of values of R in conclusions 11 to 13, as well as from conclusions 6 to 8 for the V_r function (180), the distance between the proton and the electron in the bound state cannot be greater than R_{max}. As follows from the analysis of the R_s function (133), the R_s function has its maximum value at the value of V_s determined as the real positive root of the equation (135):

$$V_s^2 b^{\left(1-V_s^2\right)} \ln b + b^{\left(1-V_s^2\right)} - 1 = 0. \tag{276}$$

Therefore, the maximum value of the distance between the proton and the electron in the bound state will be the distance between them in the bound steady state when the values of $\acute{E}_s$, J_s and R_s are determined by the value of V_s which is the real positive root of the equation (276). The bound state of the proton and the electron will be determined by the following necessary conditions:

$$J \le J_c, \quad J = \frac{\left(1 - b^{\left(1-x_{min}^2\right)}\right)}{x_{min}} = \frac{\left(1 - b^{\left(1-x_{max}^2\right)}\right)}{x_{max}}, \quad 1 < x_{min} \le V_c, \quad x_{max} \ge V_c, \tag{277}$$

$$\log_b \left(b^{x_{max}^2} - b \right) - \frac{2x_{max}^2}{1 - b^{1-x_{max}^2}} \le \acute{E} \le \log_b \left(b^{x_{min}^2} - b \right) - \frac{2x_{min}^2}{1 - b^{1-x_{min}^2}}, \quad V > 1, \quad R \le R_{sm},$$

where R_{sm} is the maximum value of R_s determined by the value of V_s which is the real positive root of the equation (276).

With the following initial conditions of motion:

$$J_0 = 0, \quad dr_0/dt > 0,$$

the electron and the proton will be in the free state since in the case of $V < 1$ the electron and the proton repel, the magnitude of their relative velocity approaches the neutral relative velocity of the proton and the electron from the zero side and the distance between them will increase ad infinitum. If $V > 1$ then the electron and the proton attract but the magnitude of their relative velocity will approach the neutral relative velocity of the proton and the electron from the side of plus-infinity and the distance between them will increase ad infinitum.

Let us write down the V_r function (180) at $\acute{E} = \acute{E}_s$ and $J = J_s$:

$$V_r = \log_b \left(b + b^{\left(\acute{E}_s + \frac{2}{R}\right)} \right) - \frac{J_s^2}{R^2}, \quad V_s > 1. \tag{278}$$

The graph of dependence of the V_r function (278) on R at $V_s = V_c$ is shown at Figure 19.
The graph of dependence of the V_r function (278) on R at $V_s < V_c$, and thus, at:

$$\acute{E} = \log_b \left(b^{x_{min}^2} - b \right) - \frac{2x_{min}^2}{1 - b^{1-x_{min}^2}}.$$

is shown at Figure 20.
The graph of dependence of the V_r function (278) on R at $V_s > V_c$, and thus, at:

$$\acute{E} = \log_b \left(b^{x_{max}^2} - b \right) - \frac{2x_{max}^2}{1 - b^{1-x_{max}^2}}.$$

is shown at Figure 21.

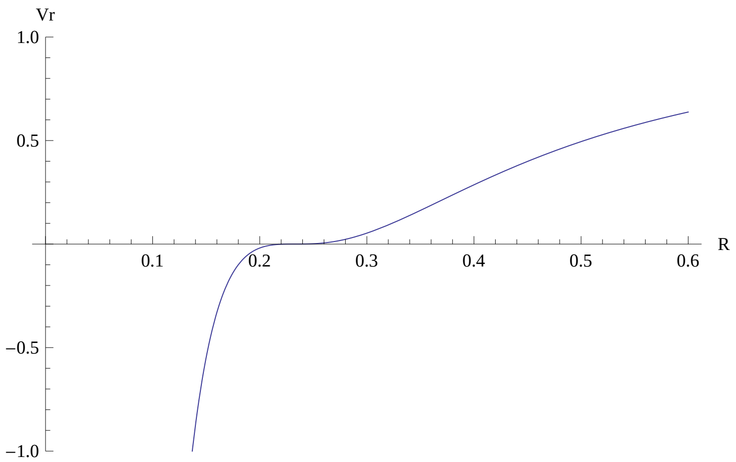

Figure 19: The graph of the V_r function (278) at $b = 2$, at $\acute{E} = \acute{E}_s$, at $J = J_s$ and at $V_s = V_c$.

Let us split the states of the electron and the proton at $J = J_s$ and at $\acute{E} = \acute{E}_s$ into two **domains of states** principally different from one another:
The first is at $V_s > V_c$.
The second is at $1 < V_s \leq V_c$.
If the electron and the proton are in the state depending on J_s and $\acute{E}_s$ which in turn both depend on V_s, then:
The state of the electron and the proton in the first domain can be free, unsteady and bound steady.
The state of the electron and the proton in the second domain can be free, unsteady and bound steady only at $J_s = J_c$ and $\acute{E}_s = \acute{E}_c$ ($V_s = V_c$), let us call it **the boundary state between the second domain and the first**. For the rest of J_s and $\acute{E}_s$ values from

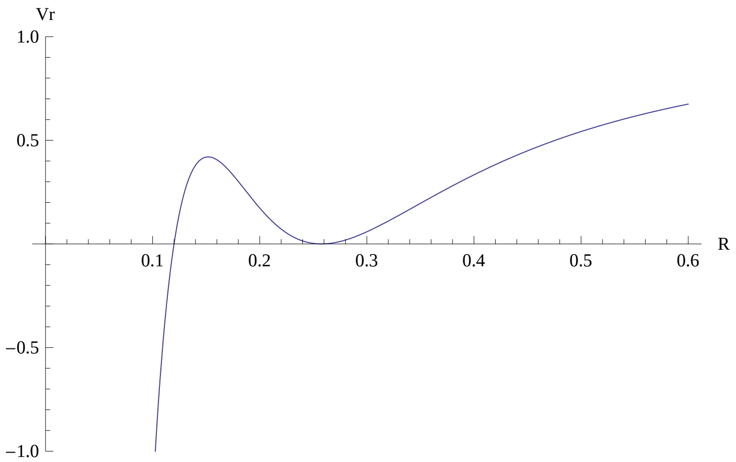

Figure 20: The graph of the V_r function (278) at $b = 2$, at $\acute{E} = \acute{E}_s$, at $J = J_s$ and at $V_s = 1.5$ ($V_s < V_c$).

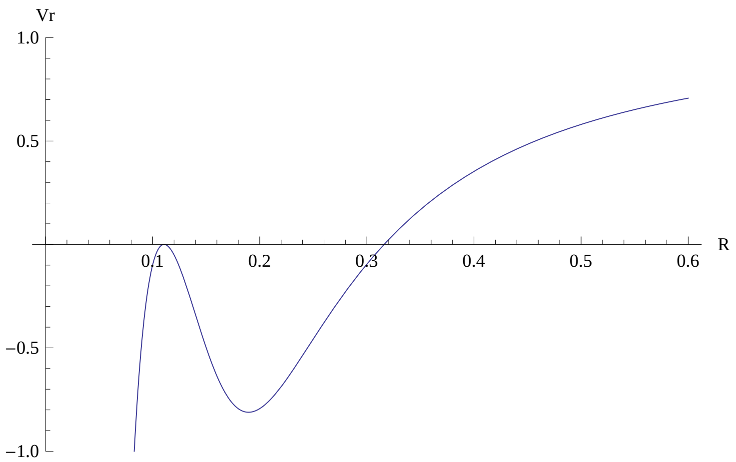

Figure 21: The graph of the V_r function (278) at $b = 2$, at $\acute{E} = \acute{E}_s$, at $J = J_s$ and at $V_s = 3$ ($V_s > V_c$).

the definition domain of the second domain the state can be free, unsteady, bound steady and bound unsteady.

All these states in PPST appear at the certain values of J_s and $\acute{E}_s$ depending on V_s.

1. If $r_0/r_h = R_s$ at $V_s > V_c$ then dr_0/dt and d^2r_0/dt^2 are equal to zero, and the proton and the electron will be in the bound steady state in the first domain.

2. If $r_0/r_h = R_s$ at $1 < V_s \leq V_c$ then dr_0/dt and d^2r_0/dt^2 are equal to zero, and the proton and the electron will be in the bound steady state in the second domain.

3. If the value of r_0/r_h will lay below the positive area of the graphs of functions presented at Fig. 19, Fig. 20 and Fig. 21 to the right and dr_0/dt will be greater than zero and thus, the value of R will increase then the particles will be free in both initial and final states, both in the first and in the second domains.

4. If the value of r_0/r_h will lay below the positive area of the graph of the function presented at Fig. 21 to the right in the first domain ($V_s > V_c$) and dr_0/dt be less than zero and thus, the value of R will decrease then the particles' initial state will be unsteady. Further on, as the value of dr/dt equals to zero and the value of R reaches the minimum for the free state, R will start to increase and the particles will turn to the free state.

5. If the value of r_0/r_h will lay below the positive area of the graphs of the functions presented at Fig. 19 and Fig. 20 to the right in the second domain ($1 < V_s \leq V_c$) and dr_0/dt will be less than zero and thus, the value of R will decrease then the particles' initial state will be unsteady. As the value of R equals to R_s or R_c, dr/dt and d^2r/dt^2 will equal to zero and the value of R stops changing, the particles will turn to the bound steady state in the second domain and will remain in it.

6. If in the second domain at $1 < V_s < V_c$ the value of r_0/r_h will lay below the positive area of the graph of the function presented at Fig. 20 to the left ($r_0/r_h < R_s$), then the particles' initial state will be the bound unsteady whereas the final one will be the bound steady. If dr_0/dt is less than zero, then the value of R initially will reach the minimum and then will increase to R_s, further on the value of R will stop changing. If dr_0/dt is greater than zero, then the value of R will immediately increase to the R_s value, and the electron and the proton will turn from the initial bound unsteady state in the second domain to the bound steady state in the second domain.

The first principal difference of the first and second domains is that in the first domain the state of particles cannot change without changing the values of J_s and $\acute{E}_s$ whereas in the second domain it can.

In the first domain the bound steady state separated from the free by **the forbidden domain of distances between particles at which particles cannot be at the constant values of J_s and $\acute{E}_s$: the distance between particles bound steady state is less than the minimum value of the distance for the free state**. There is no such forbidden domain of distances between the states in the second domain: the distance between particles in the bound steady state is boundary as well as for the bound unsteady and free states. Therefore, the electron and the proton in the second domain can turn from the bound steady state to both unsteady and free state, with the minimum possible change of the value of dr/dt approaching zero. Changes of values of J_s and $\acute{E}_s$ with the minimum possible change of the value dr/dt approaching zero will also approach zero. Thus, the transition of the electron and the proton from the bound steady state in the second domain to both unsteady and free states with the minimum possible change of the value of dr/dt approaching zero can be considered without changing of the initial conditions of motion. If at the initial moment of time, when particles leave the bound steady state, the value of dr/dt approaches zero from the side of minus-infinity, particles will turn to the unsteady state. And if at that moment of time the value of dr/dt approaches zero from the side of plus-infinity, particles will turn to the free state.

The second principal difference between bound steady states of the first domain and bound steady states of the second domain is that in the first domain the less is the distance between the electron and the proton, the greater is the magnitude of relative velocity of the electron and the proton, whereas in the second domain when the distance between the proton and the electron approaches zero, the magnitude of relative velocity of the electron and the proton approaches the value of neutral relative velocity of the electron and the proton from the side of plus-infinity.

The greater is the magnitude of attraction forces between the particles, the greater is the force to be applied for breaking the bond between them. Proceeding from this and from the analysis of the curve of the magnitude of forces acting between the proton and the electron in the bound steady states (F_s, please refer to Fig. 17 and Fig. 18), we can conclude the following:

1. In the first domain of states of the electron and the proton the bound steady state at which the distance between the electron and the proton approaches the minimum possible value with the magnitude of relative velocity of the electron and the proton approaching the maximum possible value will be the most sustainable to external actions.

2. In bound steady states of the second domain of states of the electron and the proton, if the value of magnitude of relative velocity of the electron and the proton will approach the value of neutral relative velocity of the electron and the proton from the side of plus-infinity, the distance between the proton and the electron will approach zero, but at that, in spite of the increase of the magnitude of attraction forces between the particles, they will keep the opportunity of transition to both unsteady and free state without changing the initial conditions of motion.

11 Rotation frequencies of particles in bound steady states

Rotation frequency of particles in the bound steady states will be expressed with the following formula:

$$\gamma_s = \frac{v_s}{2\pi r_s}. \tag{279}$$

Based on (133) and (279), we find the dimensionless function of the rotation frequency of the electron and the proton in bound steady states, depending on the magnitude of their relative velocity, at $V_s > 1$:

$$\frac{\gamma_s}{\gamma_{ep}} = \frac{V_s^3}{(1 - b^{(1-V_s^2)})}, \qquad \gamma_{ep} = \frac{\mu_{ep} a_{ep}^3}{2\pi e^2}, \qquad \mu_{ep} = \frac{m_e m_p}{m_e + m_p}. \tag{280}$$

Based on (53) and (279), we find the dimensionless function of the rotation frequency of two protons in bound steady states, depending on the magnitude of their relative velocity, at $0 < V_s < 1$:

$$\frac{\gamma_s}{\gamma_p} = \frac{V_s^3}{(b^{(1-V_s^2)} - 1)}, \qquad \gamma_p = \frac{m_p a_p^3}{4\pi e^2}. \tag{281}$$

In a similar way we find also the dimensionless function of the rotation frequency of two electrons in bound steady states, depending on the magnitude of their relative velocity, at $0 < V_s < 1$:

$$\frac{\gamma_s}{\gamma_e} = \frac{V_s^3}{(b^{(1-V_s^2)} - 1)}, \qquad \gamma_e = \frac{m_e a_e^3}{4\pi e^2}. \tag{282}$$

The graph of the function γ_s/γ_{ep} (280) at $V_s > 1$ is presented at Figure 22; the graph of either the function γ_s/γ_p (281) or the function γ_s/γ_e (282) at $0 < V_s < 1$ is presented at Figure 23.

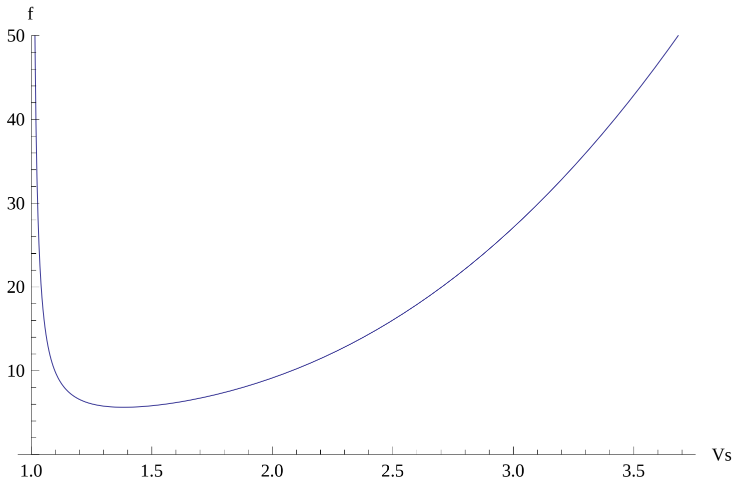

Figure 22: The graph of the dimensionless function of rotation frequency of the electron and the proton in bound steady states γ_s/γ_{ep} depending on V_s, at $V_s > 1$ and $b = 2$.

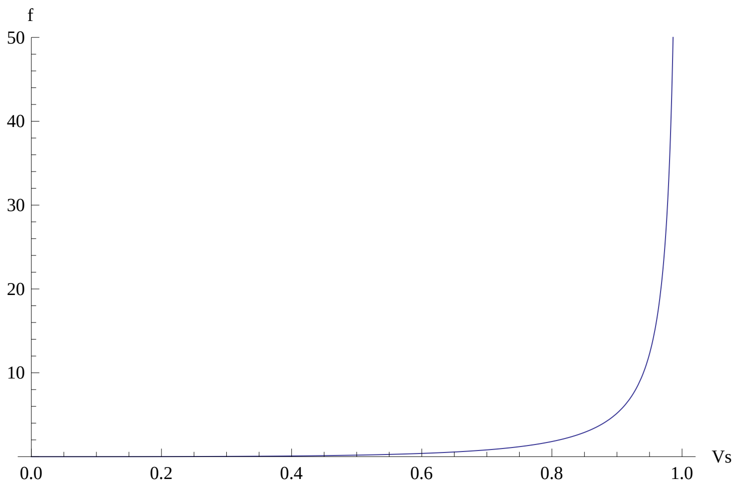

Figure 23: The graph of the dimensionless function of rotation frequency of either two protons γ_s/γ_p or two electrons γ_s/γ_e, in bound steady states depending on V_s, at $0 < V_s < 1$ and $b = 2$.

The graphs (Fig. 22 and Fig. 23) allow for the following conclusions:

1. The greater is the value of the magnitude of relative velocity of the electron and the proton in bound steady states in the first domain, the greater is their rotation frequency.

2. The less is the value of the magnitude of relative velocity of the electron and the proton in bound steady states in the second domain, starting from the certain value, the greater is their rotation frequency. With the value of magnitude of relative velocity of the electron and the proton approaching the value of neutral relative velocity of the electron and the proton from the side of plus-infinity, the rotation frequency of the electron and the proton tends to infinity.

3. The greater is the value of the magnitude of relative velocity of two protons in bound steady states, the greater is their rotation frequency. With the value of magnitude of relative velocity of two protons approaching the value of neutral relative velocity of protons from the side of minus-infinity, the rotation frequency of two protons tends to infinity.

4. The greater is the value of the magnitude of relative velocity of two electrons in bound steady states, the greater is their rotation frequency. With the value of magnitude of relative velocity of two electrons approaching the value of neutral relative velocity of electrons from the side of minus-infinity, the rotation frequency of two electrons tends to infinity.

12 General solution of the problem of two particles in PPST

Let us rewrite the equations (51) and (52) determining the squared radial relative velocity of two particles for various ranges of values of V:

$$\frac{1}{a^2}\left(\frac{dr}{dt}\right)^2 = \log_b\left(b - b^{\left(\grave{E} - \frac{q_1 q_2}{e^2}\frac{2}{R}\right)}\right) - \frac{J^2}{R^2}, \qquad 0 \le V < 1, \tag{283}$$

$$\frac{1}{a^2}\left(\frac{dr}{dt}\right)^2 = \log_b\left(b + b^{\left(\acute{E} - \frac{q_1 q_2}{e^2}\frac{2}{R}\right)}\right) - \frac{J^2}{R^2}, \qquad V > 1. \tag{284}$$

We introduce the constants s_1, s_2 and s_3 which can possess certain values under certain conditions:

$$0 \le V < 1, \qquad s_1 = -1, \qquad s_2 = \grave{E}, \tag{285}$$

$$V > 1, \qquad s_1 = +1, \qquad s_2 = \acute{E}, \tag{286}$$

$$q_1 q_2 < 0, \qquad s_3 = -2, \tag{287}$$

$$q_1 q_2 > 0, \qquad s_3 = +2. \tag{288}$$

After that we merge (283) and (284) into a single equation:

$$\frac{1}{a^2}\left(\frac{dr}{dt}\right)^2 = \log_b\left(b + s_1 b^{\left(s_2 - s_3\frac{1}{R}\right)}\right) - J^2\left(\frac{1}{R}\right)^2. \tag{289}$$

Then we convert (289) as follows:

$$\frac{r_h^2}{a^2}\left(\frac{dR}{dt}\right)^2 = \log_b\left(b + s_1 b^{\left(s_2 - s_3\frac{1}{R}\right)}\right) - J^2\left(\frac{1}{R}\right)^2. \tag{290}$$

Provided that the magnitude of angular rotation velocity of unit radius vectors of particles in the system of their mass centre can be determined as follows:

$$\frac{d\varphi}{dt} = \frac{j_0}{\mu r_h^2 R^2}, \tag{291}$$

the (290) turns into the following:

$$\left(\frac{d}{d\varphi}\left(\frac{1}{R}\right)\right)^2 = \frac{1}{J^2}\log_b\left(b + s_1 b^{\left(s_2 - s_3\frac{1}{R}\right)}\right) - \left(\frac{1}{R}\right)^2. \tag{292}$$

We introduce a variable:

$$\varpi = \frac{1}{R}, \tag{293}$$

and rewrite the (292) as:

$$\left(\frac{d\varpi}{d\varphi}\right)^2 = \frac{1}{J^2}\log_b\left(b + s_1 b^{(s_2 - s_3\varpi)}\right) - \varpi^2. \tag{294}$$

In Chapter 9 and Chapter 10 we found that the number of values of distances between particles at which the radial relative velocity of particles equals to zero is greater than or equal to 1 but less than or equal to 3. Based on it, we can determine three variants for (294):

The first is when the function of radial relative velocity has one real positive null:

$$\left(\frac{d\varpi}{d\varphi}\right)^2 = \frac{(\varpi_1 - \varpi)}{f^2_{(\varpi)1}}, \tag{295}$$

$$f_{(\varpi)1} \neq 0, \quad \varpi_1 = \frac{1}{R_1}.$$

$$\varpi_1 \geq \varpi.$$

The second is when the function of radial relative velocity has two real positive nulls:

$$\left(\frac{d\varpi}{d\varphi}\right)^2 = \frac{(\varpi_1 - \varpi)(\varpi - \varpi_2)}{f^2_{(\varpi)2}}, \tag{296}$$

$$f_{(\varpi)2} \neq 0, \quad \varpi_2 = \frac{1}{R_2}.$$

$$(\varpi_1 - \varpi)(\varpi - \varpi_2) \geq 0, \quad \varpi_1 \geq \varpi_2, \quad \varpi_1 \geq \varpi \geq \varpi_2.$$

The third is when the function of radial relative velocity has three real positive nulls:

$$\left(\frac{d\varpi}{d\varphi}\right)^2 = \frac{(\varpi_1 - \varpi)(\varpi - \varpi_2)(\varpi - \varpi_3)}{f^2_{(\varpi)3}}, \tag{297}$$

$$f_{(\varpi)3} \neq 0, \quad \varpi_3 = \frac{1}{R_3}.$$

$$(\varpi_1 - \varpi)(\varpi - \varpi_2)(\varpi - \varpi_3) \geq 0, \quad \varpi_1 \geq \varpi_2 \geq \varpi_3.$$

In (295), (296) and (297) R_1, R_2 and R_3 are the distances between particles at which the radial relative velocity of particles is equal to zero (the ranges of these values and algebraic equations for determination of these values are provided in Chapter 9 and Chapter 10); furthermore:

$$R_1 \leq R_2 \leq R_3. \tag{298}$$

Each of the functions $f_{(\varpi)_1}$, $f_{(\varpi)_2}$ and $f_{(\varpi)_3}$ is determined by expanding into the Taylor series if the series at that is convergent:

$$f_{(\varpi)_1} = \sum_{n=0}^{\infty} c_{1n} (\varpi - \varpi_0)^n = \left(\frac{(\varpi_1 - \varpi)}{\frac{1}{J^2} \log_b \left(b + s_1 b^{(s_2 - s_3 \varpi)}\right) - \varpi^2} \right)^{1/2}, \tag{299}$$

$$(\varpi_1 - \varpi_0) > 0,$$

$$f_{(\varpi)_2} = \sum_{n=0}^{\infty} c_{2n} (\varpi - \varpi_0)^n = \left(\frac{(\varpi_1 - \varpi)(\varpi - \varpi_2)}{\frac{1}{J^2} \log_b \left(b + s_1 b^{(s_2 - s_3 \varpi)}\right) - \varpi^2} \right)^{1/2}, \tag{300}$$

$$(\varpi_1 - \varpi_0)(\varpi_0 - \varpi_2) > 0$$

$$f_{(\varpi)_3} = \sum_{n=0}^{\infty} c_{3n} (\varpi - \varpi_0)^n = \left(\frac{(\varpi_1 - \varpi)(\varpi - \varpi_2)(\varpi - \varpi_3)}{\frac{1}{J^2} \log_b \left(b + s_1 b^{(s_2 - s_3 \varpi)}\right) - \varpi^2} \right)^{1/2}, \tag{301}$$

$$(\varpi_1 - \varpi_0)(\varpi_0 - \varpi_2)(\varpi_0 - \varpi_3) > 0.$$

Let us consider the first variant (295). The motion of particles in accordance with the first variant can occur at any values of constants s_1, s_2 and s_3 determined in (285-288). Let us introduce a variable function α_1 into (295):

$$\left(\frac{d\varpi}{d\alpha_1} \frac{d\alpha_1}{d\varphi} \right)^2 = \frac{(\varpi_1 - \varpi)}{f^2_{(\varpi)_1}}, \tag{302}$$

and determine it via the system of two differential equations:

$$\frac{d\varpi}{d\alpha_1} = (\varpi_1 - \varpi)^{1/2}, \tag{303}$$

$$\frac{d\alpha_1}{d\varphi} = \frac{1}{f_{(\varpi)_1}}. \tag{304}$$

Integrating (303), at the initial conditions of $\varpi = \varpi_1$ and $\alpha_1 = 0$ we obtain:

$$\varpi = \varpi_1 - \frac{\alpha_1^2}{4}. \tag{305}$$

We assume for the $f_{(\varpi)_1}$ function (299) the value of ϖ_0 equal to zero and substitute the ϖ variable with the function of α_1 (305). Proceeding from (304), we have:

$$\sum_{n=0}^{\infty} c_{1n} \left(\varpi_1 - \frac{\alpha_1^2}{4} \right)^n d\alpha_1 = d\varphi. \tag{306}$$

Using Newton's Binomial, we convert the (306) as follows:

$$\sum_{n=0}^{\infty} c_{1n} \sum_{k=0}^{n} \frac{(-1)^k n! \varpi_1^{n-k}}{k!\,(n-k)! 2^{2k}} \alpha_1^{2k} d\alpha_1 = d\varphi. \tag{307}$$

Integration of (307) at the initial conditions $\varpi = \varpi_1$, $\alpha_1 = 0$ and $\varphi = 0$ provides the following:

$$\sum_{n=0}^{\infty} c_{1n} \sum_{k=0}^{n} \frac{(-1)^k n! \varpi_1^{n-k}}{k!\,(n-k)! 2^{2k} (2k+1)} \alpha_1^{2k+1} = \varphi. \tag{308}$$

From (305) we derive:

$$\alpha_1 = 2 (\varpi_1 - \varpi)^{1/2}. \tag{309}$$

Using (309), from (308) we obtain the dependence of the angle of deflection of the radius vector linking the particles on the distance between the particles if $\varpi = \varpi_1$ and $\varphi = 0$ are assumed as initial values:

$$\sum_{n=0}^{\infty} 2c_{1n}\varpi_1^{n+1/2} \sum_{k=0}^{n} \frac{(-1)^k n!}{k!\,(n-k)!\,(2k+1)} \left(1 - \frac{\varpi}{\varpi_1}\right)^{k+1/2} = \varphi. \tag{310}$$

In the general case of interaction, two particles interacting in accordance with the first variant (295) approach from infinity and scatter to infinity after their closing in the minimum distance $r_1 = r_h/\varpi_1$. In other words, the initial state of particles is unsteady and the final is free. Thus, the final value of ϖ will equal to zero. Then from (310) we determine the maximum possible angle to which the particles scatter after their closing in the minimum distance:

$$\varphi_{max} = \sum_{n=0}^{\infty} \left(\sum_{k=0}^{n} \frac{(-1)^k n!}{k!\,(n-k)!\,(2k+1)} \right) 2c_{1n}\varpi_1^{n+1/2}. \tag{311}$$

After we substitute the numeric series in (311):

$$\sum_{k=0}^{n} \frac{(-1)^k n!}{k!\,(n-k)!\,(2k+1)} = \frac{2^{2n} (n!)^2}{(2n+1)!}, \tag{312}$$

finally, we derive the following:

$$\varphi_{max} = \sum_{n=0}^{\infty} \frac{2^{2n+1} (n!)^2}{(2n+1)!} c_{1n}\varpi_1^{n+1/2}. \tag{313}$$

Let us consider the second variant (296). The motion of particles in accordance with the second variant can occur only at the following values of constants s_1, s_2 and s_3 determined in (285-288):

$$s_1 = -1, \qquad s_2 = \grave{E}, \qquad s_3 = +2. \tag{314}$$

The second variant determines bound states of either two protons or two electrons at the magnitude of their relative velocity less than their neutral relative velocity. From (296) at $\varpi_1 = \varpi_2 = \varpi_c$ we derive:

$$\left(\frac{d\varpi}{d\varphi}\right)^2 = -\frac{(\varpi_c - \varpi)^2}{f_{(\varpi)2}^2}. \tag{315}$$

As follows from (315), at $\varpi_1 = \varpi_2$ the particles are in the bound steady state:

$$\frac{d\varpi}{d\varphi} = 0, \qquad \varpi = \varpi_c = Const.$$

Let us consider (296) at the following condition:

$$\varpi_2 \leq \varpi \leq \varpi_1.$$

Let us introduce a variable function α_2 into (296):

$$\left(\frac{d\varpi}{d\alpha_2}\frac{d\alpha_2}{d\varphi}\right)^2 = \frac{(\varpi_1 - \varpi)(\varpi - \varpi_2)}{f^2_{(\varpi)2}}, \tag{316}$$

and determine it via the system of two differential equations:

$$\frac{d\varpi}{d\alpha_2} = ((\varpi_1 - \varpi)(\varpi - \varpi_2))^{1/2}, \tag{317}$$

$$\frac{d\alpha_2}{d\varphi} = \frac{1}{f_{(\varpi)2}}. \tag{318}$$

Integrating (317), at the initial conditions of:

$$\varpi = \varpi_1, \qquad \alpha_2 = 0, \tag{319}$$

we obtain:

$$\varpi = \frac{\varpi_1 + \varpi_2}{2} + \frac{\varpi_1 - \varpi_2}{2}\cos\alpha_2. \tag{320}$$

We assume for the $f_{(\varpi)2}$ function (300) that $\varpi_0 = (\varpi_1 + \varpi_2)/2$ and substitute the ϖ variable with the function of α_2 (320). Proceeding from (318), we have:

$$\sum_{n=0}^{\infty}\frac{c_{2n}}{2^n}\varpi_{12}^n\cos^n\alpha_2 d\alpha_2 = d\varphi. \tag{321}$$

where:

$$\varpi_{12} = \varpi_1 - \varpi_2.$$

Considering that:

$$\int_0^{2\pi}\cos^{2k}\alpha_2 d\alpha_2 = 2\pi\frac{(2k)!}{2^{2k}(k!)^2}, \qquad \int_0^{2\pi}\cos^{2k+1}\alpha_2 d\alpha_2 = 0, \qquad k = 1, ..., \infty,$$

we integrate (321) with respect to α_2 from zero to 2π at the initial conditions of (319) at which $\varphi = 0$ and obtain the value of angle at which the radius vector linking the particles will rotate while the value of α_2 is changing from zero to 2π:

$$\varphi_0 = \left(c_{20} + \sum_{k=1}^{\infty}\frac{(2k)!}{2^{4k}(k!)^2}c_{2(2k)}\varpi_{12}^{2k}\right)2\pi. \tag{322}$$

In (322), $c_{2(2k)}$ is the c_{2n} constant with even n. Proceeding from (320), we find the $\cos\alpha_2$ function expressed via the ϖ variable:

$$\cos\alpha_2 = \frac{2\varpi - \varpi_1 - \varpi_2}{\varpi_1 - \varpi_2}. \tag{323}$$

From (323) we conclude that the distance between particles returns to its minimum value ($r_1 = r_h/\varpi_1$) at $\alpha_2 = 2\pi n$, $n = 0, 1..., \infty$, whereas it returns to the maximum one ($r_2 = r_h/\varpi_2$) at $\alpha_2 = \pi + 2\pi n$, $n = 0, 1..., \infty$. Thus, from (322) we can determine the value of angle of displacement of pericentres and apocentres of the particles' trajectories, either for two protons or for two electrons in the bound unsteady state:

$$\triangle\varphi = \left(c_{20} + \sum_{k=1}^{\infty} \frac{(2k)!}{2^{4k}\,(k!)^2} c_{2(2k)} \varpi_{12}^{2k} - 1 \right) 2\pi. \tag{324}$$

If $\triangle\varphi = 0$ then pericentres and apocentres of the particles' trajectories remain their spatial positions and particles move along elliptical trajectories which have one of their foci at the point of particles' mass centre. If $\triangle\varphi > 0$ then pericentres and apocentres of the particles' trajectories displace to the direction of rotation of the radius vector linking the particles. In case of $\triangle\varphi < 0$ pericentres and apocentres of the particles' trajectories displace to the direction opposite to the rotation of the radius vector linking the particles. Therefore, while moving in the coordinate system which centre matches the mass centre of particles and which rotates within the plane of rotation of particles having the following angular velocity:

$$\frac{d\varphi_1}{dt} = \frac{d\varphi}{dt} - \frac{d\alpha_2}{dt}, \tag{325}$$

or, considering (318) and determination of the magnitude of angular rotation velocity of particles via the magnitude of their moment of momentum:

$$\frac{d\varphi_1}{dt} = \frac{j_0\varpi^2}{\mu r_h^2}\left(1 - \frac{1}{f_{(\varpi)2}}\right), \tag{326}$$

the particles will move along elliptical trajectories:

$$R = \frac{R_0}{1 + \varepsilon\cos\alpha_2}, \quad R_0 = \frac{2R_2R_1}{R_2 + R_1}, \quad \varepsilon = \frac{R_2 - R_1}{R_2 + R_1}. \tag{327}$$

Let us consider the third variant (297). The motion of particles in accordance with the third variant can occur only at the following values of constants s_1, s_2 and s_3 determined in (285-288):

$$s_1 = +1, \qquad s_2 = \acute{E}, \quad s_3 = -2. \tag{328}$$

The third variant determines the states of interacting electron and proton at the magnitude of their relative velocity greater than the neutral relative velocity of the electron and the proton. From (297) at $\varpi_1 = \varpi_2 = \varpi_{c1}$ we obtain:

$$\left(\frac{d\varpi}{d\varphi}\right)^2 = -\frac{(\varpi - \varpi_{c1})^2(\varpi - \varpi_3)}{f_{(\varpi)3}^2}. \tag{329}$$

If $\varpi > \varpi_3$ then $\varpi = \varpi_{c1}$ will be the solution of (329) since the electron and the proton will be in the bound steady state in the first domain of states. If $\varpi \leq \varpi_3$ then the (329) will possess the following form:

$$\left(\frac{d\varpi}{d\varphi}\right)^2 = \frac{\left(\varpi_{c1} - \varpi\right)^2 \left(\varpi_3 - \varpi\right)}{f^2_{(\varpi)3}}, \qquad \varpi_3 - \varpi \geq 0, \qquad \varpi_{c1} - \varpi > 0. \tag{330}$$

Let us introduce a variable function α_3 into (330):

$$\left(\frac{d\varpi}{d\alpha_3}\frac{d\alpha_3}{d\varphi}\right)^2 = \frac{\left(\varpi_{c1} - \varpi\right)^2 \left(\varpi_3 - \varpi\right)}{f^2_{(\varpi)3}}. \tag{331}$$

and determine it via the system of two differential equations:

$$\frac{d\varpi}{d\alpha_3} = \left(\varpi_3 - \varpi\right)^{1/2}, \tag{332}$$

$$\frac{d\alpha_3}{d\varphi} = \frac{\varpi_{c1} - \varpi}{f_{(\varpi)3}}. \tag{333}$$

Integrating (332), at the initial conditions of:

$$\varpi = \varpi_3, \qquad \alpha_2 = 0, \tag{334}$$

we obtain:

$$\varpi = \varpi_3 - \frac{\alpha_3^2}{4}. \tag{335}$$

We assume for the $f_{(\varpi)3}$ function (301) that the value of ϖ_0 will equal to zero, and proceeding from (333), we will have:

$$\sum_{n=0}^{\infty} \frac{c_{3n}}{\varpi_{c1}} \frac{\varpi^n}{\left(1 - \frac{\varpi}{\varpi_{c1}}\right)} d\alpha_3 = d\varphi. \tag{336}$$

Then, after the left part is converted, the (336) will take the following form:

$$\sum_{n=0}^{\infty}\sum_{k=0}^{\infty} \frac{c_{3n}}{\varpi_{c1}^{k+1}} \varpi^{n+k} d\alpha_3 = d\varphi. \tag{337}$$

We substitute the ϖ variable in (337) with the function of α_3 (335):

$$\sum_{n=0}^{\infty}\sum_{k=0}^{\infty} \frac{c_{3n}}{\varpi_{c1}^{k+1}} \left(\varpi_3 - \frac{\alpha_3^2}{4}\right)^{n+k} d\alpha_3 = d\varphi. \tag{338}$$

Using Newton's Binomial, we convert the (338) as follows:

$$\sum_{n=0}^{\infty} \frac{c_{3n}\varpi_3^n}{\varpi_{c1}} \sum_{k=0}^{\infty} \frac{\varpi_3^k}{\varpi_{c1}^k} \sum_{s=0}^{n+k} \frac{(-1)^s (n+k)!\varpi_3^{-s}}{s!\,(n+k-s)!2^{2s}} \alpha_3^{2s} d\alpha_3 = d\varphi. \tag{339}$$

Integration of (339) from zero to α_3 provides the following:

$$\sum_{n=0}^{\infty} \frac{c_{3n}\varpi_3^n}{\varpi_{c1}} \sum_{k=0}^{\infty} \frac{\varpi_3^k}{\varpi_{c1}^k} \sum_{s=0}^{n+k} \frac{(-1)^s (n+k)!\varpi_3^{-s}}{s!\,(n+k-s)!2^{2s}\,(2s+1)} \alpha_3^{2s+1} = \varphi. \tag{340}$$

Substituting α_3 with the function of ϖ obtained from (335):

$$\alpha_3 = 2\,(\varpi_3 - \varpi)^{1/2}, \tag{341}$$

we will have from (340) the value of rotation angle of the radius vector linking the particles, depending on the distance between the particles after they traverse the minimum value of that distance:

$$\varphi = \sum_{n=0}^{\infty} \frac{2c_{3n}\varpi_3^{n+1/2}}{\varpi_{c1}} \sum_{k=0}^{\infty} \frac{\varpi_3^k}{\varpi_{c1}^k} \sum_{s=0}^{n+k} \frac{(-1)^s (n+k)!}{s!\,(n+k-s)!\,(2s+1)} \left(1 - \frac{\varpi}{\varpi_3}\right)^{s+1/2}. \tag{342}$$

The (342) provides the value of scattering angle to infinity after the closing to the minimum distance $r_3 = r_h/\varpi_3$:

$$\varphi_{max} = \sum_{n=0}^{\infty} \left(\sum_{k=0}^{\infty} \frac{\varpi_3^k}{\varpi_{c1}^k} \frac{2^{2(n+k)}\left((n+k)!\right)^2}{(2\,(n+k)+1)!} \right) \frac{2c_{3n}\varpi_3^{n+1/2}}{\varpi_{c1}}, \qquad \frac{\varpi_3}{\varpi_{c1}} < 1. \tag{343}$$

The (343) follows from (342) at $\varpi = 0$ and at the following:

$$\sum_{s=0}^{n+k} \frac{(-1)^s (n+k)!}{s!\,(n+k-s)!\,(2s+1)} = \frac{2^{2(n+k)}\left((n+k)!\right)^2}{(2\,(n+k)+1)!}. \tag{344}$$

From (297) at $\varpi_1 = \varpi_2 = \varpi_3 = \varpi_{c2}$ we derive:

$$\left(\frac{d\varpi}{d\varphi}\right)^2 = \frac{(\varpi_{c2} - \varpi)^3}{f_{(\varpi)3}^2}, \quad \varpi_{c2} \geq \varpi. \tag{345}$$

We introduce a variable function α_{31} into (345):

$$\left(\frac{d\varpi}{d\alpha_{31}} \frac{d\alpha_{31}}{d\varphi}\right)^2 = \frac{(\varpi_{c2} - \varpi)^3}{f_{(\varpi)3}^2}, \tag{346}$$

and determine it via the system of two differential equations:

$$\frac{d\varpi}{d\alpha_{31}} = (\varpi_{c2} - \varpi)^{3/2}, \tag{347}$$

$$\frac{d\alpha_{31}}{d\varphi} = \frac{1}{f_{(\varpi)3}}. \tag{348}$$

Integrating (347), at the initial conditions of:

$$\varpi = \varpi_{c2}, \qquad \alpha_{31} = \infty, \tag{349}$$

we obtain:

$$\varpi = \varpi_{c2} - \frac{4}{\alpha_{31}^2}. \tag{350}$$

Proceeding from (348) and considering (350), we will have:

$$\sum_{n=0}^{\infty} c_{3n} \left(\varpi_{c2} - \frac{4}{\alpha_{31}^2}\right)^n d\alpha_{31} = d\varphi. \tag{351}$$

Using Newton's Binomial, we convert the (351) as follows:

$$\sum_{n=0}^{\infty} c_{3n} \sum_{k=0}^{n} \frac{(-1)^k n! \varpi_{c2}^{n-k} 2^{2k}}{k!\,(n-k)! \alpha_{31}^{2k}} d\alpha_{31} = d\varphi. \tag{352}$$

Integrating the (352) from $\alpha_{31} = 2\varpi_{c2}^{-1/2}$ at $\varpi = 0$ and $\varphi = 0$ to α_{31}, we obtain the following:

$$\varphi = \sum_{n=0}^{\infty} 2c_{3n}\varpi_{c2}^{n-1/2} \sum_{k=0}^{n} \frac{(-1)^k n!}{k!\,(n-k)!\,(2k-1)} \left(1 - \left(\frac{2\varpi_{c2}^{-1/2}}{\alpha_{31}}\right)^{2k-1}\right). \tag{353}$$

Substituting α_{31} with its value of ϖ obtained from (350):

$$\alpha_{31} = \frac{2}{(\varpi_{c2} - \varpi)^{1/2}}, \tag{354}$$

we will determine from (353) the dependence of rotation angle of the radius vector linking the particles on the distance between the particles after they begin to approach from infinity ($\varpi = 0$):

$$\varphi = \sum_{n=0}^{\infty} 2c_{3n}\varpi_{c2}^{n-1/2} \sum_{k=0}^{n} \frac{(-1)^k n!}{k!\,(n-k)!\,(2k-1)} \left(1 - \frac{\left(1 - \frac{\varpi}{\varpi_{c2}}\right)^k}{\left(1 - \frac{\varpi}{\varpi_{c2}}\right)^{1/2}}\right). \tag{355}$$

As follows from (355), if $\varpi \to \varpi_{c2}$ then $\varphi \to \infty$, and particles turn to the bound steady state in the second domain (the boundary state of the second domain and the first).

Proceeding from (297), at $\varpi_2 = \varpi_3 = \varpi_{c3}$ we obtain:

$$\left(\frac{d\varpi}{d\varphi}\right)^2 = \frac{(\varpi_1 - \varpi)(\varpi - \varpi_{c3})^2}{f_{(\varpi)3}^2}, \qquad \varpi \leq \varpi_1. \tag{356}$$

The (356) will determine the motion of the electron and the proton in the second domain of states at $J = J_s$ and $\acute{E} = \acute{E}_s$. Let us consider the (356) at $\varpi \leq \varpi_{c3}$ and thus, at $\varpi < \varpi_1$ as well. We introduce an α_{32} variable and determine it via the system of differential equations:

$$\frac{d\varpi}{d\alpha_{32}} = \varpi_{c3} - \varpi, \tag{357}$$

$$\frac{d\alpha_{32}}{d\varphi} = \frac{(\varpi_1 - \varpi)^{1/2}}{f_{(\varpi)3}}. \tag{358}$$

Integrating (357) at the initial conditions of $\alpha_{32} = 0$, $\varpi = 0$, and at the final conditions of $\alpha_{32} = \infty$ and $\varpi = \varpi_{c3}$, we will have:

$$\varpi = \varpi_{c3}\left(1 - e^{-\alpha_{32}}\right), \tag{359}$$

where e is the Euler's number. From (358) we obtain:

$$\sum_{n=0}^{\infty} \frac{c_{3n}\varpi^n}{\varpi_1^{1/2}} \left(1 - \frac{\varpi}{\varpi_1}\right)^{-1/2} d\alpha_{32} = d\varphi. \tag{360}$$

Then, considering that at $\varpi < \varpi_1$:

$$\left(1 - \frac{\varpi}{\varpi_1}\right)^{-1/2} = \sum_{k=0}^{\infty} \frac{(2k)!\varpi^k}{2^{2k}\left(k!\right)^2 \varpi_1^k}, \tag{361}$$

we can represent the (360) as follows:

$$\sum_{n=0}^{\infty}\sum_{k=0}^{\infty} \frac{c_{3n}\,(2k)!\varpi^{n+k}}{2^{2k}\left(k!\right)^2 \varpi_1^{k+1/2}} d\alpha_{32} = d\varphi. \tag{362}$$

We substitute ϖ in (362) with the function of α_{32} (359):

$$\sum_{n=0}^{\infty} c_{3n}\varpi_{c3}^n \sum_{k=0}^{\infty} \frac{(2k)!\varpi_{c3}^k}{2^{2k}\left(k!\right)^2 \varpi_1^{k+1/2}} \left(1 - e^{-\alpha_{32}}\right)^{n+k} d\alpha_{32} = d\varphi. \tag{363}$$

Using Newton's Binomial, we convert the (363) as follows:

$$\sum_{n=0}^{\infty} c_{3n}\varpi_{c3}^n \sum_{k=0}^{\infty} \frac{(2k)!\varpi_{c3}^k}{2^{2k}\left(k!\right)^2 \varpi_1^{k+1/2}} \sum_{s=0}^{n+k} \frac{(-1)^s\,(n+k)!}{s!\,(n+k-s)!} e^{-s\alpha_{32}} d\alpha_{32} = d\varphi. \tag{364}$$

Integrating (364) at the initial conditions of $\alpha_{32} = 0$, $\varphi = 0$, we will have:

$$\varphi = \sum_{n=0}^{\infty} c_{3n}\varpi_{c3}^n \sum_{k=0}^{\infty} \frac{(2k)!\varpi_{c3}^k}{2^{2k}\left(k!\right)^2 \varpi_1^{k+1/2}} \left(\alpha_{32} + \sum_{s=1}^{n+k\neq 0} \frac{(-1)^s\,(n+k)!}{s!\,(n+k-s)!s}\left(1 - e^{-s\alpha_{32}}\right)\right). \tag{365}$$

Substituting α_{32} in (365) with the function of ϖ, derived from (359):

$$\alpha_{32} = \ln\left(\frac{\varpi_{c3}}{\varpi_{c3} - \varpi}\right), \tag{366}$$

we will have the dependence of the rotation angle of the radius vector linking the particles on the distance between the particles at the initial conditions of $\varpi = 0$, $\varphi = 0$:

$$\varphi = \sum_{n=0}^{\infty} \frac{c_{3n}\varpi_{c3}^n}{\varpi_1^{\frac{1}{2}}} \left(1 - \frac{\varpi_{c3}}{\varpi_1}\right)^{-1/2} \ln\left(\frac{1}{1 - \frac{\varpi}{\varpi_{c3}}}\right) +$$

$$+ \sum_{n=0}^{\infty} \frac{c_{3n}\varpi_{c3}^n}{\varpi_1^{\frac{1}{2}}} \sum_{k=0}^{\infty} \frac{(2k)!}{2^{2k}\left(k!\right)^2} \left(\frac{\varpi_{c3}}{\varpi_1}\right)^k \sum_{s=1}^{n+k\neq 0} \frac{(-1)^s\,(n+k)!}{s!\,(n+k-s)!s} \left(1 - \left(1 - \frac{\varpi}{\varpi_{c3}}\right)^s\right). \tag{367}$$

The (367) demonstrates that if $\varpi \to \varpi_{c3}$ then $\varphi \to \infty$, i.e., the unsteady state of particles will turn to the bound steady one.

Let us consider the (356) at $\varpi_1 \geq \varpi \geq \varpi_{c3}$. We introduce an α_{33} variable and determine it via the system of differential equations:

$$\frac{d\varpi}{d\alpha_{33}} = \varpi - \varpi_{c3}, \tag{368}$$

$$\frac{d\alpha_{33}}{d\varphi} = \frac{(\varpi_1 - \varpi)^{1/2}}{f_{(\varpi)3}}. \tag{369}$$

Integrating the (368), at the initial conditions of:

$$\varpi = \varpi_1, \qquad \alpha_{33} = 0, \tag{370}$$

we obtain:

$$\varpi = \varpi_{c3} + (\varpi_1 - \varpi_{c3})\, e^{\alpha_{33}}, \tag{371}$$

where e is the Euler's number. As follows from (371), if $\varpi = \varpi_{c3}$ then $\alpha_{33} = -\infty$. Thus, we can determine the (371) as following:

$$\varpi = \varpi_{c3} + (\varpi_1 - \varpi_{c3})\, e^{-\alpha_{33}}, \qquad 0 \leq \alpha_{33} \leq \infty. \tag{372}$$

After the substitution of ϖ in the (369) with the function of α_{33} (372), we bring the (369) to the following form:

$$\sum_{n=0}^{\infty} c_{3n} \frac{(\varpi_{c3} + \tilde{\varpi}_{1c3} e^{-\alpha_{33}})^n}{\tilde{\varpi}_{1c3}^{1/2} (1 - e^{-\alpha_{33}})^{1/2}} d\alpha_{33} = d\varphi. \tag{373}$$

where:

$$\tilde{\varpi}_{1c3} = \varpi_1 - \varpi_{c3}.$$

Then, applying Newton's Binomial, we represent the (373) as follows:

$$\sum_{n=0}^{\infty} \frac{c_{3n}}{\tilde{\varpi}_{1c3}^{1/2}} \sum_{k=0}^{n} \frac{n!\varpi_{c3}^{n-k}\tilde{\varpi}_{1c3}^{k}}{k!\,(n-k)!} \frac{e^{-k\alpha_{33}}}{(1 - e^{-\alpha_{33}})^{1/2}} d\alpha_{33} = d\varphi. \tag{374}$$

Expanding the $(1 - e^{-\alpha_{33}})^{-1/2}$ function into the Maclaurin series:

$$\left(1 - e^{-\alpha_{33}}\right)^{-1/2} = \sum_{s=0}^{\infty} \frac{(2s)!}{2^{2s}\,(s!)^2} e^{-s\alpha_{33}},$$

we will have:

$$\sum_{n=0}^{\infty} \frac{c_{3n}}{\tilde{\varpi}_{1c3}^{1/2}} \sum_{k=0}^{n} \frac{n!\varpi_{c3}^{n-k}\tilde{\varpi}_{1c3}^{k}}{k!\,(n-k)!} \sum_{s=0}^{\infty} \frac{(2s)!}{2^{2s}\,(s!)^2} e^{-(k+s)\alpha_{33}} d\alpha_{33} = d\varphi. \tag{375}$$

Let us integrate the (375):

$$\sum_{n=0}^{\infty} \frac{c_{3n}\varpi_{c3}^{n}}{\tilde{\varpi}_{1c3}^{1/2}} \left(\alpha_{33} - \sum_{s=1}^{\infty} \frac{(2s)!}{2^{2s}\,(s!)^2\, s} e^{-s\alpha_{33}}\right) -$$

$$-\sum_{n=1}^{\infty}\frac{c_{3n}}{\tilde{\varpi}_{1c3}^{1/2}}\sum_{k=1}^{n}\frac{n!\varpi_{c3}^{n-k}\tilde{\varpi}_{1c3}^{k}}{k!\,(n-k)!}\sum_{s=0}^{\infty}\frac{(2s)!}{2^{2s}\,(s!)^{2}\,(k+s)}e^{-(k+s)\alpha_{33}}=\varphi+C_0. \tag{376}$$

Proceeding from the (372), we obtain the following:

$$e^{-\alpha_{33}}=\frac{\varpi-\varpi_{c3}}{\varpi_1-\varpi_{c3}},\qquad \alpha_{33}=\ln\left(\frac{\varpi_1-\varpi_{c3}}{\varpi-\varpi_{c3}}\right). \tag{377}$$

We introduce the values of the function (377) into the (376):

$$\sum_{n=0}^{\infty}\frac{c_{3n}\varpi_{c3}^{n}}{\tilde{\varpi}_{1c3}^{1/2}}\left(\ln\left(\frac{\varpi_1-\varpi_{c3}}{\varpi-\varpi_{c3}}\right)-\sum_{s=1}^{\infty}\frac{(2s)!}{2^{2s}\,(s!)^{2}\,s}\left(\frac{\varpi-\varpi_{c3}}{\varpi_1-\varpi_{c3}}\right)^{s}\right)-$$

$$-\sum_{n=1}^{\infty}\frac{c_{3n}}{\tilde{\varpi}_{1c3}^{1/2}}\sum_{k=1}^{n}\frac{n!\varpi_{c3}^{n-k}\tilde{\varpi}_{1c3}^{k}}{k!\,(n-k)!}\sum_{s=0}^{\infty}\frac{(2s)!}{2^{2s}\,(s!)^{2}\,(k+s)}\left(\frac{\varpi-\varpi_{c3}}{\varpi_1-\varpi_{c3}}\right)^{(k+s)}=\varphi+C_0. \tag{378}$$

The value of the integrating constant C_0 is determined at the following initial conditions: $\varpi=\varpi_1$, $\varphi=0$:

$$C_0=-\sum_{n=0}^{\infty}\frac{c_{3n}\varpi_{c3}^{n}}{\tilde{\varpi}_{1c3}^{1/2}}\sum_{s=1}^{\infty}\frac{(2s)!}{2^{2s}\,(s!)^{2}\,s}-\sum_{n=1}^{\infty}\frac{c_{3n}}{\tilde{\varpi}_{1c3}^{1/2}}\sum_{k=1}^{n}\frac{n!\varpi_{c3}^{n-k}\tilde{\varpi}_{1c3}^{k}}{k!\,(n-k)!}\sum_{s=0}^{\infty}\frac{(2s)!}{2^{2s}\,(s!)^{2}\,(k+s)}. \tag{379}$$

We can substitute the sums over s in the (379) with their numeric values:

$$\sum_{s=1}^{\infty}\frac{(2s)!}{2^{2s}\,(s!)^{2}\,s}=2\ln 2. \tag{380}$$

$$\sum_{s=0}^{\infty}\frac{(2s)!}{2^{2s}\,(s!)^{2}\,(k+s)}=\frac{\pi^{1/2}\Gamma\,(k)}{\Gamma\,(k+1/2)},\quad k=1,...,\infty, \tag{381}$$

where $\Gamma\,(k)$ is the gamma function. Thus, considering (380) and (381), we can rewrite the (378) as follows:

$$\varphi=\sum_{n=0}^{\infty}\frac{c_{3n}\varpi_{c3}^{n}}{\tilde{\varpi}_{1c3}^{1/2}}\left(\ln\left(\frac{\varpi_1-\varpi_{c3}}{\varpi-\varpi_{c3}}\right)-\sum_{s=1}^{\infty}\frac{(2s)!}{2^{2s}\,(s!)^{2}\,s}\left(\frac{\varpi-\varpi_{c3}}{\varpi_1-\varpi_{c3}}\right)^{s}+2\ln 2\right)-$$

$$-\sum_{n=1}^{\infty}\frac{c_{3n}}{\tilde{\varpi}_{1c3}^{1/2}}\sum_{k=1}^{n}\frac{n!\varpi_{c3}^{n-k}\tilde{\varpi}_{1c3}^{k}}{k!\,(n-k)!}\left(\sum_{s=0}^{\infty}\frac{(2s)!}{2^{2s}\,(s!)^{2}\,(k+s)}\left(\frac{\varpi-\varpi_{c3}}{\varpi_1-\varpi_{c3}}\right)^{(k+s)}-\frac{\pi^{1/2}\Gamma\,(k)}{\Gamma\,(k+1/2)}\right). \tag{382}$$

Therefore, as follows from (382), if $\varpi\to\varpi_{c3}$ then $\varphi\to\infty$. In other words, if $\varpi\to\varpi_{c3}$ then the electron and the proton turn from the unsteady state in the second domain to the bound steady state in the second domain and remain in it.

Let us consider the (297) at the following condition: $\varpi\le\varpi_3$:

$$\left(\frac{d\varpi}{d\varphi}\right)^{2}=\frac{(\varpi_1-\varpi)\,(\varpi_2-\varpi)\,(\varpi_3-\varpi)}{f_{(\varpi)3}^{2}}. \tag{383}$$

We introduce an α_{34} variable and determine it via the system of differential equations:

$$\frac{d\varpi}{d\alpha_{34}} = (\varpi_3 - \varpi)^{1/2}, \tag{384}$$

$$\frac{d\alpha_{34}}{d\varphi} = \frac{(\varpi_1 - \varpi)^{1/2} (\varpi_2 - \varpi)^{1/2}}{f_{(\varpi)3}}. \tag{385}$$

Integrating the (384) at the following initial conditions:

$$\varpi = \varpi_3, \quad \alpha_{34} = 0, \tag{386}$$

we obtain:

$$\varpi = \varpi_3 - \frac{\alpha_{34}^2}{4}, \quad 0 \leq \frac{\alpha_{34}^2}{4} \leq \varpi_3. \tag{387}$$

We convert the (385):

$$\sum_0^\infty \frac{c_n \varpi^n}{\varpi_1^{1/2} \varpi_2^{1/2}} \left(1 - \frac{\varpi}{\varpi_1}\right)^{-1/2} \left(1 - \frac{\varpi}{\varpi_2}\right)^{-1/2} d\alpha_{34} = d\varphi. \tag{388}$$

If $\varpi \leq \varpi_3$ then $\varpi < \varpi_2 < \varpi_1$, and thus, we can determine the (388) as following:

$$\sum_{n=0}^\infty \frac{c_n}{\varpi_1^{1/2} \varpi_2^{1/2}} \sum_{s=0}^\infty \frac{(2s)!}{2^{2s} (s!)^2 \varpi_1^s} \sum_{k=0}^\infty \frac{(2k)!}{2^{2k} (k!)^2 \varpi_2^k} \varpi^{n+s+k} d\alpha_{34} = d\varphi. \tag{389}$$

We substitute ϖ in the (389) with the function of α_{34} (387):

$$\sum_{n=0}^\infty \frac{c_n}{\varpi_1^{1/2} \varpi_2^{1/2}} \sum_{s=0}^\infty \frac{(2s)!}{2^{2s} (s!)^2 \varpi_1^s} \sum_{k=0}^\infty \frac{(2k)!}{2^{2k} (k!)^2 \varpi_2^k} \left(\varpi_3 - \frac{\alpha_{34}^2}{4}\right)^{n+s+k} d\alpha_{34} = d\varphi. \tag{390}$$

Using Newton's Binomial, we derive from the (390):

$$\sum_{n=0}^\infty \frac{c_n}{\varpi_1^{1/2} \varpi_2^{1/2}} \sum_{s=0}^\infty \frac{(2s)!}{2^{2s} (s!)^2 \varpi_1^s} \sum_{k=0}^\infty \frac{(2k)!}{2^{2k} (k!)^2 \varpi_2^k} \sum_{l=0}^{n+s+k} \frac{(n+s+k)! \varpi_3^{n+s+k-l}}{l! (n+s+k-l)! 2^{2l}} \alpha_{34}^{2l} d\alpha_{34} = d\varphi. \tag{391}$$

Integrating the (391) at the initial conditions of $\varpi = \varpi_3$, $\varphi = 0$ and $\alpha_{34} = 0$, we will have:

$$\sum_{n=0}^\infty \frac{c_n}{\varpi_1^{1/2} \varpi_2^{1/2}} \sum_{s=0}^\infty \frac{(2s)!}{2^{2s} (s!)^2 \varpi_1^s} \sum_{k=0}^\infty \frac{(2k)!}{2^{2k} (k!)^2 \varpi_2^k} \sum_{l=0}^{n+s+k} \frac{(n+s+k)! \varpi_3^{n+s+k-l} \alpha_{34}^{2l+1}}{l! (n+s+k-l)! 2^{2l} (2l+1)} = \varphi. \tag{392}$$

Substituting α_{34} in (392) with the function of ϖ derived from (387), we will have the dependence of the rotation angle of the radius vector linking the particles on the distance between them if at the moment of approach of particles to each other to the minimum distance the value of this angle will equal to zero:

$$\sum_{n=0}^\infty \frac{2c_n \varpi_3^{n-1/2}}{\varpi_1^{1/2} \varpi_2^{1/2}} \sum_{s=0}^\infty \frac{(2s)! \varpi_3^s}{2^{2s} (s!)^2 \varpi_1^s} \sum_{k=0}^\infty \frac{(2k)! \varpi_3^k}{2^{2k} (k!)^2 \varpi_2^k} \sum_{l=0}^{n+s+k} \frac{(n+s+k)! \left(1 - \frac{\varpi}{\varpi_3}\right)^{l+1/2}}{l! (n+s+k-l)! (2l+1)} = \varphi. \tag{393}$$

From (393) we determine the maximum possible angle to which the particles scatter ad infinitum after their closing in the minimum distance of $r_3 = r_h/\varpi_3$:

$$\varphi_0 = \sum_{n=0}^{\infty} \frac{2c_n \varpi_3^{n-1/2}}{\varpi_1^{1/2} \varpi_2^{1/2}} \sum_{s=0}^{\infty} \frac{(2s)! \varpi_3^s}{2^{2s} (s!)^2 \varpi_1^s} \sum_{k=0}^{\infty} \frac{(2k)! \varpi_3^k}{2^{2k} (k!)^2 \varpi_2^k} \sum_{l=0}^{n+s+k} \frac{(n+s+k)!}{l! \, (n+s+k-l)! \, (2l+1)}. \tag{394}$$

Let us consider the (297) at $\varpi_2 \leq \varpi \leq \varpi_1$:

$$\left(\frac{d\varpi}{d\varphi}\right)^2 = \frac{(\varpi_1 - \varpi)(\varpi - \varpi_2)(\varpi - \varpi_3)}{f_{(\varpi)3}^2}. \tag{395}$$

We introduce an α_{35} variable and determine it via the system of differential equations:

$$\frac{d\varpi}{d\alpha_{35}} = \left((\varpi_1 - \varpi)(\varpi - \varpi_2)\right)^{1/2}, \tag{396}$$

$$\frac{d\alpha_{35}}{d\varphi} = \frac{(\varpi - \varpi_3)^{1/2}}{f_{(\varpi)3}}. \tag{397}$$

Integrating the (396) at the following initial conditions:

$$\varpi = \varpi_1, \quad \alpha_{35} = 0, \tag{398}$$

we obtain:

$$\varpi = \frac{\varpi_1 + \varpi_2}{2} + \frac{\varpi_1 - \varpi_2}{2} \cos \alpha_{35}. \tag{399}$$

We convert the (397):

$$\frac{f_{(\varpi)3}}{(\varpi - \varpi_3)^{1/2}} d\alpha_{35} = d\varphi. \tag{400}$$

We substitute ϖ in the (400) with the function of α_{35} (399):

$$\sum_{n=0}^{\infty} \frac{c_n \varpi_{12}^n (1 + \kappa_1 \cos \alpha_{35})^n}{\varpi_{13}^{1/2} (1 + \kappa_2 \cos \alpha_{35})^{1/2}} d\alpha_{35} = d\varphi, \tag{401}$$

where:

$$\varpi_{12} = \frac{\varpi_1 + \varpi_2}{2}, \quad \varpi_{13} = \frac{\varpi_1 + \varpi_2 - 2\varpi_3}{2}, \quad \varpi_{13} > 0,$$

$$\kappa_1 = \frac{\varpi_1 - \varpi_2}{\varpi_1 + \varpi_2}, \quad \kappa_1 < 1, \quad \kappa_2 = \frac{\varpi_1 - \varpi_2}{\varpi_1 + \varpi_2 - 2\varpi_3}, \quad \kappa_2 < 1. \tag{402}$$

Using the expansion into the series:

$$\frac{1}{(1 + \kappa_2 \cos \alpha_{35})^{1/2}} = \sum_{s=0}^{\infty} \frac{(-1)^s (2s)!}{2^{2s} (s!)^2} \kappa_2^s \cos^s \alpha_{35}, \tag{403}$$

and using Newton's Binomial, from (401) we derive:

$$\sum_{n=0}^{\infty} \frac{c_n \varpi_{12}^n}{\varpi_{13}^{1/2}} \sum_{k=0}^{n} \frac{n! \kappa_1^k}{k! \, (n-k)!} \sum_{s=0}^{\infty} \frac{(-1)^s (2s)! \kappa_2^s}{2^{2s} (s!)^2} \cos^{k+s} \alpha_{35} d\alpha_{35} = d\varphi. \tag{404}$$

We integrate the (404) with respect to α_{35} from zero to 2π and obtain the value of angle at which the radius vector linking the particles will rotate while the value of α_{35} is changing from zero to 2π:

$$\varphi_0 = \left(\sum_{n=0}^{\infty} \frac{c_n \varpi_{12}^n}{\varpi_{13}^{1/2}} \sum_{k=0}^{n} \frac{n! \kappa_1^k}{k!\,(n-k)!} \sum_{s=0}^{\infty} \frac{(-1)^s\,(2s)! \kappa_2^s}{2^{2s}\,(s!)^2} \frac{(k+s)!}{2^{(k+s)}\left(\left(\frac{k+s}{2}\right)!\right)^2} \right) 2\pi. \tag{405}$$

In (405), the summing over the indices k and s is performed over the parts of the sum for which $(k+s)/2$ is either a whole or zero. Proceeding from (399), we find the $\cos\alpha_{35}$ function expressed via the ϖ variable:

$$\cos\alpha_{35} = \frac{2\varpi - \varpi_1 - \varpi_2}{\varpi_1 - \varpi_2}. \tag{406}$$

From (406) we conclude that the distance between particles returns to its minimum value ($r_1 = r_h/\varpi_1$) at $\alpha_{35} = 2\pi n$, $n = 0, 1..., \infty$, whereas it returns to the maximum one ($r_2 = r_h/\varpi_2$) at $\alpha_{25} = \pi + 2\pi n$, $n = 0, 1..., \infty$. Thus, from (405) we can determine the value of angle of displacement of pericentres and apocentres of the particles' trajectories, the proton and the electron, in the bound unsteady state:

$$\triangle\varphi = \varphi_0 - 2\pi. \tag{407}$$

If $\triangle\varphi = 0$ then pericentres and apocentres of the particles' trajectories remain their spatial positions and particles move along elliptical trajectories which have one of their foci at the point of particles' mass centre. If $\triangle\varphi > 0$ then pericentres and apocentres of the particles' trajectories displace to the direction of rotation of the radius vector linking the particles. In case of $\triangle\varphi < 0$ pericentres and apocentres of the particles' trajectories displace to the direction opposite to the rotation of the radius vector linking the particles. Therefore, while moving in the coordinate system which centre matches the mass centre of particles and which rotates within the plane of rotation of particles having the following angular velocity:

$$\frac{d\varphi_2}{dt} = \frac{d\varphi}{dt} - \frac{d\alpha_{35}}{dt}, \tag{408}$$

or, considering determination of the magnitude of angular rotation velocity of particles via the magnitude of their moment of momentum:

$$\frac{d\varphi_2}{dt} = \frac{j_0 \varpi^2}{\mu r_h^2} \left(1 - \frac{(\varpi - \varpi_3)^{1/2}}{f_{(\varpi)3}} \right), \tag{409}$$

the particles will move along elliptical trajectories:

$$R = \frac{R_0}{1 + \varepsilon \cos\alpha_{35}}, \quad R_0 = \frac{2R_2R_1}{R_2 + R_1}, \quad \varepsilon = \frac{R_2 - R_1}{R_2 + R_1}. \tag{410}$$

13 Types of interactions in PPST

Let us split the interaction of particles in PPST into three types:
1. **interaction at high velocities**;

2. **interaction at low velocities**;
3. **interaction at the zero velocity**.

We determine the interaction at high velocities as interaction at which the values of the magnitude of relative velocity of interacting particles are greater than the value of these particles' neutral relative velocity (a_p, a_e, a_{ep}). In other words, this is the interaction at which likely charged particles repel whereas unlikely charged those attract.

We determine the interaction at low velocities as interaction at which the values of the magnitude of relative velocity of interacting particles are less than the value of these particles' neutral relative velocity (a_p, a_e, a_{ep}) **but greater than zero**. In other words, this is the interaction at which likely charged particles attract whereas unlikely charged those repel, at the same time the magnitude of their relative velocity is not equal to zero.

We determine the interaction at the zero velocity as interaction of particles which are in the same state; at this type of interaction the value of the magnitude of relative velocity of interacting particles is changing from zero to the value less than the value of these particles' neutral relative velocity (a_p, a_e, a_{ep}). Equality of the magnitude of relative velocity of particles to zero will be possible only in case of simultaneous equality of unit vectors and magnitudes of particles' velocities in the arbitrary coordinate system. In the moment of the zero value of magnitude of relative velocity likely charged particles will attract with the maximum possible force whereas unlikely charged particles will repel with the maximum possible force for the distance between them at which the interaction occurs. This is a consequence of equality of the magnitude of relative velocity of particles to zero in the equation (12):

$$v_{12} = 0, \qquad \mu_{12} \frac{d^2 r_{12}}{dt^2} = -\frac{q_1 q_2}{r_{12}^2} (b-1), \qquad b \geq 2. \tag{411}$$

In (411)) there is no centrifugal forces of inertia which are opposite to the forces of interaction between the particles at $j_0 \neq 0$. Therefore, at the moment of time when the magnitude of relative velocity of the particles equals to zero, the radial relative acceleration of the particles $(d^2 r_{12}/dt^2)$ will not equal to zero like it would at the constant value of the magnitude of relative velocity of the particles not equal to zero in the bound steady state at $j_0 \neq 0$ or in the neutral state while the particles are moving along the same straight line. Thus, after this moment of time the magnitude of relative velocity of the particles will increase whereas the magnitude of forces acting between the particles will decrease. The maximum possible forces in the (411) depend on the $(b-1)$ parameter. The maximum magnitudes of interaction forces at the zero velocity will be determined by this parameter. If this parameter will be greater than one $(b > 2)$ then magnitudes of interaction forces at the zero velocity of particles, at the certain distance, in the moment of equality of the magnitude of their relative velocity to zero, will be greater than the maximum possible magnitude of interaction forces between these particles at high velocities and at the same distance, whereas their sign will be opposite to that of interaction forces at high velocities.

During the interaction of particles within the range of magnitudes of relative velocities $0 \leq v < a$, where a is the neutral relative velocity of particles, the interaction at the zero velocity and the interaction at low velocities will be possible whereas the interaction at high velocities will be impossible.

Let us consider a limited volume consisting of N likely charged particles (either protons or electrons) which interact within the range of magnitudes of relative velocities $0 \le v < a$, and the value of the interaction constant of these particles is greater than two ($b > 2$), with that, the maximum possible magnitude of relative velocity of particles has the value at which none of the particles can leave the volume. Particles in this volume will permanently attract and will be in the bound state. Being at certain distances, particles which magnitude of relative velocity will equal to zero within a certain period of time, until the magnitude of their relative velocity during the interaction increases to the value at which the interaction forces between them decrease and become equal to the forces of their interaction with surrounding particles, will be able to change their momenta both relatively one another and relatively surrounding particles. Let us call **the changing of particles' momenta during the interaction at the zero velocity as interchange of momenta**. If S acts of interaction at the zero velocity will simultaneously occur in that volume and the total number of acts of interaction between particles in the volume (the number of bonds between particles in the considered dynamic system) will be as follows:

$$S_N = \sum_{n=1}^{N-1} n, \quad N > 1, \tag{412}$$

then we can determine the following function:

$$S_{sN} = \frac{S}{S_N}, \quad 0 \le S_{sN} \le 1. \tag{413}$$

With S_{sN} equal to one all particles of the volume will interact at the zero velocity. In this case unit vectors of velocities of all particles will be parallel and magnitudes of velocities of all particles will be equal to one another.

The value of the S_{sN} function will be the measure of contribution of interactions at the zero velocity into the overall attraction of particles in the volume. The greater is this measure, the stronger will particles attract between one another.

The average number of simultaneous acts of interaction at the zero velocity, S, will be the function of the number of degrees of freedom of unit vectors of particles' velocities. With the decrease of the number of degrees of freedom of unit vectors of particles' velocities the probability of their parallelism increases, and the parallelism of unit vectors of velocities is a necessary condition of existence of the zero relative velocity of particles. Thus, as the number of degrees of freedom of unit vectors of particles' velocities decrease, the S in the (413) should increase – in other words, the average number of simultaneous acts of interaction at the zero velocity should increase.

If the motion of particles is chaotic, or disordered, then unit vectors of particles' velocities will be spread over all possible degrees of freedom, and thus, the S_{sN} will have the minimum value. As unit vectors of particles' velocities will lose some degrees of freedom, then the S_{sN} value will increase. It means that with the decrease of the number of degrees of freedom of unit vectors of particles' velocities the volume of particles determined hereinabove will start to shrink.

Thus, during the interaction of protons with protons, electrons with electrons and electrons with protons at the zero velocity particles will interchange their momenta. The greater will be the values of constants b_p, b_e, b_{ep}, the greater will be the distances at which particles are able to interchange their momenta.

Proceeding from this, we can establish the following analogy between quantum-mechanical effects and effects of PPST:

Emission and absorption of energy quanta by particles in the quantum mechanics is analogous to the interchange of momenta during the interaction at the zero velocity of particles in PPST.

The interchange of momenta during the interaction of two electrons results to their attraction, during the interaction of two protons – to their attraction, and during the interaction of the proton and the electron – to their repulsion.

Determination of the process of momenta interchange between particles during the interaction at the zero velocity in PPST as the process of emission and absorption of energy quanta in the quantum mechanics is related, first, with the possibility of interaction of particles at the long distances (depending on the values of b_p, b_e, b_{ep} constants); second, with the limited duration of such interaction (as the magnitude of relative velocity of particles increases, the interaction stops since as the magnitude of relative velocity of particles increases, the magnitudes of forces acting between the particles decreases); third, with the existence of the maximum value of magnitude of relative velocity of particles which they acquire during the interaction (less than the neutral relative velocity of particles (a_p, a_e, a_{ep}), please refer to Chapter 7); fourth, with the selective nature of the interaction (only those particles interact which relative velocities are equal to zero). If this process is interpreted in PPST as emission and absorption of the energy quantum in the quantum mechanics, then the emission of the energy quantum by a particle or by the system of particles will be possible only in case if this energy quantum is simultaneously absorbed by another particle or the system of particles. In other words, according to the laws of classical dynamics, the system of particles can't change by itself the sum of momenta of particles belonging to the system without interaction with another system of particles.

In PPST, at $b > 2$, volumes of particles which magnitudes of interaction forces at high velocities between them tend to zero can interchange the momenta. Let us consider two dynamic systems which are remote from one another at the distance at which the magnitudes of interaction forces at high velocities between particles of the systems can be accepted as equal to zero, but at which the interactions of particles at the zero velocities are possible. In the moment of time when the interactions between the systems at low velocities as well as the interaction between them at the zero velocities will be lacking, we can presume that the momenta of mass centres of each system relatively to the arbitrary coordinate system are constant and equal to some certain values. If at the next moment of time an interaction act of a particle of one dynamic system and a particle of another dynamic system occurs at the zero velocity and if in the further period of time there will be no interaction acts between particles of the systems at the zero velocities, then the momenta of mass centres of each system will change and possess other constant values but the sum of these values will remain unchanged as it was before the interaction. This process as the analogue of the process of emission and absorption of energy quanta by particles or systems of particles in the quantum mechanics is exactly what we will call the interchange of momenta during the interaction of particles at the zero velocity in PPST.

This work considers the emission and absorption of energy only within the framework of corpuscular component of a physical phenomenon determined in the quantum mechanics as the corpuscular-wave dualism. Here we consider the corpuscular component of dualism. The wave component of dualism is not considered in the present work.

14 Formation and evaporation of condensate consisting of bound pairs of like particles

From the determination of the state of two like particles we can conclude about the state of a set of like particles. According to (123), if:

$$\frac{ma^2}{4}\log_b\left(\frac{b-b^{v_0^2/a^2}}{b-1}\right)+\frac{e^2}{r_0}>0,\qquad v_0<a,\qquad j_0\neq 0, \tag{414}$$

then particles are bound.
In the (414):
m is a mass of a single particle, either the electron or the proton,
b is the constant of interaction of likely charged particles with respect to their masses, either electrons or protons,
a is the neutral relative velocity of likely charged particles with respect to their masses, either electrons or protons.
We introduce the value of the density of particles:

$$\rho=\frac{m}{r_\rho^3}, \tag{415}$$

where m is the mass of a single particle, r_ρ is the average distance between the neighbour particles in the limited volume which can be expressed as a function of density:

$$r_\rho=\left(\frac{m}{\rho}\right)^{1/3}. \tag{416}$$

Based on the Maxwell–Boltzmann distribution, we write down the value of the most probable velocity of particles as a function of temperature:

$$v_v=\left(\frac{2k_bT}{m}\right)^{1/2}, \tag{417}$$

where:
m is the mass of a particle,
k_b is the Boltzmann's constant,
T is the temperature,
v_v is the most probable velocity of particles.
Let us consider the interaction of likely charged particles in the limited volume. If we assume that the most probable velocity of particles is the velocity relatively to the mass centre of the volume, then, proceeding from the (417), we can determine **the maximum value of the most probable relative velocity of particles in the volume** as the doubled most probable velocity of particles:

$$v_m=\left(\frac{8k_bT}{m}\right)^{1/2}. \tag{418}$$

If we consider as the parameters of the bound state of two likely charged particles (414) the squared magnitude of their relative velocity as the squared maximum value of the most probable relative velocity of particles and the distance between the particles as a function of density, then, based on the (418), (416) and (414), we obtain conditions depending on temperature and density of the certain volume of likely charged particles at which the neighbour particles of the volume which values of magnitudes of relative velocities are less than or equal to the maximum value of the most probable relative velocity of particles in the volume will be able to form bound pairs:

$$\frac{ma^2}{4}\log_b\left(\frac{b-b^{\frac{8k_bT}{ma^2}}}{b-1}\right)+e^2\left(\frac{\rho}{m}\right)^{1/3}>0, \qquad T<\frac{ma^2}{8k_b}. \tag{419}$$

At the conditions of (419), the particles of volume which maximum magnitudes of their velocities relatively to the mass centre of the volume is less than the halved value of the neutral relative velocity of these particles will participate in the process of formation of bound pairs of like particles. Thus, the forming bound pairs of particles will attract one another, and the conditions of (419) should be those of formation of the condensate of bound pairs of like particles which particles had the values of their velocities relatively to the mass centre of the volume less than or equal to the value of the most probable velocity in the volume of particles with the temperature T and the density ρ. As follows from the (419), the greater is the density of particles, the closer the value of the temperature at which particles start condensation will be to the value of $ma^2\left(8k_b\right)^{-1}$ from the side of zero.

Let us introduce the following definitions:

Particles fast relatively to one another are the particles which interact at high velocities (as determined in Chapter 13);

Particles slow relatively to one another are the particles interact at low velocities and at the zero velocity (as determined in Chapter 13).

Using these definitions, the process of formation of a drop of condensate can be described as follows:

If a small volume of particles slow relatively to one another but fast relatively to the rest particles of volume is formed in the volume of particles fast relatively to one another, then the volume of particles slow relatively to one another will start to shrink, repelling particles fast relatively to it. The volume of particles fast relatively to one another will start to grow, repelling the volume of slow particles as fast relatively to itself, shrinking by this the volume of slow particles. If the temperature and the density of particles in the small volume will comply to the conditions of (419) as a result of this process, then particles which velocities in the small volume are equal to or less than the most probable velocity of particles in the small volume will bind into pairs and form the condensate. Therefore, a drop of condensate is formed in the small volume from the bound pairs of like particles.

Now let us assume that there is a drop of condensate consisting of bound pairs of like particles. We pretend that, as a result of external action on this drop, the magnitude of relative velocity of particles of the bound pair and the distance between them are changing. If the conditions of (414) are violated at that, then these two particles will turn to the free state. If the magnitude of relative velocity of free particles will become greater than a at that, then they will repel one another. And if the magnitudes of velocities particles which turned to the free state relatively the rest particles of the drop will become greater than a, then these two particles will repel from the drop as well with the force proportional to the cumulative charge of the drop. This is the way the evaporation, or the process inverse to the condensation, occurs.

In other words, if in the volume of particles slow relatively to one another appear some particles which are fast relatively to those of volume, then the fast particles will be repulsed outside the volume.

In the processes of condensation and evaporation described hereinabove we didn't consider a distribution of momenta between the fast and the slow particles (an equalising of temperatures). It is believed that the processes of condensation and evaporation in the considered cases are going faster than the process of equalising of temperatures. Therefore, using the values of temperature and density of particles in the (419) is to be considered as a qualitative determination of processes which requires some further correction. Also, here we didn't consider the interaction of particles at the zero velocity; it is believed that the value of the S_{sN} function (413) is small enough if the motion of particles is chaotic.

As the condensate evaporates emitting two free particles which have been bound in the condensate, the following scenarios can take place, depending on changing of the magnitude of relative velocity of particles and the distance between them:
First scenario is the emission in the opposite directions relatively the evaporation zone.
Second scenario is the emission alongside at the value of magnitude of relative velocity of scattering particles less than the neutral relative velocity of these particles.

The first scenario is realised if the external action results to the increase of the magnitude of relative velocity of the particles which becomes much greater than the neutral relative velocity of these particles. In this case the particles repel both from one another and from the condensate according to the Coulomb law and scatter in the opposite directions.

The second scenario is realised if the external action turns the particles into the free state while the magnitude of their relative velocity and the distance between them are changing and the particles nevertheless still attract. In this case the mass centre of the particles should have the velocity enough for emission of particles from the condensate. The magnitude of relative velocity of the scattering particles at that will be less than the neutral relative velocity of these particles, if the interaction with the condensate during the emission of particles will not change this magnitude.

Perhaps both these scenarios of the proton condensate evaporation are realised during the double-proton decay of the ^6B nucleus as a primary emission of two protons either alongside or in the opposite directions [15].

For the interaction of two likely charged particles at the magnitude of their initial relative velocity greater than the neutral relative velocity of these particles, we obtain from the (50):

$$v^2 = a^2 \log_b \left(b + b^{\left(E - \frac{2}{R}\right)} \right). \tag{420}$$

Based on the (420), we conclude:
The magnitude of relative velocity of two interacting like particles cannot equal to zero if the magnitude of their initial relative velocity is greater than the neutral relative velocity of these particles. Thus, at the motion of the particles towards each other, if their moment of momentum equals to zero, the distance between the particles will tend to zero and the magnitude of relative velocity of the particles will approach the neutral relative velocity of these particles from the side of plus-infinity.

If the three likely charged particles will be located at the same straight line and two outermost of them will be at the same distance from the central one and will have initial velocities relatively to the central particle equal in modulus but directed oppositely – toward the central particle, with the magnitude of the initial velocity of the outermost particle relatively the central one is greater than the value of the neutral relative velocity of these particles, then the radial relative acceleration of the outermost and the central particles can be described by the following equation:

$$\frac{d^2r}{dt^2} = \frac{e^2}{4mr^2}\left(5 - 4b^{\left(1-\left(\frac{dr}{dt}\right)^2/a^2\right)} - b^{\left(1-4\left(\frac{dr}{dt}\right)^2/a^2\right)}\right), \quad \left(\frac{dr_0}{dt}\right)^2 > a^2, \quad \frac{dr_0}{dt} < 0, \quad (421)$$

where:
r is the distance between the central and the outermost particles,
dr/dt is the radial relative velocity of the central and the outermost particles,
dr_0/dt - is the initial radial relative velocity of the central and the outermost particles.
In this case the distance between particles will tend to zero and the magnitude of relative velocity of the outermost and central particles will decrease approaching a certain value. Setting the radial relative acceleration of the outermost and central particles to zero, we obtain from the (421) the algebraic equation for determination of the value of this magnitude (v):

$$5 - 4b^{\left(1-v^2/a^2\right)} - b^{\left(1-4v^2/a^2\right)} = 0. \quad (422)$$

From the (422) we form and determine the function:

$$f_{(v)} = 5 - 4b^{\left(1-v^2/a^2\right)} - b^{\left(1-4v^2/a^2\right)}, \quad 0 \le v \le \infty. \quad (423)$$

We find the limiting values of the $f_{(v)}$ function.
First:

$$v = 0, \quad f_{(v)} = 5\,(1-b) < 0. \quad (424)$$

Second:

$$v = \infty, \quad f_{(v)} = 5 > 0. \quad (425)$$

Then:

$$\frac{\partial f_{(v)}}{\partial v} = \frac{8v\ln b}{a^2}\left(b^{\left(1-v^2/a^2\right)} + b^{\left(1-4v^2/a^2\right)}\right). \quad (426)$$

The first derivative of the $f_{(v)}$ function with respect to v is greater than zero; thus, the $f_{(v)}$ function (423) does not have stationary points and increases from the negative range to the positive. Therefore, the (422) equation has one real positive root. Proceeding from the (422), with $v^2 > a^2$ we have:

$$b^{\left(1-v^2/a^2\right)} < 1, \quad b^{\left(1-4v^2/a^2\right)} < 1, \quad 5 - 4b^{\left(1-v^2/a^2\right)} - b^{\left(1-4v^2/a^2\right)} > 0. \quad (427)$$

With $v^2 = a^2$ we obtain from the (422):

$$1 - b^{-3} > 0, \quad 5 - 4b^{\left(1-v^2/a^2\right)} - b^{\left(1-4v^2/a^2\right)} > 0. \quad (428)$$

Based on the (427) and (428), we conclude that the algebraic equation (422) where v is an unknown will have the real positive root at $v^2 < a^2$ only and with any value of b. It means that the set of like particles moving along a straight line relatively one another will have an opportunity to decrease the magnitudes of their relative velocities to the values less than those of neutral relative velocities and to switch from repulsion to attraction. If while moving towards with the value of moment of momentum relatively one another close to zero two particles enter the zone of the short-term action of the third particle and the magnitude of their relative velocity after this interaction becomes less than the neutral relative velocity of these particles and the distance between them becomes that at which the conditions of (414) are satisfied, then the particles turn to the bound state. The short-term action force should prevent from the closing of particles and its magnitude should tend to zero at the moment as the dynamical parameters of closing particles reach the values required for the bound state. The termination of action preventing from the closing can occur upon receding of one particle from the zone of interaction of three particles via its interaction at the zero velocity with other particles (please refer to Chapter 13).

If a set of parallel trajectories along which a lot of like particles moves will exist, then the attraction between particles will be possible not only along trajectories as described hereinabove but also across them. Unit vectors of particles' velocities in the trajectories will have only two degrees of freedom, and once the ranges of values of magnitudes of particles' velocities along trajectories relatively an arbitrary coordinate system match one another, the value of the S_{sN} function (413) will increase which will result to the crosswise attraction of particles at the parallel trajectories. Thus, while moving in a beam parallel to each other both along the straight line and along closed trajectories, likely charged particles will have the opportunity of attraction and formation of the condensate.

Therefore, within the PPST framework some free and separated volumes of both electron and proton condensates can exist.

Once an external magnetic field appears, bound pairs of like particles which form the condensate will acquire a dedicated orientation of the angular rotation velocity of particles in the bound pairs. An ordered rotation of pairs of particles appears, unit vectors of which velocities will lose some degrees of freedom. The number of acts of interaction between particles at the zero velocity will increase, and the value of the S_{sN} function (413) will grow. Additional forces of attraction of particles of the condensate to one another will appear. Thus, in the external magnetic field of a certain value the volume of the condensate formed by bound pairs of like particles should shrink.

If we have an interaction of the electron and the proton, then in accordance with the (12) we obtain:

$$\mu_{ep}\frac{d\vec{v}_{ep}}{dt} = -\frac{e^2}{r_{ep}^2}\left(1 - b^{\left(1-v_{ep}^2/a_{ep}^2\right)}\right)\hat{r}_{ep}. \tag{429}$$

With $v_{ep} < a_{ep}$ the proton and the electron repel. And thus, separated volumes of condensates of these particles at the certain velocity at which these volumes move relatively one another and which is less in modulus than a_{ep} will repel. Correspondingly, at the certain velocity at which volumes of condensates move relatively one another and which is greater in modulus than a_{ep}, these volumes will attract. On the contrary, volumes of condensates consisting of the same particles at the certain magnitude of relative velocity of volumes which is less than the neutral relative velocity of particles will attract. And at the certain magnitude of relative velocity which is greater than the neutral relative velocity the volumes will repel.

If we go back to Chapter 9 and analyse the changing of the magnitude of attraction forces between two likely charged particles in the bound steady states (please refer to the graphs at Fig. 7 and Fig. 8) depending on the magnitude of relative velocity of particles and on the distance between them (please refer to the graphs at Fig. 1 and 2), we can see that under the certain conditions like particles in the state of condensate will attract each other with forces very strong in moduli. And thus, we can expect that a dynamic system formed by the volumes of condensates of likely charged particles can be more solid than a crystal structure of neutral atoms.

15 Dynamic system of two protons and electron

The values of neutral relative velocities of particles play a special role in the dynamics of a system consisting of both electrons and protons if the number of particles in the system is greater than or equal to three. Therefore, starting from the first principle of selection of the type of modifying function, the correspondence of processes of particles' interaction in the theory to really observable physical processes (please refer to Chapter 3), we determine an inequality:

$$a_p << a_{ep} < a_e. \tag{430}$$

Let us consider conditions of interaction of particles determined by the inequality (430), by the inequality $b \geq 2$ (24), by the equality $b_p = b_{ep} = b_e = b$ (23) and by the system of equations (7) as one of the possible variants of PPST and further on, analysing the system of equations (7), we will use conditions of (430), (24) and (23).

Let us consider a dynamic system consisting of two protons and an electron. We write down the system of equations (7) which determines the motion of particles in this dynamic system:

$$m_e \frac{d\vec{v}_e}{dt} = -\frac{e^2}{r_{ep_1}^2}\left(1 - b^{\left(1-v_{ep_1}^2/a_{ep}^2\right)}\right)\hat{r}_{ep_1} - \frac{e^2}{r_{ep_2}^2}\left(1 - b^{\left(1-v_{ep_2}^2/a_{ep}^2\right)}\right)\hat{r}_{ep_2}, \tag{431}$$

$$m_p \frac{d\vec{v}_{p_1}}{dt} = -\frac{e^2}{r_{p_1e}^2}\left(1 - b^{\left(1-v_{p_1e}^2/a_{ep}^2\right)}\right)\hat{r}_{p_1e} + \frac{e^2}{r_{p_1p_2}^2}\left(1 - b^{\left(1-v_{p_1p_2}^2/a_{p}^2\right)}\right)\hat{r}_{p_1p_2}, \tag{432}$$

$$m_p \frac{d\vec{v}_{p_2}}{dt} = -\frac{e^2}{r_{p_2e}^2}\left(1 - b^{\left(1-v_{p_2e}^2/a_{ep}^2\right)}\right)\hat{r}_{p_2e} + \frac{e^2}{r_{p_2p_1}^2}\left(1 - b^{\left(1-v_{p_2p_1}^2/a_{p}^2\right)}\right)\hat{r}_{p_2p_1}, \tag{433}$$

where:
$\vec{r}_e$ is the radius vector of position of the electron,
$\vec{r}_{p_1}$ is the radius vector of position of the first proton,
$\vec{r}_{p_2}$ is the radius vector of position of the second proton,
$\vec{r}_{ep_1}$ is the radius vector of position of the electron relatively to the first proton,
$\vec{r}_{ep_2}$ is the radius vector of position of the electron relatively to the second proton,
$\vec{r}_{p_1e}$ is the radius vector of position of the first proton relatively to the electron,
$\vec{r}_{p_2e}$ is the radius vector of position of the second proton relatively to the electron,
$\vec{r}_{p_1p_2}$ is the radius vector of position of the first proton relatively to the second proton,
$\vec{r}_{p_2p_1}$ is the radius vector of position of the second proton relatively to the first proton.

Let us assume that the electron and the first proton are in the bound state. From (431) and (432) we obtain an equation of motion of the mass centre of bound pair of electron and the first proton:

$$(m_p + m_e)\frac{d\vec{v}_c}{dt} = -\frac{e^2}{r_{ep_2}^2}\left(1 - b^{\left(1-v_{ep_2}^2/a_{ep}^2\right)}\right)\hat{r}_{ep_2} + \frac{e^2}{r_{p_1p_2}^2}\left(1 - b^{\left(1-v_{p_1p_2}^2/a_{p}^2\right)}\right)\hat{r}_{p_1p_2}, \tag{434}$$

where $\vec{r}_c$ is the radius vector of position of the mass centre of electron and the first proton and $\vec{v}_c$ is its velocity correspondingly. From equations (433) and (434) we obtain the equation of motion of the second proton relatively to the mass centre of the bound pair of electron and the first proton:

$$\frac{m_p\left(m_p+m_e\right)}{\left(2m_p+m_e\right)}\frac{d\vec{v}_{p_2c}}{dt}=-\frac{e^2}{r^2_{p_2e}}\left(1-b^{\left(1-v^2_{p_2e}/a^2_{ep}\right)}\right)\hat{r}_{p_2e}+\frac{e^2}{r^2_{p_2p_1}}\left(1-b^{\left(1-v^2_{p_2p_1}/a^2_{p}\right)}\right)\hat{r}_{p_2p_1}. \tag{435}$$

Based on determination of the mass centre of the system of particles, we can write down:

$$m_p\vec{r}_{p_1c}=-m_e\vec{r}_{ec},\quad \vec{r}_{p_2e}=\vec{r}_{p_2c}-\vec{r}_{ec},\quad \vec{r}_{p_2p_1}=\vec{r}_{p_2c}+\frac{m_e}{m_p}\vec{r}_{ec}. \tag{436}$$

With the condition of $r_{p_2c}>>r_{ec}$, the (435) with regard to (436) will acquire the following form:

$$\frac{m_p\left(m_p+m_e\right)}{\left(2m_p+m_e\right)}\frac{d\vec{v}_{p_2c}}{dt}=\frac{e^2}{r^2_{p_2c}}\left(b^{\left(1-\left(\vec{v}_{p_2c}-\vec{v}_{ec}\right)^2/a^2_{ep}\right)}-b^{\left(1-\left(\vec{v}_{p_2c}-\vec{v}_{p_1c}\right)^2/a^2_{p}\right)}\right)\hat{r}_{p_2c}. \tag{437}$$

In the (437):
$\vec{v}_{p_2c}$ is the velocity of the second proton relatively to the mass centre of the bound pair of electron and the first proton;
$\vec{v}_{ec}$ is the velocity of the electron relatively to the mass centre of the bound pair of electron and the first proton;
$\vec{v}_{p_1c}$ is the velocity of the first proton relatively to the mass centre of the bound pair of electron and the first proton.

We represent the scalar function of interaction of the second proton and the bound pair of electron and the first proton as follows:

$$\Phi_{p_2c}=\frac{e^2}{r^2_{p_2c}}Q_{p_2c}. \tag{438}$$

From the (437) we separate a Q_{p_2c} function which determines the sign of the scalar function of interaction of the second proton and the bound pair of electron and the first proton:

$$Q_{p_2c}=b^{\left(1-\left(\vec{v}_{p_2c}-\vec{v}_{ec}\right)^2/a^2_{ep}\right)}-b^{\left(1-\left(\vec{v}_{p_2c}-\vec{v}_{p_1c}\right)^2/a^2_{p}\right)}. \tag{439}$$

Or, considering that $\vec{v}_{p_2p_1}=\vec{v}_{p_2c}+\frac{m_e}{m_p}\vec{v}_{ec}$:

$$Q_{p_2c}=b^{\left(1-\left(\vec{v}_{p_2c}-\vec{v}_{ec}\right)^2/a^2_{ep}\right)}-b^{\left(1-\left(\vec{v}_{p_2c}+\frac{m_e}{m_p}\vec{v}_{ec}\right)^2/a^2_{p}\right)}. \tag{440}$$

Then, as $v_{p_2c}>>v_{ec}$, we write down the (440):

$$Q_{p_2c}=b^{\left(1-v^2_{p_2c}/a^2_{ep}\right)}-b^{\left(1-v^2_{p_2c}/a^2_{p}\right)}. \tag{441}$$

As follows from (430), $v^2_{p_2c}/a^2_{ep}<<v^2_{p_2c}/a^2_{p}$, and thus, the (441) can be determined as:

$$Q_{p_2c}=b^{\left(1-v^2_{p_2c}/a^2_{ep}\right)}. \tag{442}$$

Considering the (442), we obtain from the (437):

$$\frac{m_p\,(m_p+m_e)}{(2m_p+m_e)}\frac{d\vec{v}_{p2c}}{dt}=\frac{e^2}{r_{p2c}^2}b^{\left(1-v_{p2c}^2/a_{ep}^2\right)}\hat{r}_{p2c}. \tag{443}$$

The scalar multiplication of the (443) by $\vec{v}_{p2c}$ and further integration provide the following:

$$\frac{m_p\,(m_p+m_e)}{(2m_p+m_e)}\frac{a_{ep}^2}{2b\ln b}b^{v_{p2c}^2/a_{ep}^2}+\frac{e^2}{r_{p2c}}=C_0. \tag{444}$$

Therefore, as follows from the (443), with:

$$r_{p2c}>>r_{ec},\qquad v_{p2c}>>v_{ec}, \tag{445}$$

the scalar function of interaction of the second proton and the bound pair of electron and the first proton (438) is greater than zero, and therefore, the second proton and the bound pair of electron and the first proton repel, and with the further increase of the magnitude of relative velocity of the second proton and the mass centre of the bound pair of electron and the first proton (v_{p2c}) the magnitude of repulsion forces between them will tend to zero.

Based on the (439) we determine inequalities:

$$\frac{v_{p2c}-v_{ec}}{a_{ep}}>\frac{v_{p2c}+v_{p1c}}{a_p},\qquad v_{p2c}>v_{ec}, \tag{446}$$

which fulfilment should result to that of the following condition: $Q_{p2c}<0$. In the (446), the difference of magnitudes of velocities of the second proton and the electron determines the minimum possible magnitude of their relative velocity. The sum of magnitudes of velocities of the first and second protons determines the maximum possible magnitude of their relative velocity. Conversion of the (446) provides the following:

$$v_{p2c}\,(a_p-a_{ep})>v_{ec}a_p+v_{p1c}a_{ep}. \tag{447}$$

Considering that $a_p<<a_{ep}$ (430), we conclude from the (447) that inequalities (446) are not fulfilled. Then, based on the (439), we determine inequalities:

$$\frac{v_{ec}-v_{p2c}}{a_{ep}}>\frac{v_{p2c}+v_{p1c}}{a_p},\qquad v_{p2c}<v_{ec}, \tag{448}$$

which fulfilment should result to that of the following condition: $Q_{p2c}<0$. Conversion of the (448) with regard to $m_e v_{ec}=m_p v_{p1c}$ provides the following:

$$v_{p2c}<\frac{m_p a_p-m_e a_{ep}}{m_p\,(a_p+a_{ep})}v_{ec}. \tag{449}$$

Thus, if the following inequalities fulfil:

$$r_{p2c}>>r_{ec},\quad v_{p2c}<\frac{m_p a_p-m_e a_{ep}}{m_p\,(a_p+a_{ep})}v_{ec},\quad m_p a_p>m_e a_{ep}, \tag{450}$$

then the second proton and the bound pair of electron and the first proton will attract since as $Q_{p2c}<0$, the scalar function of their interaction (438) will be less than zero. For this case, the (450) considering (430) provides an additional limitation for neutral relative velocities of particles:

$$\frac{m_e}{m_p} < \frac{a_p}{a_{ep}} << 1. \tag{451}$$

The second proton and the bound pair of electron and the first proton will repel at $Q_{p_2c} > 0$ if the following conditions fulfil:

$$\frac{v_{p_2c} - v_{p_1c}}{a_p} > \frac{v_{p_2c} + v_{ec}}{a_{ep}}, \qquad v_{p_2c} > v_{p_1c}, \tag{452}$$

and thus, with:

$$r_{p_2c} >> r_{ec}, \quad v_{p_2c} > \frac{m_p a_p + m_e a_{ep}}{m_p \left(a_{ep} - a_p\right)} v_{ec}, \tag{453}$$

the second proton and the bound pair of electron and the first proton repel.

The following conditions:

$$\frac{v_{p_1c} - v_{p_2c}}{a_p} > \frac{v_{p_2c} + v_{ec}}{a_{ep}}, \qquad v_{p_2c} < v_{p_1c}, \quad Q_{p_2c} > 0, \tag{454}$$

will not fulfil as the (454) results to the following:

$$v_{ec}(m_e a_{ep} - m_p a_p) > m_p v_{p_2c}(a_{ep} + a_p), \tag{455}$$

and the inequality (455) contradicts to conditions of (451).

In order to determine conditions at which two protons and the electron will attract each other, we write down the following conclusions from Chapter 7:
1. If the magnitude of relative velocity of two protons is less than the value of neutral relative velocity of protons then the protons attract.
2. If the magnitude of relative velocity of the electron and the proton is greater than the value of neutral relative velocity of electron and proton then the proton and the electron attract.

Let us write down a system of inequalities using these conclusions:

$$v_{p_2c} + v_{p_1c} < a_p, \quad v_{ec} - v_{p_2c} > a_{ep}, \quad v_{ec} + v_{p_1c} > a_{ep}, \quad v_{ec} > v_{p_2c}, \tag{456}$$

where v_{ec}, v_{p_1c} and v_{p_2c} are the magnitudes of velocities of particles relatively to the mass centre of the bound pair of electron and the first proton. If the system of inequalities (456) always fulfils then two protons and the electron will permanently attract each other. Proceeding from the (456) and considering that $m_e v_{ec} = m_p v_{p_1c}$, we obtain the following:

$$v_{p_2c} < \frac{m_p a_p - m_e a_{ep}}{m_p + m_e}, \quad \frac{m_e a_{ep}}{m_p + m_e} < v_{p_1c} < a_p, \quad \frac{m_p a_{ep}}{m_p + m_e} < v_{ec} < \frac{m_p}{m_e} a_p. \tag{457}$$

Let us conclude from this chapter:
1. The proton and the bound pair of electron and proton being at the distance much longer than the distance between the proton and the electron in the bound pair will attract at the conditions of (450):

$$r_{p_2c} >> r_{ec}, \quad v_{p_2c} < \frac{m_p a_p - m_e a_{ep}}{m_p \left(a_p + a_{ep}\right)} v_{ec}.$$

2. The proton and the bound pair of electron and proton being at the distance much longer than the distance between the proton and the electron in the bound pair will repel at the conditions of (453):

$$r_{p2c} >> r_{ec}, \quad v_{p2c} > \frac{m_p a_p + m_e a_{ep}}{m_p \left(a_{ep} - a_p\right)} v_{ec},$$

whereas at the conditions of (445):

$$r_{p2c} >> r_{ec}, \qquad v_{p2c} >> v_{ec},$$

the magnitude of repulsion forces between them will begin to tend to zero.
3. Two protons and the electron will attract each other at the conditions of (457):

$$v_{p2c} < \frac{m_p a_p - m_e a_{ep}}{m_p + m_e}, \quad \frac{m_e a_{ep}}{m_p + m_e} < v_{p1c} < a_p, \quad \frac{m_p a_{ep}}{m_p + m_e} < v_{ec} < \frac{m_p}{m_e} a_p.$$

4. Within the range of values of magnitudes of relative velocities of the proton and the mass centre of the bound pair of electron and proton (v_{p2c}) being at the distance much longer than the distance between the proton and the electron in the bound pair:

$$\frac{m_p a_p - m_e a_{ep}}{m_p \left(a_p + a_{ep}\right)} v_{ec} \leq v_{p2c} \leq \frac{m_p a_p + m_e a_{ep}}{m_p \left(a_{ep} - a_p\right)} v_{ec},$$

there will exist the values at which the magnitude of the interaction force between the proton and the bound pair of electron and proton equals to zero.

16 Atom of hydrogen, neutron and deuteron

A link between experimentally observable physical objects and dynamic systems of particles which are in the certain states according to PPST can be established by comparison of their properties. In PPST, determination of boundaries at which the properties of one dynamic system end and those of another one begin is rather conventional. Forces acting between particles in accordance with the system of equations (7) are responsible for all states. The balance of these forces determines the state of particles depending on initial conditions of motion, and thus, it also determines the properties of dynamic systems. Therefore, the boundaries of correspondence of experimentally observable physical objects to dynamic systems of particles in various states in PPST proposed herein are the matter of convention.

An atom of hydrogen is a dynamic system of the electron and the proton which bound steady state can be in the first domain of states only (please refer to Chapter 10).

A neutron is a dynamic system of the electron and the proton which bound steady state can be in the second domain of states only (please refer to Chapter 10).

A deuteron is a dynamic system of the proton and the neutron in the bound state when all three particles (two protons and electron) attract each other (please refer to conclusion 3 in Chapter 15).

Based on PPST, let us determine the properties which these objects should possess.

If the electron and the proton in the hydrogen atom are in the bound steady state, then the less is the distance between electron and proton the greater is the value of the magnitude of relative velocity of electron and proton and their rotation frequency; with that there is an always existing forbidden domain of distances between the bound steady and the free states at the constant values of $\acute{E}_s$ and J_s. The atom of hydrogen does not have an opportunity of being ionised without changing the values of $\acute{E}_s$ and J_s (please refer to Chapter 10). The most sustainable to external action bound steady state of the hydrogen atom is the state at which the distance between the electron and the proton tends to the minimum possible at the same time as the value of magnitude of relative velocity of electron and proton tends to the maximum possible (conclusion 1 of Chapter 10).

If the electron and the proton in the neutron are in the bound steady state, then the less is the distance between electron and proton the less is the value of magnitude of relative velocity of electron and proton and the greater is their rotation frequency; with that the forbidden domain of distances between the bound unsteady and the free states at the constant values of $\acute{E}_s$ and J_s is always lacking. A decay of the neutron, or transformation of the bound steady state of electron and proton into the free state without changing the values of $\acute{E}_s$ and J_s (i.e., without changing of initial conditions of motion, please refer to Chapter 10) is possible. If the distance between the electron and the proton being in the bound steady state in the neutron tends to zero, then the magnitude of relative velocity of electron and proton tends to the value of the neutral relative velocity of electron and proton from the side of plus-infinity; at that, the possibility of decay of the neutron into the electron and the proton without changing of initial conditions of motion always exists (conclusion 2 at the end of Chapter 10).

In the deuteron, the maximum value of magnitude of relative velocity of protons is less than the value of the neutral relative velocity of protons and the minimum value of magnitude of velocity of electron relative to each of protons is greater than the value of the neutral relative velocity of electron and proton (conclusion 3 of Chapter 15); at that there are limitations for velocities of particles in the deuteron represented as the system of inequalities (457).

17 Nucleus and electron shells of the atom

Presuming that the nucleus of atom consists of bound protons and neutrons, and the neutron in accordance to PPST consists of bound electron and proton, let us determine the boundaries of localisation of electrons in the atom separating them into **electrons of nucleus** and electrons of atom's electron shells.

As follows from the experience, the boundary between the nucleus and electron shells of the atom does exist. As also follows from the experience, while interacting with protons, electrons in electron shells behave like the electron in the atom of hydrogen. Thus, as the distance between the nucleus and the electron of the shell decreases, the velocity of electron relatively the mass centre of atom will increase. The longer is the distance between electrons in shells and the nucleus, the less should be their velocity relatively to the mass centre of atom. Therefore, let us split **electron shells of atom into two types, internal and external**.

Based on the hereinabove, let us introduce the following definitions for electrons of atom:

Electrons of nucleus are the electrons of atom which values of maximum magnitudes of velocities of motion relatively one another are less than the value of neutral relative velocity of electrons and those which are bound with protons in neutrons.

Electrons of internal electron shells are the electrons of atom which minimum values of magnitudes of velocities of motion relatively the mass centre of atom are greater than or equal to the halved value of neutral relative velocity of electrons and those which are more distant from the mass centre of atom than electrons of the nucleus.

Electrons of external electron shells are the electrons of atom which maximum values of magnitudes of velocities of motion relatively the mass centre of atom are less than the halved value of neutral relative velocity of electrons and those which are more distant from the mass centre of atom than electrons of internal electron shells of atom.

If the atom is stable and does not ionise and its nucleus does not decay, then, in accordance with definitions of the neutron and the deuteron, considering definitions for electrons of nuclei and those of electron shells of atoms, we can conclude the following:

1. All electrons in the atom should have the minimum values of velocities of motion relatively protons in the nucleus, including those in neutrons, greater than the value of neutral relative velocity of electron and proton - all electrons should attract with all protons of the nucleus.

2. All protons in the nucleus, including those in neutrons, should have the maximum values of velocities of motion relatively one another less than the value of neutral relative velocity of protons - all protons of the atom nucleus should attract one another.

3. All electrons in the nucleus should have the maximum values of velocities of motion relatively one another less than the value of neutral relative velocity of electrons - all electrons of the atom nucleus should attract one another.

4. The minimum values of velocities of electrons in the internal electron shells of atom relatively the mass centre of atom should be greater than or equal to the halved value of the neutral relative velocity of electrons.

5. The maximum values of velocities of electrons in the external electron shells of atom relatively the mass centre of atom should be less than the halved value of the neutral relative velocity of electrons. All electrons in the external electron shells of atoms should attract one another.

Based on these conclusions, let us determine the inequalities for magnitudes of velocities of two arbitrary taken protons and two arbitrary chosen electrons in the nucleus of atom relatively the mass centre of atom:

$$\begin{aligned} v_{e1} - v_{p1} > a_{ep}, \qquad v_{e1} - v_{p2} > a_{ep}, \\ v_{e2} - v_{p1} > a_{ep}, \qquad v_{e2} - v_{p2} > a_{ep}, \\ v_{e1} + v_{e2} < a_e, \qquad v_{p1} + v_{p2} < a_p. \end{aligned} \tag{458}$$

Proceeding from the inequalities of (458), we obtain the following inequalities determining the values of magnitudes of velocities of protons and electrons in the atomic nucleus at which protons and electrons will always attract one another:

$$0 \leq v_p < a_p/2, \qquad a_{ep} + a_p/2 < v_e < a_e/2, \tag{459}$$

where:
v_p is the magnitude of velocity of protons in the nucleus of atom relatively the mass centre of atom,
v_e is the magnitude of velocity of electrons in the nucleus of atom relatively the mass centre of atom.

The last inequality in the (459) provides an additional limitation for neutral relative velocities of particles:

$$a_e > 2a_{ep} + a_p. \tag{460}$$

According to the (459), interaction at the zero velocity between the particles of atoms will occur in the various domains of values of magnitudes of velocities of particles relatively the mass centre of the atom since the equality of magnitudes of velocities of particles is the necessary condition of interaction at the zero velocity. Non-intersection of domains of values of velocities results to impossibility of existence of the zero relative velocity of particles from different domains.

As follows from that, particles of different and same atoms should interact with one another at the zero velocity in the three domains of values of magnitudes of velocities if the velocities of mass centres of atoms relatively each other are equal to zero:

1. Interaction at the zero velocity of electrons of internal electron shells of atoms - the domain of highest magnitudes of velocities:

$$v \geq a_e/2. \tag{461}$$

2. Interaction at the zero velocity of electrons of nuclei and electrons of external electron shells of atoms - the domain of average magnitudes of velocities:

$$a_{ep} + a_p/2 < v < a_e/2. \tag{462}$$

3. Interaction at the zero velocity of protons of nuclei of atoms - the domain of lowest magnitudes of velocities:

$$0 \leq v < a_p/2, \tag{463}$$

the hydrogen atom is an exception where the proton can have the magnitude of velocity relatively the mass centre of atom greater than or equal to the halved neutral relative velocity of protons. The proton in the neutron can also have the magnitude of velocity relatively the mass centre of neutron greater than or equal to the halved neutral relative velocity of protons. This state of neutron to be considered in the chapter "Decay of a neutron and neutron emission".

As follows from that, the particles of the same atoms, which magnitudes of relative velocities of mass centres are equal to zero, will interact at the zero velocity most probably.

As also follows from definitions of domains of values of magnitudes of velocities of interaction of particles of atoms at the zero velocity, particles of atoms which nuclei are in the unperturbed states, excluding hydrogen atoms, will not interact at the zero velocity if magnitudes of relative velocities of mass centres of atoms are equal to zero, in the following range of magnitudes of velocities:

$$a_p/2 \leq v \leq a_{ep} + a_p/2. \tag{464}$$

As follows from the (464), the extent of this range is equal to the value of neutral relative velocity of the electron and the proton, a_{ep}.

Electrons of external electron shells of different and same atoms can attract each other since magnitudes of their relative velocities will be less than the neutral relative velocity of electrons if magnitudes of relative velocities of mass centres of atoms equal to zero. This attraction should contribute to formation of chemical bonds between atoms in molecules with pairing of electrons of external electron shells of atoms. The presence of paired electrons in external electron shells of atoms probably has been observed experimentally [16]: the photoemission of bound pairs of electrons from aromatic hydrocarbons.

Attraction of Rydberg atoms and formation of condensate and molecules of them [17] can be explained by the decrease of magnitude of rotation velocity of electrons in electron shells of atoms while the distance between electrons and nuclei of atoms increases. As magnitudes of velocities of electrons of various atoms relatively one another become less than the neutral relative velocity of electrons, these electrons become attract one another providing by this the attraction of atoms. The process of interaction of Rydberg atoms of hydrogen within the frame of PPST can be described as follows:

Once the magnitudes of velocities of the electron and the proton relatively their mutual mass centre in atoms of hydrogen and the magnitudes of velocities of mass centres of atoms relatively one another will be so that the magnitudes of relative velocities of electrons of atoms will be less than the neutral relative velocity of electrons, and the magnitudes of relative velocities of protons of atoms will be less than the neutral relative velocity of protons, then both electrons of atoms and protons of atoms will attract. At that, if the magnitudes of relative velocities of electrons and protons in hydrogen atoms will be greater than the neutral relative velocity of electron and proton, and the distances between them will be so that they will be bound, then hydrogen atoms will not ionise. Interactions between particles of atoms of hydrogen can occur at the zero velocity. Domains of values of magnitudes of velocities of electrons and protons will not match during this process, thus, the attraction between atoms should be stronger while the number of degrees of freedom of unit vectors of velocities of electrons and protons will decrease. At that, two acts of interaction at the zero velocity will occur simultaneously - between the electrons and between the protons of two interacting atoms of hydrogen since the unit vectors of velocities of the electron and the proton in the atom of hydrogen are antiparallel. And if the magnitudes of velocities of electrons of interacting atoms are equal, the magnitudes of velocities of their protons will be equal as well.

18 Interaction between particles of atoms and particle beam at zero velocity

During the interaction of particles at the zero velocity the magnitude of relative velocity of interacting particles will increase from zero to a certain value. This certain value will depend on the distance between particles, on the value of interaction constant b (in this chapter we will assume that $b >> 2$), on the neutral relative velocity of particles and on the interaction of particles with surrounding those. The magnitude of velocity of interacting particles relatively to surrounding particles can both increase and decrease. Therefore, particles while interacting with other particles at the zero velocity can change the state of particles of the dynamic system which particles they are bound with, both without turning to the free state and with turning to the free state relatively to particles of the system. Turning the particle into the free state relatively to particles of dynamic system which it is bound with depends both on forces tending to turn the particle into the free state and on forces tending to keep it in the bound state. The balance of these forces will determine what is going to happen, either changing of initial conditions of motion of particles of the dynamic system without turning its particles into the free state (according to terms of quantum mechanics, either the decrease or the increase of the bond energy of particles in the system), or turning of individual particles into the free state relatively to particles of the system (according to terms of quantum mechanics, either the ionisation of atom or the decay of the nucleus of atom. In PPST, a decay of a neutron and turning of a bound pair of like particles into the free state is added to that). At that, the velocity of the mass centre of particles of the system will change in any case.

Let us consider the interaction at the zero velocity between particles of atoms located at a certain volume and a particle beam which is either decelerated or accelerated by external forces along a straight line relatively the volume of atoms. The magnitude of interaction at the zero velocity between the particles of beam and the particles of atoms will be permanently changing either from the maximum of the particles of beam relatively the mass centre of the volume of atoms to the minimum one during the deceleration or vice versa during the acceleration. Therefore, the particles of atoms will interact at the zero velocity with the particles of beam at the coincidence of the magnitude and the unit vector of their velocity and the magnitude and the unit vector of velocity of particles in the beam. What exact particles in the atom will interact the particles of beam with at the zero velocity, either electrons of shells, or electrons of the nucleus, or protons of the nucleus, will depend on the maximum magnitude of velocities of particles in the beam during the deceleration or acceleration. If the maximum magnitude of velocities of particles in the beam relatively mass centres of atoms will equal to the halved neutral relative velocity of protons, then the interaction at the zero velocity with protons of nuclei only will occur. As the maximum magnitude increases, the beam will begin to interact with electrons in nuclei and electrons in external shells, and with electrons of internal shells of atoms at the further increase. Within the range of values of magnitudes of velocities of particles of the beam relatively mass centres of atoms determined in the (464):

$$a_p/2 \leq v \leq a_{ep} + a_p/2,$$

there will be no interaction at the zero velocity between particles of the beam and particles of atoms which nuclei are in unperturbed states.

The range of values of magnitudes of velocities at which particles of atoms will interact with particles of the beam at the zero velocity will depend on velocities of atoms relatively to the beam. As the temperature of the volume of atoms increases, the maximum magnitude of interaction at the zero velocity will increase whereas the minimum one will decrease. The domain of magnitudes of velocities of interaction between particles of atoms and particles of the beam should expand due to summation of the temperature velocity of mass centre of the atom and velocity of particle in the atom.

The magnitude of interaction force at the zero velocity between a particle of the atom and particles of the beam will be directly proportional to the number of particles of the beam participating in the simultaneous interaction at the zero velocity with the particle of the atom. This interaction can be an analogue of the process of bremsstrahlung produced by particles.

The magnitude of interaction force at the zero velocity between a particle of the beam and particles of atoms will also depend on the number of particles of atoms participating in the simultaneous interaction at the zero velocity with the particle of the beam. This interaction can be an analogue of processes at which the maximum scattering of particle beam appears in a substance.

The interaction at the zero velocity between the beam consisting of a single proton and a single atom of hydrogen while the distance between the mass centre of the atom and the proton of the beam is much greater than the distance between the proton and the electron in the hydrogen atom can be considered using the (437) equation:

$$\frac{m_p\,(m_p+m_e)}{(2m_p+m_e)}\frac{d\vec{v}_{p2c}}{dt}=\frac{e^2}{r_{p2c}^2}\left(b^{\left(1-\left(\vec{v}_{p2c}-\vec{v}_{ec}\right)^2/a_{ep}^2\right)}-b^{\left(1-\left(\vec{v}_{p2c}-\vec{v}_{p1c}\right)^2/a_p^2\right)}\right)\hat{r}_{p2c}, \tag{465}$$

where:
$\vec{r}_{p_2}$ is a radius vector of position of the proton of beam;
$\vec{r}_{p_1}$ is a radius vector of position of the proton of hydrogen atom;
$\vec{r}_e$ is a radius vector of position of the electron of hydrogen atom;
$\vec{r}_c$ is a radius vector of position of the mass centre of hydrogen atom.

Let us assume that an increment of magnitude of relative velocity of the proton of the beam and the mass centre of the atom of hydrogen resulted by their interaction is much less than the magnitude of their relative velocity, and the hydrogen atom does not ionise at that.

If the magnitude of velocity of the proton of the beam relatively to the mass centre of the hydrogen atom will match the magnitude of velocity of the proton in the atom of hydrogen relatively the mass centre of the atom and the unit vector of its velocity will lay within the plane of rotation of electron and proton in the atom of hydrogen, then the expression enclosed in large parentheses in the (465) will look as follows:

$$b^{\left(1-\frac{4\pi^2m_p^2\gamma^2r_{pc}^2}{m_e^2a_{ep}^2}\left(1+\frac{m_e^2}{m_p^2}+2\frac{m_e}{m_p}\cos(2\pi\gamma t+\varphi_0)\right)\right)}-b^{\left(1-\frac{8\pi^2\gamma^2r_{pc}^2}{a_p^2}(1-\cos(2\pi\gamma t+\varphi_0))\right)}, \tag{466}$$

where:
γ is a rotation frequency of the proton in the atom of hydrogen,
r_{pc} is a distance between the proton of hydrogen atom and the mass centre of the atom,
t is the time,
φ_0 is an initial angle between the unit vector of velocity of the proton in the beam and the unit vector of velocity of the proton in the atom of hydrogen.

Considering that:

$$\left|\frac{m_e^2}{m_p^2}+2\frac{m_e}{m_p}\cos\left(2\pi\gamma t+\varphi_0\right)\right|<<1, \tag{467}$$

we can rewrite the (466) as follows:

$$b^{\left(1-\frac{4\pi^2m_p^2\gamma^2r_{pc}^2}{m_e^2a_{ep}^2}\right)}-b^{\left(1-\frac{8\pi^2\gamma^2r_{pc}^2}{a_p^2}(1-\cos(2\pi\gamma t+\varphi_0))\right)}. \tag{468}$$

At the moment of time t_1:

$$t_1=\frac{2\pi-\varphi_0}{2\pi\gamma},\qquad 0\leq\varphi_0\leq 2\pi,$$

the scalar function of interaction between the proton of the beam and the proton of the atom of hydrogen will possess the following value:

$$\Phi_{p2c}=-\frac{e^2}{r_{p2c}^2}\left(b-b^{\left(1-\frac{4\pi^2m_p^2\gamma^2r_{pc}^2}{m_e^2a_{ep}^2}\right)}\right). \tag{469}$$

Thus, at this moment of time $\Phi_{p2c} < 0$. At the following moment of time:

$$t_2 = \frac{3\pi - \varphi_0}{2\pi\gamma},$$

the scalar function will possess the following value:

$$\Phi_{p2c} = \frac{e^2}{r_{p2c}^2} \left(b^{\left(1 - \frac{4\pi^2 m_p^2 \gamma^2 r_{pc}^2}{m_e^2 a_{ep}^2}\right)} - b^{\left(1 - \frac{16\pi^2 \gamma^2 r_{pc}^2}{a_p^2}\right)} \right). \tag{470}$$

As follows from the (470), if $m_p a_p > 2m_e a_{ep}$, then $\Phi_{p2c} < 0$, and thus, in this case the proton and the atom of hydrogen during the time period of $t_2 - t_1 = (2\gamma)^{-1}$ will acquire the momenta toward each other. And if $m_p a_p < 2m_e a_{ep}$, then $\Phi_{p2c} > 0$, and the proton and the atom of hydrogen during the interaction within the time period of $t_2 - t_1 = (2\gamma)^{-1}$ will acquire the momenta relatively to one another equal to the momenta acquired during the attraction and repulsion.

Let us consider the interaction of the atom of hydrogen and the beam consisting of a single electron while the distance between the mass centre of the atom and the electron of the beam is much greater than the distance between the proton and the electron in the hydrogen atom:

$$\frac{m_e (m_p + m_e)}{(2m_e + m_p)} \frac{d\vec{v}_{e2c}}{dt} = \frac{e^2}{r_{e2c}^2} \left(b^{\left(1 - \left(\vec{v}_{e_2c} - \vec{v}_{pc}\right)^2 / a_{ep}^2\right)} - b^{\left(1 - \left(\vec{v}_{e_2c} - \vec{v}_{e_1c}\right)^2 / a_e^2\right)} \right) \hat{r}_{e2c}, \tag{471}$$

where:
$\vec{r}_{e_2}$ is a radius vector of position of the electron of beam;
$\vec{r}_p$ is a radius vector of position of the proton of hydrogen atom;
$\vec{r}_{e_1}$ is a radius vector of position of the electron of hydrogen atom;
$\vec{r}_c$ is a radius vector of position of the mass centre of hydrogen atom.

Let us assume that an increment of magnitude of relative velocity of the electron of the beam and the mass centre of the atom of hydrogen resulted by their interaction is much less than the magnitude of their relative velocity, and the hydrogen atom does not ionise at that.

If the magnitude of velocity of the electron of the beam relatively to the mass centre of the hydrogen atom will match the magnitude of velocity of the electron in the atom of hydrogen relatively the mass centre of the atom and the unit vector of its velocity will lay within the plane of rotation of electron and proton in the atom of hydrogen, then the expression enclosed in parentheses in the (471) will look as follows:

$$b^{\left(1 - \frac{4\pi^2 \gamma^2 r_{ec}^2}{a_{ep}^2} \left(1 + \frac{m_e^2}{m_p^2} + 2\frac{m_e}{m_p} \cos(2\pi\gamma t + \varphi_0)\right)\right)} - b^{\left(1 - \frac{8\pi^2 \gamma^2 r_{ec}^2}{a_e^2} (1 - \cos(2\pi\gamma t + \varphi_0))\right)}, \tag{472}$$

where:
r_{ec} is a radius of rotation of the electron in the atom of hydrogen.

If we consider the (467), then at the moment of time when the unit vector of velocity of the electron of the atom will be parallel to the unit vector of velocity of the electron in the beam, the scalar function of interaction between the electron and the atom of hydrogen will possess the following value:

$$\Phi_{e2c} = -\frac{e^2}{r_{e2c}^2} \left(b - b^{\left(1 - \frac{4\pi^2 \gamma^2 r_{ec}^2}{a_{ep}^2}\right)} \right). \tag{473}$$

Thus, at this moment of time $\Phi_{e_2c} < 0$.

At the moment of time when the unit vector of velocity of electron of the atom becomes antiparallel to the unit vector of velocity of electron in the beam, the scalar function will acquire the following value:

$$\Phi_{e_2c} = \frac{e^2}{r^2_{e_2c}} \left(b^{\left(1 - \frac{4\pi^2\gamma^2 r^2_{ec}}{a^2_{ep}}\right)} - b^{\left(1 - \frac{16\pi^2\gamma^2 r^2_{ec}}{a^2_{e}}\right)} \right). \tag{474}$$

As determined in the (460), $a_e > 2a_{ep}+a_p$, and thus, in the (474) $\Phi_{e_2c} < 0$. Therefore, the electron of the beam and the atom of hydrogen during the time period of $t_2 - t_1 = (2\gamma)^{-1}$ will acquire the momenta toward each other.

We can consider in a similar way some other types of interaction at the zero velocity:

1. Interaction between the proton of the beam and the electron of the hydrogen atom.
2. Interaction between the electron of the beam and the proton of the hydrogen atom.
3. Interaction between the proton of the beam and the proton of the neutron.
4. Interaction between the proton of the beam and the electron of the neutron.
5. Interaction between the electron of the beam and the electron of the neutron.
6. Interaction between the electron of the beam and the proton of the neutron.

If the force acting on the electron of the atom of hydrogen during the act of interaction at the zero velocity from particles of the beam will be greater than the force acting on the electron of the atom of hydrogen from the proton of the atom that much that it will be able to turn the proton and the electron of the hydrogen atom into the free state, then a ionisation of the hydrogen atom will occur during the one act of interaction at the zero velocity. Otherwise, the mass centre of the atom will change its velocity, having the opportunity to convert the atom into another bound state (changing of the quantum state of the electron in the atom of hydrogen). The momentum acquired by the electron during several acts of interaction at the zero velocity with the particle beam is the sum of momenta acquired at each of acts. Therefore, in PPST the ionisation of atom is possible both at the single and at the multiple interaction at the zero velocity between the particle beam and the electron of the atom. In PPST, the ionisation of atoms in the certain volume during the interaction with the particle beam should depend, first, on the following parameters of particle beam dynamics:

1. the maximum and minimum magnitudes of velocities of particles of the beam relatively the mass centre of the volume;
2. the number of particles of the beam which have equal magnitudes and unit vectors of velocities;
3. the repetition rate of equal magnitudes and unit vectors of particles in the beam (depends on the oscillation frequency of particles in the beam).

Second, it should depend on parameters that determine the dynamics of particles of the volume of atoms with which the particle beam interacts:

1. magnitudes of velocities of particles in atoms relatively to mass centres of atoms and magnitudes of velocities of mass centres of atoms relatively to the mass centre of volume;
2. number of degrees of freedom of unit vectors of velocities of particles of atoms in the volume;

3. rotation frequencies of particles in atoms.

An orientation of unit vectors of velocities of particles of the beam relatively the volume of atoms and distances between particles of the beam and particles of atoms of the volume will be the common parameters for the beam and the volume.

The ionisation of atoms of the volume during the interaction with the particle beam will depend on certain coincidences of values of parameters of dynamics of the particle beam and the volume of particles atoms (coincidence or multiplicity of integer value of oscillation frequencies of particles of the beam and rotation frequencies of particles in atoms; coincidence or intersection of ranges of values of magnitudes of velocities of particles of the beam and particles of the volume of atoms relatively the mass centre of the volume), on the number of particles of the beam participating in the simultaneous interaction at the zero velocity with the particle of the atom and on the orientation of unit vectors of velocities of particles of the beam relatively to the volume of atoms (the more coincidences between unit vectors of velocities of particles of the beam and unit vectors of velocities of particles of the volume occur, the greater is the probability of ionisation). The less is the distance between particles of the beam and particles of the volume, the greater are magnitudes of interaction forces between particles, and thus, the greater is the probability of ionisation.

All changes of states of atoms of the volume in these processes will be related to the change of momenta of particles in the beam. In other words, according to the terms of quantum mechanics, the processes of emission and absorption of energy quanta between particles of the beam and atoms of the volume will occur.

Undetection of bound pairs of protons outside nuclei of atoms can be related, first, to the low relative velocity of protons required for the formation of bound pairs; second, to the formation of deuteron during the binding of electron with the bound pair of protons; third, to the interaction of bound pairs of protons at the zero velocity with protons of atomic nuclei. The ranges of magnitudes of velocities of protons in the bound pair of protons and in the nuclei of atoms will match each other. The highest magnitude of this range will be less than the halved neutral relative velocity of protons. Besides the mutual attraction, protons in the nuclei of atoms are attracted by electrons of neutrons. Therefore, during the interaction at the zero velocity of the bound pair of protons with protons of the nucleus of atom, the probability of turning of the bound pair of protons into the free state is greater than that of emission of the proton from the nucleus of atom. And as the bound pair of protons, in contrast to the atom, is not electrically neutral, it will experience a permanent acceleration and deceleration while interacting with other particles. It results to the permanent interaction at the zero velocity between protons of the pair and protons of the atom which is similar to the interaction at the zero velocity between the particle beam and atoms, as described hereinabove.

Proceeding from the analysis of interaction of particles at the zero velocity, let us make six conclusions:

1. If the beam of electrons goes through the volume of atoms which magnitudes of velocities match the magnitudes of velocities of electrons of electron shells of atoms, then the following processes can be observable:

- changing of quantum states of electrons of electron shells of atoms;
- ionisation of atoms with emission of electrons having a projection of the vector of velocity towards the beam;
- scattering of electrons of the beam;

- acceleration of atoms towards the beam.

2. If the beam of electrons goes through the volume of atoms which magnitudes of velocities match the magnitudes of velocities of electrons of atomic nuclei, then the following processes can be observable:
- changing of quantum states of nuclei of atoms;
- beta decay of nuclei of atoms with emission of electrons having a projection of the vector of velocity towards the beam;
- decay of nuclei of atoms with emission of neutrons having a projection of the vector of velocity towards the beam;
- scattering of electrons of the beam;
- acceleration of atoms towards the beam.

3. If the beam of electrons goes through the volume of atoms which magnitudes of velocities match the magnitudes of velocities of protons of atomic nuclei, then the following processes can be observable:
- changing of quantum states of nuclei of atoms;
- decay of nuclei of atoms with emission of protons or neutrons having a projection of the vector of velocity away from the beam;
- scattering of electrons of the beam;
- acceleration of atoms away from the beam.

4. If the beam of protons goes through the volume of atoms which magnitudes of velocities match the magnitudes of velocities of electrons of electron shells of atoms, then the following processes can be observable:
- changing of quantum states of electrons of electron shells of atoms;
- ionisation of atoms with emission of electrons having a projection of the vector of velocity away from the beam;
- scattering of protons of the beam during the interaction of the proton of beam with the large number of electrons of electron shells of atoms;
- acceleration of atoms away from the beam.

5. If the beam of protons goes through the volume of atoms which magnitudes of velocities match the magnitudes of velocities of electrons of atomic nuclei, then the following processes can be observable:
- changing of quantum states of nuclei of atoms.
- beta decay of nuclei of atoms with emission of electrons having a projection of the vector of velocity away from the beam;
- decay of nuclei of atoms with emission of neutrons having a projection of the vector of velocity away from the beam;
- scattering of protons of the beam during the interaction of the proton of beam with the large number of electrons of atomic nuclei;
- acceleration of atoms away from the beam.

6. If the beam of protons goes through the volume of atoms which magnitudes of velocities match the magnitudes of velocities of protons of atomic nuclei, then the following processes can be observable:
- changing of quantum states of nuclei of atoms;
- decay of nuclei of atoms with emission of protons or neutrons having a projection of the vector of velocity towards the beam;
- scattering of protons of the beam;
- acceleration of atoms towards the beam.

Neutron impulses correlating with those of X-rays have been detected in high-voltage discharges produced in laboratory conditions: "It has been established that during the process of high-voltage discharge in the air there are neutrons emitted, possessing the energy > 10 MeV, which are the products of nuclear reactions yet unknown... The data obtained allow for assumption that the process of discharge results to formation of fast neutrons, and their generation occurs at the initial phase of discharge and correlates to the generation of quanta of hard X-ray radiation" [18], [19]. In this experiment neutron impulses have been observed at the beginning of the discharge process when particles of the discharge just start to accelerate and have the lowest in moduli velocities relatively atoms surrounding the discharge. It means that neutron impulses can be the result of the process determined either by conclusion 2, or by conclusion 5, at the magnitudes of velocities of electrons or protons of discharge relatively atoms surrounding the discharge comparable to the magnitudes of velocities of electrons in the nucleus of atom, or by conclusion 3, or by conclusion 6, at the magnitudes of velocities of electrons or protons in the discharge less than the halved neutral relative velocity of protons. Conditions of interaction of particles in PPST which can result to correlation of emission of a neutron from the nucleus of atom with the impulse of X-ray radiation to be considered in Chapter 19 ("Decay of a neutron and neutron emission") and Chapter 20 ("Correspondence of ranges of magnitudes of particles' velocities in PPST to ranges of radiation").

In the experiment [20] the process of collision of accelerated hydrogen atoms and molecules of deuterium has been studied. The gas of deuterium molecules has been cooled using the method of supersonic outflow from the nozzle. Perhaps the process of interaction at the zero velocity between particles of hydrogen atoms and particles of deuterium molecules at the coincidence of magnitudes and unit vectors of velocities of like particles in hydrogen and in a deuterium molecule has been observed, when molecules of deuterium attract atoms of hydrogen and force them to accelerate towards direction of their motion, ahead to the molecules of deuterium.

Using the mechanism of interaction of particles at the zero velocity described in conclusion 4, the Bragg peak of ionisation of atoms during the transition of the beam of heavy charged particles through the volume of atoms and molecules can be explained [21, 22]:

The beam of protons in which magnitudes of velocities of protons relatively the mass centre of the volume of atoms are greater than magnitudes of velocities of electrons of internal electron shells of atoms relatively the mass centre of the volume of atoms cannot interact at the zero velocity with particles of the volume. If protons of the beam during the deceleration at the interaction of atoms of the volume decrease magnitudes of their velocities to the values of magnitudes of electrons of the electron shells of atoms in the volume, then the mass interaction of protons of the beam and electrons of the electron shells of atoms at the zero velocity will occur. In this case the beam of protons will begin to scatter in that part of its trajectory where such mass interaction at the zero velocity with electrons of atoms appeared. Being emitted from atoms during this interaction, electrons will acquire a component of velocity away from the beam of protons, which will result to additional ionisation of atoms around the scattering beam of protons. New ions will repel from the beam of protons. Volumes of resulting ions will begin to expand if protons of ions in volumes will have magnitudes of velocities relatively to one another greater than the neutral relative velocity of protons, and will shrink if they will have less magnitudes of velocities, which will result to destruction of molecules in volumes.

As a result of this process, a local ionisation explosion deep in the volume of atoms and molecules will occur. The volume of this explosion along the trajectory of the beam of protons will depend on the maximum radius of interaction at the zero velocity between protons and electrons in this volume of atoms. As the beam of protons begins to scatter, then unit vectors of velocities of protons will acquire different directions. Thus, with the further decrease of magnitudes of velocities of protons in the beam, their interaction with electrons of nuclei and with protons of nuclei of atoms at the zero velocity yet will not be the mass but individual, and the affection on the structure of nuclei of atoms will be the minimum within this process.

Processes similar to the Bragg peak of ionisation of atoms can occur both during the explosive destruction of conductors and during the explosive electron emission at the formation of vacuum arc [23], when magnitudes of velocities of a certain number of electrons in the small section of conductor reach the values relatively mass centres of atoms of conductor equal to the values of magnitudes of velocities of electrons in atoms. As a result of this process, electrons of atoms interacting at the zero velocity with electrons of current will be removed from atoms and will acquire the component of velocity towards the direction of electrons of current. The resulting volume of ions in the conductor can either explode under the action of Coulomb repulsion forces, or condensate if relative velocities of protons of ions will be less than the neutral relative velocity of protons, and then can either evaporate or stay in the fluid state. According to PPST, this process can be controlled if one could arrange the rotation of electrons in atoms of conductor in the way that the unit vector of the current of electrons will be parallel to planes of rotation of electrons, then the maximum of the process of explosion can be reached. And as the unit vector of the current of electrons will be normal to planes of rotation of electrons, then there will be no interaction at the zero velocity between electrons of the current and electrons of atoms, and thus, the process will not occur. But if the electronic current will form a strong enough magnetic field around itself, then atoms in the neighbourhood of the current will be oriented so that the unit vector of the current of electrons will be parallel to planes of rotation of electrons in atoms. Therefore, the strong enough current will establish conditions for the explosive destruction.

19 Decay of a neutron and neutron emission

There are three variants of decay of a neutron in PPST.

First variant of decay is realised when the electron and the proton in the neutron turn to the free state from the bound steady one while preserving initial parameters of motion (please refer to Chapter 10). In other words, when the proton and electron in the neutron begin their rotation around the mutual mass centre without changing the value of distance relatively one another, the decay of the neutron becomes possible while preserving initial parameters of motion, $\acute{E}_s$ and J_s (please refer to Chapters 10 and Chapter 16).

In a certain volume containing a certain number of free neutrons along with other particles there will exist a certain number of neutrons where the proton and the electron are in the bound steady state. The state of particles in the volume will permanently change while they are interacting with each other. And since there is no forbidden domain of distances between the bound steady, bound unsteady and free states of electron and proton in the neutron, and the bound steady state is the boundary one for both bound unsteady and free states, the electron and the proton of the neutron will turn from the bound steady state either to the free state or to the unsteady state at the minimum possible external action which would be able to force the electron and the proton of the neutron to leave the equilibrium state of the bound steady state.

The magnitude of relative velocity of scattering electron and proton in the first variant of decay of the neutron can be determined from the (50):

$$\left(\frac{dr_\infty}{dt}\right)^2 = a_{ep}^2 \log_b \left(b + b^{E_s}\right). \tag{475}$$

Proceeding from the (475), based on that the value of the distance between electron and proton in the neutron approaches zero, the magnitude of relative velocity of electron and proton in the neutron tends to a_{ep} from the side of plus-infinity whereas the value of E_s at that tends to the greater in modulus negative value (please refer to graphs of the E_s function at Figure 5 and Figure 6), we conclude that the magnitude of relative velocity of scattering electron and proton will tend to the neutral relative velocity of electron and proton from the side of plus-infinity.

According to terms of quantum mechanics, the decay of neutron to electron and proton according to the first variant will occur without emission and absorption of energy quanta and without changing of moment of momentum of particles of disintegrated neutron.

Second variant of decay of neutron is realised when due to external action the proton and the electron in the neutron decrease the value of magnitude of their relative velocity, and the value of magnitude of their relative velocity becomes less than the value of the neutral relative velocity of electron and proton. In this case proton and electron repel and become free. The relative velocity of their scattering tends at that to the neutral relative velocity of electron and proton from the side of zero. The decay of neutron to electron and proton according to the second variant will occur while the initial conditions of motion are changing.

Third variant of decay of neutron is realised in the case when due to external action the proton and the electron in the neutron turn to the free state and the initial condition of motion are changing, at that the value of magnitude of their relative velocity remains greater than the value of the neutral relative velocity of electron and proton.

All three variants of decay of neutron can be realised in the nucleus of atom. The decay of neutron according to the first variant in the nucleus should not differ from its decay according to the first variant in the free state since all conditions for that variant remain in the nucleus of atom. The number of proton in the nucleus of atom is greater than that of electrons. Protons and neutrons in the nucleus are located close to one another. The value of magnitude of velocity of the free electron according to the (475) during the decay of neutron under the first variant matches the values of velocities of electron in the neutron. The lack of beta radioactivity of stable nuclei is an ascertained fact. Thus, distances between protons and neutrons in stable nuclei should be so that an electron leaving a proton during the decay of a neutron immediately binds a neighbour proton, forming a new neutron. As follows from that, the decay of neutron in the nucleus according to the first variant with emission of electron from the nucleus should occur either while distances between protons and neutrons in the nucleus increase or in the nucleus where the number of protons is less than the number of neutrons. The lack of a pair proton for the free electron formed due to the decay of the first neutron with which proton it should form the second neutron after the first one disintegrates can result to emission of electron from the nucleus. At that, the velocity of electron relatively to protons of the nucleus, according to the (475), will tend to the neutral relative velocity of electron and proton from the side of plus-infinity. Therefore, the existence of a stable dineutron (which should consist of two neutrons) is impossible in PPST, whereas the existence of a stable deuteron (consists of a proton and a neutron) is possible. This mechanism can determine the beta decay of tritium (its nucleus consists of a proton and two neutrons).

The decay of neutron according to the second variant can result to the emission of electron from the nucleus. The electron and the proton of the neutron in the nucleus can decrease the value of their relative velocity, at that the electron and the proton of the neutron should turn to the free state with the relative velocity less than a_{ep}. If in this case the velocity of electron relatively to protons of the nucleus will also be less than a_{ep}, then protons of the nucleus will repel the electron of disintegrated neutron, and the electron will be able to leave the nucleus with the velocity relatively to protons of the nucleus less than the neutral relative velocity of electron and proton.

The beta decay of the nucleus can also occur under the third variant of decay of a neutron in the nucleus. According to the third variant, if the velocity of electron of a neutron disintegrated in the nucleus relatively to protons of the nucleus will not tend to the neutral relative velocity of electron and proton from the side of plus-infinity as it occurs in the first variant of decay, then the electron should acquire a high velocity in order to overcome the attraction of protons – the higher is the velocity of electron, the stronger is the attraction of it by protons of the nucleus.

A neutron emission (i.e., emission of a single neutron from the nucleus) can occur during the transition of electron and proton in the neutron from the bound steady state to unsteady (please refer to Chapter 10). As it is shown at Figure 24, using the (50), the following graphs were plotted: f_1 (476) which is a dependence of dimensionless function of magnitude of radial relative velocity of electron and proton in the neutron, and f_2 (477) which is a dependence of dimensionless function of magnitude of relative velocity of electron and proton in the neutron on R, with $V_s = 1.15$ and $b = 2$:

$$f_1 = \frac{1}{a_{ep}}\left|\frac{dr}{dt}\right| = \left(\log_b\left(b + b^{\left(E_s+\frac{2}{R}\right)}\right) - \frac{J_s^2}{R^2}\right)^{1/2}, \quad R \geq R_{05}, \tag{476}$$

$$f_2 = \frac{v}{a_{ep}} = \left(\log_b\left(b + b^{\left(E_s+\frac{2}{R}\right)}\right)\right)^{1/2}, \quad R \geq R_{05}. \tag{477}$$

In the (476) and (477) R_{05} is the minimum value of R, at which $dr/dt = 0$.

Given graphs (Figure 24) demonstrate that during the transition of electron and proton of the neutron from the bound steady state to the bound unsteady and back while preserving initial conditions of motion, the short-time increase of the magnitude of their relative velocity occurs. The f_2 function which determines this magnitude is changing from V_s to V_{max} as R is changing from R_s to R_{05}, then from V_{max} to V_s as R is changing from R_{05} to R_s. At that, the less is the value of R_{05} the greater is the value of V_{max}. If during this process the magnitude of velocity of proton of the neutron relatively protons of the nucleus becomes greater than the neutral relative velocity of protons and the magnitude of velocity of electron of the neutron relatively to electrons of the nucleus becomes greater than the neutral relative velocity of electrons, then the proton of the neutron will repel from protons of the nucleus and the electron of the neutron will repel

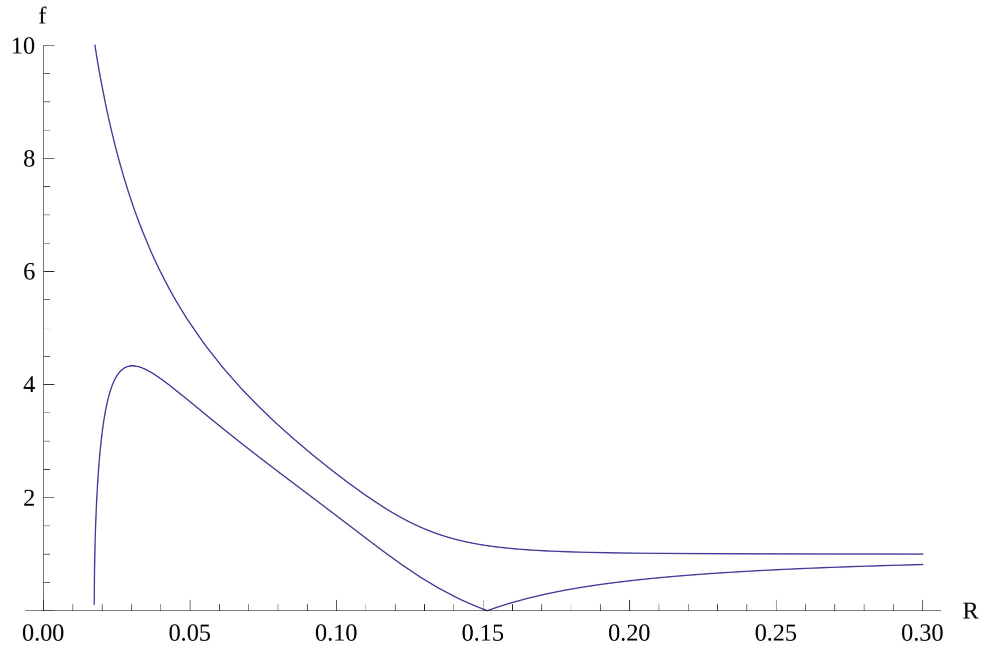

Figure 24: Graph of the change of dimensionless function of magnitude of relative velocity f_2 (the upper curve) and graph of the change of dimensionless function of magnitude of radial relative velocity f_1 (the lower curve) of electron and proton in the neutron depending on the change of R, with $b = 2$ and $V_s = 1.15$.

from electrons of the nucleus, and attraction of the neutron by the nucleus will weaken. At that, if the force of inertia acting on the neutron in the nucleus becomes greater than attraction forces of the neutron by the nucleus, then the neutron will be able to leave the nucleus.

20 Correspondence of ranges of magnitudes of particles' velocities in PPST to ranges of radiation

Figure 25 shows the following graphs: f_1 (476) which is a dependence of dimensionless function of magnitude of radial relative velocity of electron and proton in the neutron, and f_2 (477) which is a dependence of dimensionless function of magnitude of relative velocity of electron and proton in the neutron on R, with $V_s = 1.002$ and $b = 200$. These graphs allow for conclusion that during the transition of electron and proton from the bound steady state to the unsteady state at the longer section of trajectory almost all the value of magnitude of relative velocity of electron and proton can be concentrated in the radial relative velocity of particles when the proton and electron of the neutron begin to move along trajectories similar to elliptical with the greater value of eccentricity close to one (please refer to Chapter 12). Particles move along the most of such elliptical trajectory with lesser curvature of the motion trajectory. Therefore, during the transition into the unsteady state the neutron can be easily represented as two particle beams: the first beam consists of one electron, the second beam consists of one proton, and they move in the different directions with a certain relative acceleration within a certain time period. Interaction at the zero velocity between such particle beams has been considered

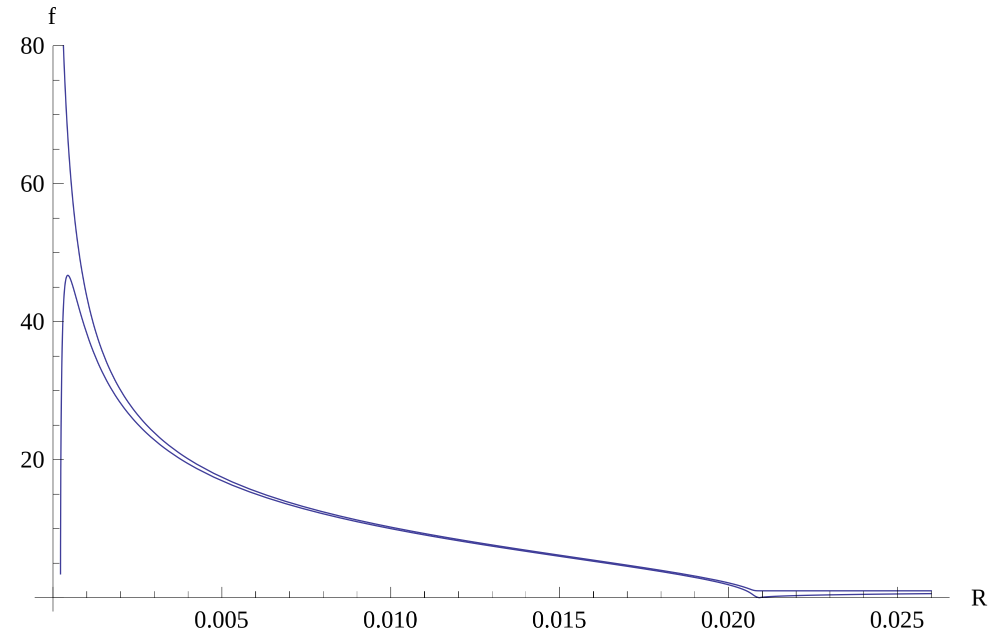

Figure 25: Graph of the change of dimensionless function of magnitude of relative velocity f_2 (the upper curve) and graph of the change of dimensionless function of magnitude of radial relative velocity f_1 (the lower curve) of electron and proton in the neutron depending on the change of R, with $b = 200$ and $V_s = 1.002$.

in Chapter 18. As follows from that, during the transition of proton and electron of the neutron from the bound steady state to the unsteady some acts of interaction between particles of the neutron and particles surrounding the nucleus of atom at the zero velocity can occur, since at this time, first, ranges of values of magnitudes of velocities of electron and proton relatively to surrounding particles will expand to the side of maximum values; second, the curvature of trajectories of their motion will become less at the distant sections of these trajectories. These acts of interaction will be similar to the process of observation of bursts of radiation of atoms. As follows from that, radiation can occur both at the neutron emission and at the decay of a neutron through the unsteady state of electron and proton, i.e., during the sequential change of the states of electron and proton in the neutron: bound steady – unsteady – free.

X-ray impulses during the neutron emission from the nucleus of atom [18] and, probably the gamma radiation as well can be related to the interaction at the zero velocity of electron of the neutron with other particles, when electron in the neutron briefly increases the magnitude of its velocity and straightens the trajectory of its motion relatively to particles surrounding it. However, similar processes occur with the proton in the neutron simultaneously with it.

Correlation of gamma radiation to radio radiation, similarity of their forms and commonness of their source, lightning discharges (lightnings), have been determined experimentally [24]. Proceeding from this experimental fact, we can presume that the interaction of proton of the neutron with surrounding particles during the transition of electron and proton of the neutron from the bound steady state to the unsteady can be the cause of bursts of radio radiation in these cases. Therefore, during the lightning discharges three events correlating with one another can occur simultaneously: a burst of the neutron flow, a burst of gamma radiation and a burst of radio radiation. In other words, as the interaction between electron or proton of the neutron of the nucleus of atom at the zero velocity and the beam of electrons of the lightning discharge, velocities of which electrons coincide with the velocity of electron or proton in the neutron being in the bound steady state, turns the proton and the electron of the neutron into the bound unsteady state which, in turn, allows the neutron to leave the nucleus, with simultaneous interaction between electron and proton of the neutron being emitted from the nucleus at the zero velocity and particles surrounding the atom, the three events correlating with one another can occur: the neutron emission, the burst of gamma radiation and the burst of radio radiation.

As follows from presumption that the radio radiation during the neutron emission is the consequence of velocity of proton in the neutron and the gamma radiation is the consequence of velocity of electron in the neutron relatively to the receiver of radiation (the consequence of interaction between particles of the neutron and particles of receiver at the zero velocity), the range of values of magnitudes of particles' velocities relatively to mass centres of atoms as it was determined in the (464):

$$a_p/2 \leq v \leq a_{ep} + a_p/2, \tag{478}$$

should determine the range of radiation at which both sources and receivers of radiation are lacking, if we consider as those atoms and their nuclei in the unperturbed state at relative velocities of mass centres of atoms or their nuclei equal to zero (this determination does not include molecules formed by atoms since mass centres of atoms in a molecule can have different velocities). Probably this range includes the terahertz range with certain zones of regions of microwave and infrared ranges adjacent to it from the left and from the right, creation of sources and receivers of radiation in which requires the development of new technologies which would be different from traditional those applied in the radio and optical ranges. This range is called a terahertz gap since creation of powerful and compact sources and sensitive receivers of radiation is very complicated in this range [7].

If, in accordance to the (460):

$$a_e > 2a_{ep} + a_p,$$

then in a certain volume, within the range of magnitudes of velocities relatively the volume as determined as (478), there will be electrons slow relatively to one another and able to form the condensate. Then, if the presumption that the range of velocities (478) corresponds to the range of radiation which includes the terahertz range and regions of microwave and infrared ranges adjacent to it corresponds to the reality, then the electron condensate and electrons slow relatively to one another should radiate within this range, and observation of their states requires a special receiver of radiation since slow electrons radiating in this range do not interact at the zero velocity with atoms and nuclei of atoms being in the unperturbed state (those that do not interchange the energy quanta). That is why the electron condensate localised in the volume of atoms should vaporise either with the increase of the temperature of volume, or with the increase of the velocity of condensate flow relatively to individual atoms of the volume, or under the radiation of the range determined hereinabove acting on the condensate, when particles of the radiation source will interact at the zero velocity with electrons of the condensate.

Therefore, each range of magnitudes of velocities of particles in PPST will correspond to the certain range of radiation. In other words, if the magnitude of velocity of the particle relatively the receiver of radiation with which particles this particle can interact at the zero velocity will change from v_{min} to v_{max}, then the radiation which can be registered by the receiver while interacting with this particle will be determined by the range of wavelengths from l_{max} to l_{min}, where every value of wavelength will correspond to the certain value of magnitude of velocity of the particle relatively to the receiver of radiation. The highest value of wavelength within the range of wavelengths will correspond to the lowest value of magnitude of velocity within the range of magnitudes of velocities of the particle, and vice versa, the lowest value of wavelength will correspond to the highest value of magnitude of velocity. The theory of this phenomenon within the frame of PPST, the propagation of radiation within the volume of particles as the consequence of momenta interchanges between particles during the interaction at the zero velocity, is planned to be considered in the next study dedicated to the wave component of corpuscular-wave dualism.

21 Interaction between single particles and atoms or ions

Let us consider the interaction of an electron and a neutral atom (the number of positive charges in the atom is equal to that of negative charges). At that we determine that the distance between the electron and the mass centre of atom is much greater than the radius of atom. Proceeding from the (7), we obtain the following system of equations:

$$m_e \frac{d\vec{v}_e}{dt} = \frac{e^2}{r_{ec}^2} \sum_{n=1}^{N} \left(b^{\left(1-(\vec{v}_e-\vec{v}_{pn})^2/a_{ep}^2\right)} - b^{\left(1-(\vec{v}_e-\vec{v}_{en})^2/a_e^2\right)} \right) \hat{r}_{ec}, \tag{479}$$

$$N\left(m_e+m_p\right) \frac{d\vec{v}_c}{dt} = \frac{e^2}{r_{ce}^2} \sum_{n=1}^{N} \left(b^{\left(1-(\vec{v}_{pn}-\vec{v}_e)^2/a_{ep}^2\right)} - b^{\left(1-(\vec{v}_{en}-\vec{v}_e)^2/a_e^2\right)} \right) \hat{r}_{ce},$$

where:
N is the number of protons equal to the number of electrons in the atom,
$\vec{r}_e$ is the radius vector of position of the electron,
$\vec{r}_c$ is the radius vector of position of the mass centre of the atom,
$\vec{r}_{pn}$ is the radius vector of position of a proton No. n of the atom,
$\vec{r}_{e_n}$ is the radius vector of position of an electron No. n of the atom.

From the equations of (479) we obtain an equation of the motion of electron relatively the mass centre of the atom:

$$\frac{Mm_e}{(M+m_e)} \frac{d\vec{v}_{ec}}{dt} = \frac{Ne^2}{r_{ec}^2} \frac{1}{N} \sum_{n=1}^{N} \left(b^{\left(1-(\vec{v}_{ec}-\vec{v}_{pnc})^2/a_{ep}^2\right)} - b^{\left(1-(\vec{v}_{ec}-\vec{v}_{enc})^2/a_e^2\right)} \right) \hat{r}_{ec}, \tag{480}$$

where:
$M = N\left(m_e+m_p\right)$ is the mass of atom,
$\vec{v}_{ec}$ is the velocity of electron relatively to the mass centre of atom,
$\vec{v}_{pnc}$ is the velocity of a proton No. n relatively to the mass centre of atom,
$\vec{v}_{enc}$ is the velocity of an electron No. n relatively to the mass centre of atom.

We emphasise from the (480) the Q_{ec} function which determines the sign of forces acting between the electron and the neutral atom:

$$Q_{ec} = \frac{1}{N} \sum_{n=1}^{N} \left(b^{\left(1-(\vec{v}_{ec}-\vec{v}_{pnc})^2/a_{ep}^2\right)} - b^{\left(1-(\vec{v}_{ec}-\vec{v}_{enc})^2/a_{e}^2\right)} \right). \tag{481}$$

Let us write down the Q_{ec} function (481) for interaction of electron and atom of hydrogen:

$$Q_{ec} = b^{\left(1-\left(\vec{v}_{ec}-\vec{v}_{p_1c}\right)^2/a_{ep}^2\right)} - b^{\left(1-\left(\vec{v}_{ec}-\vec{v}_{e_1c}\right)^2/a_{e}^2\right)}, \tag{482}$$

where $\vec{v}_{ec}$ is the velocity of electron interacting with the atom relatively to the mass centre of the atom of hydrogen, and $\vec{v}_{e_1c}$ and $\vec{v}_{p_1c}$ are correspondingly the velocity of electron and the velocity of proton of the hydrogen atom relatively the mass centre of the atom.

Let us determine inequalities at which in the (482) $Q_{ec} > 0$:

$$\frac{v_{p_1c} + v_{ec}}{a_{ep}} < \frac{v_{e_1c} - v_{ec}}{a_e}, \quad v_{e_1c} > v_{ec}. \tag{483}$$

As follows from the (483), considering that $m_p v_{p_1c} = m_e v_{e_1c}$ if:

$$v_{ec} < v_{e_1c} \frac{m_p a_{ep} - m_e a_e}{m_p (a_e + a_{ep})}, \tag{484}$$

then the atom of hydrogen at the distance much longer than the distance between proton and electron in the atom of hydrogen will repel the electron interacting with the atom. As follows from the (483) and (482), while the magnitude of relative velocity of electron and mass centre of the hydrogen atom decreases to zero, the magnitude of repulsion forces between them will increase. From the (484) we obtain an additional limitation for neutral relative velocities of particles:

$$m_p a_{ep} > m_e a_e. \tag{485}$$

Let us determine inequalities at which in the (482) $Q_{ec} < 0$:

$$\frac{v_{ec} - v_{p_1c}}{a_{ep}} > \frac{v_{ec} + v_{e_1c}}{a_e}, \quad v_{ec} > v_{p_1c}. \tag{486}$$

As follows from the (486), considering that $m_p v_{p_1c} = m_e v_{e_1c}$, if:

$$v_{ec} > v_{e_1c} \frac{m_p a_{ep} + m_e a_e}{m_p (a_e - a_{ep})}, \tag{487}$$

then the atom of hydrogen at the distance much longer than the distance between proton and electron in the atom of hydrogen will attract the electron interacting with the atom.

With $v_{ec} >> v_{e_1c}$, considering that the velocity of proton in the atom of hydrogen relatively to the mass centre of atom is less than the velocity of electron relatively to the mass centre of atom, the Q_{ec} (482) function will have the following form:

$$Q_{ec} = b^{\left(1-v_{ec}^2/a_{ep}^2\right)} - b^{\left(1-v_{ec}^2/a_e^2\right)}. \tag{488}$$

As follows from the (430), $a_{ep} < a_e$. Thus, from the (488) we conclude:

$$v_{ec} >> v_{e_1c}, \quad Q_{ec} < 0. \tag{489}$$

Therefore, if the velocity of electron relatively to the mass centre of the hydrogen atom is much greater than the velocity of electron in the atom of hydrogen, then the electron and the atom of hydrogen attract one another. As also follows from the (488), with the further increase of relative velocity of the electron and the mass centre of atom of hydrogen the magnitude of attraction forces between the electron and the atom of hydrogen will tend to zero.

Based on the (484), (487) and (489), we can conclude that, considering all conditions determined for the (484), (487) and (489):

1. With the magnitude of relative velocity of the electron and the mass centre of the atom of hydrogen satisfying the conditions of (484):

$$v_{ec} < v_{e_1c}\frac{m_p a_{ep} - m_e a_e}{m_p(a_e + a_{ep})},$$

the electron and the atom of hydrogen being at the distance much longer than the radius of hydrogen atom will repel. If the magnitude of relative velocity of the electron and the mass centre of the atom of hydrogen decreases to zero, then the magnitude of repulsion forces between the electron and the atom of hydrogen will tend to a certain maximum value.

2. With the magnitude of relative velocity of the electron and the mass centre of the atom of hydrogen satisfying the conditions of (487):

$$v_{ec} > v_{e_1c}\frac{m_p a_{ep} + m_e a_e}{m_p(a_e - a_{ep})},$$

the electron and the atom of hydrogen being at the distance much longer than the radius of hydrogen atom will attract.

3. During the interaction between the electron and the mass centre of the atom of hydrogen at the distance much longer than the radius of hydrogen atom, within the range of magnitude of relative velocity of the electron and the mass centre of the atom of hydrogen:

$$v_{e_1c}\frac{m_p a_{ep} - m_e a_e}{m_p(a_e + a_{ep})} \le v_{ec} \le v_{e_1c}\frac{m_p a_{ep} + m_e a_e}{m_p(a_e - a_{ep})}, \qquad (490)$$

there will exist the values at which the magnitude of force acting between them will equal to zero. At a certain value of magnitude of relative velocity of the electron and the mass centre of the atom of hydrogen less than these values the electron and the hydrogen atom will repel whereas at this value greater than those they will attract.

4. With the magnitude of relative velocity of the electron and the mass centre of the atom of hydrogen satisfying the conditions of (489):

$$v_{ec} >> v_{e_1c},$$

the electron and the atom of hydrogen will attract and the magnitude of forces acting between them will tend to zero.

Let us consider the interaction between an electron and a neutral atom. For Q_{ec} (481) we obtain conditions at which satisfaction $Q_{ec} > 0$:

$$\frac{v_{p_nc} + v_{ec}}{a_{ep}} < \frac{v_{e_nc} - v_{ec}}{a_e}, \quad v_{e_nc} > v_{ec}, \quad n = 1, 2, .., N. \qquad (491)$$

Taking into account that in the (491) $v_{p_nc} < a_p/2$ and $v_{e_nc} > a_{ep} + a_p/2$ (please refer to Chapter 17), we can rewrite conditions of (491) as follows:

$$\frac{a_p/2 + v_{ec}}{a_{ep}} < \frac{a_{ep} + a_p/2 - v_{ec}}{a_e}, \quad v_{ec} < a_{ep} + a_p/2. \tag{492}$$

After transformation of the (492) we come to the following conditions:

$$v_{ec} < \frac{a_{ep}^2 - a_p(a_e - a_{ep})/2}{a_e + a_{ep}}, \quad Q_{ec} > 0, \tag{493}$$

from which we get an additional limitation for the values of neutral relative velocities of particles:

$$a_p < \frac{2a_{ep}^2}{a_e - a_{ep}}. \tag{494}$$

Thus, at the conditions of (493) and (494) the electron and the neutral atom will repel. As also follows from the (492), as the relative velocity of the electron and the mass centre of atom decreases to zero, repulsion forces between them will increase to a certain maximum value.

For Q_{ec} (481) we obtain conditions at which $Q_{ec} < 0$:

$$\frac{v_{ec} - v_{p_nc}}{a_{ep}} > \frac{v_{ec} + v_{e_nc}}{a_e}, \quad v_{ec} > v_{p_nc}, \quad n = 1, 2, .., N. \tag{495}$$

Considering that $v_{p_nc} < a_p/2$ (please refer to Chapter 17), we will have from the (495):

$$v_{ec} > \frac{v_{e_nc}a_{ep} + a_pa_e/2}{a_e - a_{ep}}, \quad n = 1, 2, .., N. \tag{496}$$

If we determine that v_{e_mc} is the maximum magnitude of velocity of electrons in the atom relatively to the mass centre of atom, then the following arises from the (496):

$$v_{ec} > \frac{v_{e_mc}a_{ep} + a_pa_e/2}{a_e - a_{ep}}, \quad Q_{ec} < 0. \tag{497}$$

Thus, at the conditions of (497) the electron and the neutral atom will attract.

Let us consider the interaction between an electron and a neutral atom at $v_{ec} >> v_{e_mc}$. In this case, considering that magnitudes of velocities of protons in atoms are less than magnitudes of velocities of electrons, the following is obtained from the (481):

$$Q_{ec} = b^{\left(1 - v_{ec}^2/a_{ep}^2\right)} - b^{\left(1 - v_{ec}^2/a_e^2\right)}. \tag{498}$$

According to the (460) and (498), we can write down the following inequalities:

$$v_{ec} >> v_{e_mc}, \quad a_e > 2a_{ep} + a_p, \quad Q_{ec} < 0. \tag{499}$$

Therefore, the electron and the neutral atom with the magnitude of relative velocity of the electron and the mass centre of the atom greater than the maximum magnitude of velocity of electrons in the atom relatively to the mass centre of the atom will attract. As also follows from the (498), with the further increase of relative velocity of the electron and the mass centre of the neutral atom, attraction forces between the electron and the neutral atom will tend to zero.

Based on the (493), (497) and (499), considering all conditions determined for the (493), (497) and (499), we can conclude the following:

1. If the magnitude of relative velocity of the electron and the mass centre of the neutral atom satisfies to conditions of (493):

$$v_{ec} < \frac{a_{ep}^2 - a_p(a_e - a_{ep})/2}{a_e + a_{ep}},$$

then the electron and the neutral atom being at the distance much longer than the radius of neutral atom will repel. As the magnitude of relative velocity of the electron and the mass centre of neutral atom decreases to zero, the magnitude of repulsion forces between the electron and the neutral atom will tend to a certain maximum value.

2. If the magnitude of relative velocity of the electron and the mass centre of the neutral atom satisfies to conditions of (497):

$$v_{ec} > \frac{v_{emc} a_{ep} + a_p a_e/2}{a_e - a_{ep}},$$

then the electron and the neutral atom being at the distance much longer than the radius of neutral atom will attract.

3. During the interaction between the electron and the mass centre of the neutral atom at the distance much longer than the radius of atom, within the range of magnitude of relative velocity of the electron and the mass centre of the neutral atom:

$$\frac{a_{ep}^2 - a_p(a_e - a_{ep})/2}{a_e + a_{ep}} \leq v_{ec} \leq \frac{v_{emc} a_{ep} + a_p a_e/2}{a_e - a_{ep}}, \tag{500}$$

there will exist the values at which the magnitude of force acting between them will equal to zero. At a certain value of magnitude of relative velocity of the electron and the mass centre of the neutral atom less than these values the electron and the neutral atom will repel whereas at this value greater than those they will attract.

4. With the magnitude of relative velocity of the electron and the mass centre of the neutral atom satisfying the conditions of (499):

$$v_{ec} >> v_{emc},$$

the magnitude of forces acting between them will tend to zero from the side of minus-infinity.

If we presume that the Ramsauer effect (i.e., the phenomenon of anomalously faint scattering of slow electrons by atoms of noble gases) is determined by interaction of electron and neutral atom as described hereinabove, then the deep minimum of scattering of electrons can be a consequence of magnitudes of forces, which values are close to zero, acting between electrons and atoms relatively to which electrons are moving with the certain magnitudes of velocities. Electrons with higher magnitudes of velocities will scatter under the attraction to atoms. Electrons with lower magnitudes of velocities will scatter under the repulsion from atoms.

Let us consider the interaction between an electron and a positively charged ion with the $+Ze$ charge, at the distance much longer than the radius of ion. Proceeding from the system of equations (7), for this case we will obtain the following:

$$m_e \frac{d\vec{v}_e}{dt} = \frac{e^2}{r_{ec}^2} \sum_{n=1}^{N} \left(b^{\left(1-(\vec{v}_e-\vec{v}_{pn})^2/a_{ep}^2\right)} - b^{\left(1-(\vec{v}_e-\vec{v}_{en})^2/a_e^2\right)} \right) \hat{r}_{ec} -$$

$$- \frac{e^2}{r_{ec}^2} \left(Z - \sum_{z=1}^{Z} b^{\left(1-(\vec{v}_e-\vec{v}_{pz})^2/a_{ep}^2\right)} \right) \hat{r}_{ec}, \quad (501)$$

$$\left((N+Z)\, m_p + N m_e\right) \frac{d\vec{v}_c}{dt} = \frac{e^2}{r_{ce}^2} \sum_{n=1}^{N} \left(b^{\left(1-(\vec{v}_{pn}-\vec{v}_e)^2/a_{ep}^2\right)} - b^{\left(1-(\vec{v}_{en}-\vec{v}_e)^2/a_e^2\right)} \right) \hat{r}_{ce} -$$

$$- \frac{e^2}{r_{ce}^2} \left(Z - \sum_{z=1}^{Z} b^{\left(1-(\vec{v}_{pz}-\vec{v}_e)^2/a_{ep}^2\right)} \right) \hat{r}_{ce}, \quad (502)$$

where:
Z is the number of positive charges of ion.

We transform equations (501) and (502) into the equation of motion of electron relatively to the mass centre of ion:

$$\frac{M_i m_e}{(M_i + m_e)} \frac{d\vec{v}_{ec}}{dt} = \frac{N e^2}{r_{ec}^2} Q_{ei} \hat{r}_{ec}, \quad (503)$$

where $M_i = (N+Z)\, m_p + N m_e$ is the mass of ion, and Q_{ei} is determined by the expression:

$$\frac{1}{N} \sum_{n=1}^{N} \left(b^{\left(1-(\vec{v}_{ec}-\vec{v}_{pnc})^2/a_{ep}^2\right)} - b^{\left(1-(\vec{v}_{ec}-\vec{v}_{enc})^2/a_e^2\right)} \right) - \frac{Z}{N} + \frac{1}{N} \sum_{z=1}^{Z} b^{\left(1-(\vec{v}_{ec}-\vec{v}_{pzc})^2/a_{ep}^2\right)}. \quad (504)$$

From the (504) we obtain the system of inequalities upon fulfilment of which $Q_{ei} > 0$:

$$\frac{v_{pnc} + v_{ec}}{a_{ep}} < \frac{v_{enc} - v_{ec}}{a_e}, \quad v_{enc} > v_{ec}, \quad n = 1, 2, .., N, \quad (505)$$

$$\frac{v_{pzc} + v_{ec}}{a_{ep}} < 1, \quad z = 1, 2, .., Z. \quad (506)$$

Inequalities of (505) coincide with those of (491), and thus, it follows from the (505):

$$v_{ec} < \frac{a_{ep}^2 - a_p(a_e - a_{ep})/2}{a_e + a_{ep}}. \quad (507)$$

With $v_{pzc} < a_p/2$ (please refer to Chapter 17), from the (506) we can determine the following:

$$v_{ec} < a_{ep} - a_p/2. \quad (508)$$

The inequality (507) for v_{ec} is stricter than the inequality (508):

$$\frac{a_{ep}^2 - a_p(a_e - a_{ep})/2}{a_e + a_{ep}} < a_{ep} - a_p/2. \quad (509)$$

Thus, the conditions at which $Q_{ei} > 0$ will be those of (507). Therefore, with the values of magnitude of relative velocity of the electron and the mass centre of ion satisfying conditions of (507), the electron and the ion repel, and as their relative velocity decreases, the magnitude of repulsion forces between them will increase.

From the (504) we obtain the system of inequalities upon fulfilment of which $Q_{ei} < 0$:

$$\frac{v_{ec} - v_{p_n c}}{a_{ep}} > \frac{v_{ec} + v_{e_n c}}{a_e}, \quad v_{ec} > v_{p_n c}, \quad n = 1, 2, .., N, \tag{510}$$

$$\frac{v_{ec} - v_{p_z c}}{a_{ep}} > 1, \quad v_{ec} > v_{p_z c}, \quad z = 1, 2, .., Z. \tag{511}$$

Inequalities of (510) coincide with those of (495), and thus, it follows from the (510):

$$v_{ec} > \frac{v_{e_m c} a_{ep} + a_p a_e/2}{a_e - a_{ep}}, \tag{512}$$

where $v_{e_m c}$ is the maximum magnitude of velocity of electrons in the ion relatively to the mass centre of ion. Proceeding from (511), with $v_{p_z c} < a_p/2$ (please refer to Chapter 17), we can determine the following:

$$v_{ec} > a_{ep} + a_p/2. \tag{513}$$

We form an equality from the (513) and (512):

$$\frac{v_{e_m c} a_{ep} + a_p a_e/2}{a_e - a_{ep}} = a_{ep} + a_p/2, \tag{514}$$

from which we determine the following:

$$v_{e_m c} = a_e - a_{ep} - a_p/2. \tag{515}$$

From the (515), (513) and (512) arise the first system of inequalities:

$$v_{e_m c} \geq a_e - a_{ep} - a_p/2, \quad v_{ec} > \frac{v_{e_m c} a_{ep} + a_p a_e/2}{a_e - a_{ep}}, \quad Q_{ei} < 0, \tag{516}$$

and the second:

$$v_{e_m c} < a_e - a_{ep} - a_p/2, \quad v_{ec} > a_{ep} + a_p/2, \quad Q_{ei} < 0. \tag{517}$$

Therefore, with the values of magnitude of relative velocity of the electron and the mass centre of ion satisfying either conditions of (516) or conditions of (517), the electron and the ion attract.

If $v_{ec} >> v_{e_n c}$, with $n = 1, 2, .., N$ from the (504) we obtain the following:

$$Q_{ei} = b^{\left(1 - v_{ec}^2/a_{ep}^2\right)} - b^{\left(1 - v_{ec}^2/a_e^2\right)} - \frac{Z}{N}\left(1 - b^{\left(1 - v_{ec}^2/a_{ep}^2\right)}\right). \tag{518}$$

In the (518) $a_e > a_{ep}$, $v_{ec} > a_{ep}$, and thus:

$$b^{\left(1 - v_{ec}^2/a_{ep}^2\right)} < b^{\left(1 - v_{ec}^2/a_e^2\right)}, \quad 1 > b^{\left(1 - v_{ec}^2/a_{ep}^2\right)}. \tag{519}$$

From the (518) and (519) we conclude the following:

$$v_{ec} >> v_{emc}, \qquad Q_{ei} < 0. \tag{520}$$

Therefore, the electron and the ion with the magnitude of relative velocity of the electron and the mass centre of ion much greater than the maximum magnitude of velocity of electrons in ion will attract, and with the further increase of their relative velocity this attraction will be approximately described by the Coulomb law since in this case $Q_{ei} \to -Z/N$. And the (503) will look as follows:

$$\frac{M_i m_e}{(M_i + m_e)} \frac{d\vec{v}_{ec}}{dt} = -\frac{Ze^2}{r_{ec}^2} \hat{r}_{ec}.$$

From (507), (516), (517) and (520) we can conclude the following:

1. With the value of magnitude of relative velocity of the electron and the mass centre of ion satisfying conditions of (507):

$$v_{ec} < \frac{a_{ep}^2 - a_p(a_e - a_{ep})/2}{a_e + a_{ep}},$$

the electron and the ion being at the distance much longer than the radius of ion will repel, and as the magnitude of their relative velocity decreases to zero, the magnitude of repulsion forces between them will increase to the certain maximum value.

2. With the value of the maximum magnitude of velocity of electrons in the ion relatively the mass centre of ion (v_{emc}) and the value of magnitude of relative velocity of the electron and the mass centre of ion (v_{ec}) satisfying either conditions of (516):

$$v_{emc} \geq a_e - a_{ep} - a_p/2, \quad v_{ec} > \frac{v_{emc} a_{ep} + a_p a_e/2}{a_e - a_{ep}},$$

or conditions of (517):

$$v_{emc} < a_e - a_{ep} - a_p/2, \quad v_{ec} > a_{ep} + a_p/2,$$

the electron and the ion being at the distance much longer than the radius of ion will attract.

3. During the interaction of the electron and the ion being at the distance much longer than the radius of ion, either within the range of the value of magnitude of relative velocity of the electron and the mass centre of ion:

$$\frac{a_{ep}^2 - a_p(a_e - a_{ep})/2}{a_e + a_{ep}} \leq v_{ec} \leq \frac{v_{emc} a_{ep} + a_p a_e/2}{a_e - a_{ep}}, \tag{521}$$

at:

$$v_{emc} \geq a_e - a_{ep} - a_p/2,$$

or within the following range:

$$\frac{a_{ep}^2 - a_p(a_e - a_{ep})/2}{a_e + a_{ep}} \leq v_{ec} \leq a_{ep} + a_p/2, \tag{522}$$

at:

$$v_{e_m c} < a_e - a_{ep} - a_p/2,$$

there will exist the values at which the magnitude of force acting between them will equal to zero. With the certain value of magnitude of relative velocity of the electron and the mass centre of ion less than these values the electron and the ion will repel whereas at the value greater than these values they will attract.

4. With the value of magnitude of relative velocity of the electron and the mass centre of ion satisfying conditions of (520):

$$v_{ec} >> v_{e_m c},$$

the electron and the ion being at the distance much greater than the radius of ion will attract, and as the magnitude of their relative velocity increases, this attraction will be approximately described by the Coulomb law.

Let us consider the interaction of a proton and a neutral atom. At that we determine that the distance between the proton and the mass centre of atom is much greater than the radius of atom. Proceeding from the (7), we obtain the following system of equations:

$$m_p \frac{d\vec{v}_p}{dt} = \frac{e^2}{r_{pc}^2} \sum_{n=1}^{N} \left(b^{\left(1-(\vec{v}_p-\vec{v}_{en})^2/a_{ep}^2\right)} - b^{\left(1-(\vec{v}_p-\vec{v}_{pn})^2/a_p^2\right)} \right) \hat{r}_{pc}, \tag{523}$$

$$N\left(m_e+m_p\right) \frac{d\vec{v}_c}{dt} = \frac{e^2}{r_{cp}^2} \sum_{n=1}^{N} \left(b^{\left(1-(\vec{v}_p-\vec{v}_{en})^2/a_{ep}^2\right)} - b^{\left(1-(\vec{v}_p-\vec{v}_{pn})^2/a_p^2\right)} \right) \hat{r}_{cp},$$

where:
N is the number of protons equal to the number of electrons in the atom,
$\vec{r}_p$ is the radius vector of position of the proton,
$\vec{r}_c$ is the radius vector of position of the mass centre of the atom,
$\vec{r}_{p_n}$ is the radius vector of position of a proton No. n of the atom,
$\vec{r}_{e_n}$ is the radius vector of position of an electron No. n of the atom.

From the equations of (523) we obtain an equation of motion of the proton relatively the mass centre of the atom:

$$\frac{M m_p}{(M+m_p)} \frac{d\vec{v}_{pc}}{dt} = \frac{Ne^2}{r_{pc}^2} \frac{1}{N} \sum_{n=1}^{N} \left(b^{\left(1-(\vec{v}_{pc}-\vec{v}_{e_n c})^2/a_{ep}^2\right)} - b^{\left(1-(\vec{v}_{pc}-\vec{v}_{p_n c})^2/a_p^2\right)} \right) \hat{r}_{pc}, \tag{524}$$

where:
$M = N\left(m_e+m_p\right)$ is the mass of atom,
$\vec{v}_{pc}$ is the velocity of proton relatively to the mass centre of atom,
$\vec{v}_{p_n c}$ is the velocity of a proton No. n relatively to the mass centre of atom,
$\vec{v}_{e_n c}$ is the velocity of an electron No. n relatively to the mass centre of atom.

We emphasise from the (524) the Q_{pc} function which determines the sign of forces acting between the proton and the neutral atom:

$$Q_{pc} = \frac{1}{N} \sum_{n=1}^{N} \left(b^{\left(1-(\vec{v}_{pc}-\vec{v}_{e_n c})^2/a_{ep}^2\right)} - b^{\left(1-(\vec{v}_{pc}-\vec{v}_{p_n c})^2/a_p^2\right)} \right), \tag{525}$$

Proceeding from the (525), we determine conditions at which $Q_{pc} < 0$:

$$\frac{v_{e_n c} - v_{pc}}{a_{ep}} > \frac{v_{p_n c} + v_{pc}}{a_p}, \quad v_{e_n c} > v_{pc}, \quad n = 1, 2, .., N. \tag{526}$$

Considering that $v_{e_n c} > a_{ep} + a_p/2$ and $v_{p_n c} < a_p/2$ with $n = 1, 2, .., N$ (please refer to Chapter 17), we can rewrite the (526) as follows:

$$\frac{a_{ep} + a_p/2 - v_{pc}}{a_{ep}} > \frac{a_p/2 + v_{pc}}{a_p}, \tag{527}$$

and obtain from the (527):

$$v_{pc} < \frac{a_p}{2}, \quad Q_{pc} < 0. \tag{528}$$

Thus, at the conditions of (528) the neutral atom attracts the proton, and as follows from the (526), as the relative velocity of proton and mass centre of the neutral atom decreases to zero, the magnitude of attraction forces between them will tend to the maximum value.

Proceeding from the (525), we determine conditions at which $Q_{pc} > 0$:

$$\frac{v_{pc} - v_{p_n c}}{a_p} > \frac{v_{pc} + v_{e_n c}}{a_{ep}}, \quad v_{pc} > v_{p_n c}, \quad n = 1, 2, .., N. \tag{529}$$

Upon the condition that $v_{p_n c} < a_p/2$, we can rewrite the (529) as follows:

$$\frac{v_{pc} - a_p/2}{a_p} > \frac{v_{pc} + v_{e_n c}}{a_{ep}}, \quad v_{pc} > a_p/2, \quad n = 1, 2, .., N. \tag{530}$$

Being transformed, the (530) provides the following:

$$v_{pc} > a_p \frac{a_{ep}/2 + v_{e_n c}}{a_{ep} - a_p}, \quad n = 1, 2, .., N, \quad Q_{pc} > 0. \tag{531}$$

If we determine that $v_{e_m c}$ is the maximum magnitude of velocity of electrons in the atom relatively to the mass centre of the atom, then it follows from the (531):

$$v_{pc} > a_p \frac{a_{ep}/2 + v_{e_m c}}{a_{ep} - a_p}, \quad Q_{pc} > 0. \tag{532}$$

Thus, upon satisfying conditions of (532), the neutral atom and the proton repel. In case of $v_{pc} >> v_{e_m c}$, from the (525) we obtain the following:

$$Q_{ec} = b^{\left(1 - v_{pc}^2/a_{ep}^2\right)} - b^{\left(1 - v_{pc}^2/a_p^2\right)}. \tag{533}$$

From the (533), the following conditions arise:

$$v_{pc} >> v_{e_m c}, \quad a_p << a_{ep}, \quad Q_{pc} > 0, \tag{534}$$

and with the further increase of the magnitude of relative velocity of the proton and the mass centre of the atom, the Q_{pc} will tend to zero from the side of plus-infinity.

From (528), (532) and (534) we can conclude the following:

1. The proton and the neutral atom being at the distance much longer than the radius of atom, upon satisfying the condition (528):

$$v_{pc} < \frac{a_p}{2},$$

will attract. As the relative velocity of proton and mass centre of the neutral atom decreases to zero, the magnitude of attraction forces between them will tend to the maximum value.

2. The proton and the neutral atom being at the distance much longer than the radius of atom, upon satisfying the condition (532):

$$v_{pc} > a_p \frac{a_{ep}/2 + v_{e_m c}}{a_{ep} - a_p},$$

will repel.

3. During the interaction of the proton and the neutral atom being at the distance much longer than the radius of atom, within the range of the value of magnitude of relative velocities of the proton and the mass centre of the neutral atom:

$$\frac{a_p}{2} \leq v_{pc} \leq a_p \frac{a_{ep}/2 + v_{e_m c}}{a_{ep} - a_p}, \tag{535}$$

there will exist the values of magnitude of relative velocities of the proton and the mass centre of the neutral atom at which the magnitude of force acting between them will equal to zero. With the certain value of magnitude of relative velocity of the proton and the mass centre of the neutral atom less than these values the proton and the neutral atom will attract whereas at the value greater than these values they will repel.

4. Upon the condition of (534):

$$v_{pc} >> v_{e_m c},$$

the magnitude of the repulsion force between the proton and the neutral atom will tend to zero from the side of plus-infinity.

Let us consider the interaction between a proton and a positively charged ion with the $+Ze$ charge, at the distance much longer than the radius of ion. Proceeding from the system of equations (7), for this case we will obtain the following:

$$m_p \frac{d\vec{v}_p}{dt} = \frac{e^2}{r_{pc}^2} \sum_{n=1}^{N} \left(b^{\left(1-(\vec{v}_p-\vec{v}_{e_n})^2/a_{ep}^2\right)} - b^{\left(1-(\vec{v}_p-\vec{v}_{p_n})^2/a_p^2\right)} \right) \hat{r}_{pc} +$$

$$+ \frac{e^2}{r_{pc}^2} \left(Z - \sum_{z=1}^{Z} b^{\left(1-(\vec{v}_p-\vec{v}_{p_z})^2/a_p^2\right)} \right) \hat{r}_{pc}, \tag{536}$$

$$((N+Z)\, m_p + N m_e) \frac{d\vec{v}_c}{dt} = \frac{e^2}{r_{cp}^2} \sum_{n=1}^{N} \left(b^{\left(1-(\vec{v}_{e_n}-\vec{v}_p)^2/a_{ep}^2\right)} - b^{\left(1-(\vec{v}_{p_n}-\vec{v}_p)^2/a_p^2\right)} \right) \hat{r}_{cp} +$$

$$+ \frac{e^2}{r_{cp}^2} \left(Z - \sum_{z=1}^{Z} b^{\left(1-(\vec{v}_{p_z}-\vec{v}_p)^2/a_p^2\right)} \right) \hat{r}_{cp}, \tag{537}$$

where:
Z is the number of positive charges of ion.

We transform equations (536) and (537) into the equation of motion of proton relatively to the mass centre of ion:

$$\frac{M_i m_p}{(M_i + m_p)} \frac{d\vec{v}_{pc}}{dt} = \frac{Ne^2}{r_{pc}^2} Q_{pi} \hat{r}_{pc}, \tag{538}$$

where $M_i = (N + Z)\, m_p + N m_e$ is the mass of ion, and Q_{pi} is determined by the expression:

$$\frac{1}{N} \sum_{n=1}^{N} \left(b^{\left(1-(\vec{v}_{pc}-\vec{v}_{e_n c})^2/a_{ep}^2\right)} - b^{\left(1-(\vec{v}_{pc}-\vec{v}_{p_n c})^2/a_p^2\right)} \right) + \frac{Z}{N} - \frac{1}{N} \sum_{z=1}^{Z} b^{\left(1-(\vec{v}_{pc}-\vec{v}_{p_z c})^2/a_p^2\right)}. \tag{539}$$

From the (539) we obtain the system of inequalities upon fulfilment of which $Q_{pi} < 0$:

$$\frac{v_{e_n c} - v_{pc}}{a_{ep}} > \frac{v_{p_n c} + v_{pc}}{a_p}, \quad v_{e_n c} > v_{pc}, \quad n = 1, 2, .., N, \tag{540}$$

$$\frac{v_{p_z c} + v_{pc}}{a_p} < 1, \quad z = 1, 2, .., Z. \tag{541}$$

Inequalities of (540) coincide with those of (526), and thus, it follows from the (540):

$$v_{pc} < \frac{a_p}{2}, \quad Q_{pc} < 0, \tag{542}$$

Taking into account that in the (541) $v_{p_z c} < a_p/2$ (please refer to Chapter 17), from the (541) we obtain the following:

$$v_{pc} < \frac{a_p}{2}, \quad Q_{pc} < 0. \tag{543}$$

Therefore, at $v_{pc} < a_p/2$ the proton and the ion being at the distance much longer than the radius of ion will attract. And as the magnitude of relative velocity of the proton and the mass centre of ion approaches zero, the magnitude of force acting between them will tend to the certain maximum value.

Further on, from the (539) we obtain the system of inequalities upon fulfilment of which $Q_{pi} > 0$:

$$\frac{v_{pc} + v_{e_n c}}{a_{ep}} < \frac{v_{pc} - v_{p_n c}}{a_p}, \quad v_{pc} > v_{p_n c}, \quad n = 1, 2, .., N, \tag{544}$$

$$\frac{v_{pc} - v_{p_z c}}{a_p} > 1, \quad z = 1, 2, .., Z. \tag{545}$$

Proceeding from the (544) and (545), upon the conditions of $v_{p_n c} < a_p/2$ and $v_{p_z c} < a_p/2$, we have the following:

$$v_{pc} > a_p \frac{a_{ep}/2 + v_{e_n c}}{a_{ep} - a_p}, \quad n = 1, 2, .., N, \tag{546}$$

$$v_{pc} > 3\frac{a_p}{2}. \tag{547}$$

If v_{e_mc} is the maximum magnitude of velocity of electrons in the ion, then we can rewrite the (546) as follows:

$$v_{pc} > a_p \frac{a_{ep}/2 + v_{e_mc}}{a_{ep} - a_p}. \tag{548}$$

From the condition of $v_{e_mc} > a_{ep} + a_p/2$ (462) arises the following:

$$a_p \frac{a_{ep}/2 + v_{e_mc}}{a_{ep} - a_p} > \frac{3}{2} a_p, \tag{549}$$

and from the (549), (548) and (547) the following:

$$v_{pc} > a_p \frac{a_{ep}/2 + v_{e_mc}}{a_{ep} - a_p}, \quad Q_{pi} > 0. \tag{550}$$

Thus, upon conditions of (550), the proton and the ion being at the distance much longer than the radius of ion repel.

Let us consider the (539) at $v_{pc} >> v_{e_mc}$:

$$Q_{pi} = \frac{1}{N} \sum_{n=1}^{N} \left(b^{\left(1 - v_{pc}^2/a_{ep}^2\right)} - b^{\left(1 - v_{pc}^2/a_p^2\right)} \right) + \frac{Z}{N} - \frac{1}{N} \sum_{z=1}^{Z} b^{\left(1 - v_{pc}^2/a_p^2\right)}. \tag{551}$$

In the (551) $v_{pc} >> a_{ep}$, and $a_{ep} >> a_p$, and thus:

$$b^{\left(1 - v_{pc}^2/a_{ep}^2\right)} > b^{\left(1 - v_{pc}^2/a_p^2\right)}, \quad b^{\left(1 - v_{pc}^2/a_p^2\right)} < 1. \tag{552}$$

Therefore, as follows from the (552) and (551):

$$v_{pc} >> v_{e_mc}, \quad Q_{pi} > 0. \tag{553}$$

Under the conditions of (553) the proton and the ion being at the distance much longer than the radius of ion repel, and with the further increase of relative velocity of the proton and the mass centre of ion, repulsion forces acting between them will be approximately described by the Coulomb law since in this case $Q_{pi} \to Z/N$. And the (538) will look as follows:

$$\frac{M_i m_p}{(M_i + m_p)} \frac{d\vec{v}_{pc}}{dt} = \frac{Ze^2}{r_{pc}^2} \hat{r}_{pc}.$$

From (543), (550) and (553) we can conclude the following:

1. The proton and the ion being at the distance much longer than the radius of ion, upon the condition of (543):

$$v_{pc} < \frac{a_p}{2},$$

will attract. As the magnitude of relative velocity of the proton and the mass centre of ion decreases to zero, the magnitude of attraction force between them will tend to the maximum value.

2. The proton and the ion being at the distance much longer than the radius of ion and upon the condition of (550):

$$v_{pc} > a_p \frac{a_{ep}/2 + v_{e_mc}}{a_{ep} - a_p},$$

will repel.

3. During the interaction of the proton and the ion being at the distance much longer than the radius of ion, within the range of values of magnitudes of relative velocities of the proton and the mass centre of ion:

$$\frac{a_p}{2} \leq v_{pc} \leq a_p \frac{a_{ep}/2 + v_{e_m c}}{a_{ep} - a_p}, \tag{554}$$

there will exist the values of magnitudes of relative velocities of the proton and the mass centre of ion at which the magnitude of force acting between them will equal to zero. With the certain value of magnitude of relative velocity of the proton and the mass centre of ion less than these values the proton and the ion will attract whereas at the value greater than these values they will repel.

4. Upon the condition of (553):

$$v_{pc} >> v_{e_m c},$$

the repulsion forces between the proton and the ion being at the distance much longer than the radius of ion will be approximately described by the Coulomb law.

As follows from the conclusions made for the interaction of both electron and proton with the neutral atom and positively charged ion, all these interactions have the ranges of relative velocities within which the electron or the proton and the neutral atom, the electron or the proton and the ion attract, repel and do not interact. The difference of these interaction, first, is so that the magnitude of interaction forces of electron or proton with the neutral atom is less than the magnitude of forces of their interaction with ion; second, as the value of magnitude of relative velocity of electron or proton and the neutral atom increases to the certain value, the magnitude of force acting between them tends to zero, whereas while the value of magnitude of relative velocity of electron or proton and the ion increases to the certain value, their interaction can be approximately described by the Coulomb law.

Conclusions of this chapter allow for making three presumptions:

1. A separated volume of electrons which electrons have the maximum magnitudes of velocities relatively to the mass centre of volume less than the certain value should possess the effect of attenuation of gravitational interaction with the volume of neutral atoms at the distance much longer than the maximum radius of volumes.

2. A separated volume of protons which protons have the minimum magnitudes of velocities relatively to the mass centre of volume greater than the certain value should possess the effect of attenuation of gravitational interaction with the volume of neutral atoms at the distance much longer than the maximum radius of volumes.

3. Effects of attenuation of gravitational interaction should depend on the magnitude of velocity of the mass centre of the volume of like particles relatively to the mass centre of the volume of neutral atoms and on the magnitudes of velocities of motion of neutral atoms in the volume.

22 Thermo-electrical phenomena

If there is a temperature gradient in the volume of neutral atoms, then, according to PPST, at certain conditions there will exist an electromotive force acting on free charged particles in this volume. It follows from conclusions of consideration of interaction of both single electron and single proton with the neutral atom in Chapter 21. These conclusions can be applied to the qualitative description of such thermo-electrical phenomena as the Seebeck effect, the Peltier effect, the Thomson effect and inversion of thermo-current according to the Avenarius law.

Let us consider the force acting on a free charged particle located at the boundary of contact of two equal volumes of neutral atoms: atoms in the volumes are the same and are in the same conditions, volumes are equal and densities of atoms in all points of volumes are also equal. In this case the magnitude of resulting force acting on the free charged particle from all atoms of volumes will equal to zero. If the temperature of the first volume starts to increase whereas in the second volume it remains unchanged, then, according to conclusions of the previous chapter, with the increase of relative velocities of mass centres of atoms in the first volume relatively the free charged particle, the magnitude of force acting on this particle will change, whereas the magnitude of force acting from atoms of the second volume will remain the same. Let us call the first volume where the temperature increases hot, and the second where the temperature does not change cold.

Let us consider the force acting on an electron located at the boundary of contact of two equal volumes of neutral atoms determined hereinabove. If the initial temperature of volumes is so that the magnitudes of velocities of the electron relatively to mass centres of atoms of volumes satisfy conditions of (493):

$$v_{ec} < \frac{a_{ep}^2 - a_p(a_e - a_{ep})/2}{a_e + a_{ep}}, \tag{555}$$

where v_{ec} are the magnitudes of velocities of the electron relatively to mass centres of atoms of volumes, then both volumes will repel the electron with equal forces. As the temperature of the first volume rises, velocities of mass centres of atoms in it relatively to the electron will increase. Thus, the magnitude of repulsion force acting on the electron from the side of atoms of hot volume will decrease, and the resulting force acting on the electron will be directed from the cold volume to the hot. The cold volume will repel the electron stronger than the hot. Upon the further rise of temperature of hot volume, the magnitude of force acting on the electron from the side of hot volume will become equal to zero, and the electron will be affected by the repulsion force from the cold volume only. Further on, as the temperature rises, the hot volume will begin to attract the electron, and the electron will be affected by the attraction force from the hot volume and the repulsion force from the cold one. As the attraction force of the hot volume reaches the maximum, the resulting force acting on the electron will also possess the maximum value. With the further increase of the temperature, the magnitude of resulting force will start to decrease but the force will always act along the direction from the cold volume to the hot.

If the initial temperature of volumes will be so that the magnitudes of velocities of the electron relatively to mass centres of atoms of volumes satisfy the conditions of (497):

$$v_{ec} > \frac{v_{e_m c} a_{ep} + a_p a_e/2}{a_e - a_{ep}}, \tag{556}$$

where $v_{e_m c}$ is the maximum magnitude of velocity of electrons in atoms of volumes, then both volumes will attract the electron with equal forces, and the resulting force acting on the electron will equal to zero. As the temperature of the first volume rises, velocities of mass centres of atoms in it relatively to the electron will increase. If initial relative velocities of the electron and mass centres of atoms of volumes upon conditions of (556) will be so that the magnitudes of forces of attraction of the electron by volumes of atoms under the rise of temperatures of volumes will increase, then the magnitude of attraction force acting on the electron from the side of atoms of hot volume will increase, and the resulting force acting on the electron will be directed from the cold volume to the hot. The hot volume will attract the electron stronger than the cold. Upon the further rise of temperature of hot volume, the magnitude of force acting on the electron from the side of hot volume will reach the maximum, and the resulting force acting on the electron will also possess the maximum value. It will be the result of action of the constant attraction force of the cold volume and the maximum attraction force of the hot one. With the further increase of the temperature, the magnitude of force acting from the side of the hot volume will start to decrease, and once this force becomes equal in modulus to the attraction force acting from the side of cold volume, the resulting force acting on the electron will equal to zero. Further on, as the temperature rises, the force from the hot volume will decrease and the resulting force acting on the electron will change is direction to the opposite. The cold volume will attract the electron stronger than the hot. The electron will be affected by the force acting along the direction from the hot volume to the cold.

Let us consider the force acting on a proton located at the boundary of contact of two equal volumes of neutral atoms determined hereinabove. If the initial temperature of volumes is so that the magnitudes of velocities of the proton relatively to mass centres of atoms of volumes satisfy conditions of (528):

$$v_{pc} < \frac{a_p}{2}, \tag{557}$$

where v_{pc} are the magnitudes of velocities of the proton relatively to mass centres of atoms of volumes, then both volumes will attract the proton with equal forces. As the temperature of the first volume rises, velocities of mass centres of atoms in it relatively to the proton will increase. Thus, the magnitude of attraction force acting on the proton from the side of atoms of hot volume will decrease, and the resulting force acting on the proton will be directed from the hot volume to the cold. The cold volume will attract the proton stronger than the hot. Upon the further rise of temperature of hot volume, the magnitude of force acting on the proton from the side of hot volume will become equal to zero, and the proton will be affected by the attraction force from the cold volume only. Further on, as the temperature rises, the hot volume will begin to repel the proton, and the proton will be affected by the repulsion force from the hot volume and the attraction force from the cold one. As the repulsion force of the hot volume reaches the maximum, the resulting force acting on the proton will also possess the maximum value. With the further increase of the temperature, the magnitude of resulting force will start to decrease but the force will always act along the direction from the hot volume to the cold.

If the initial temperature of volumes will be so that the magnitudes of velocities of the proton relatively to mass centres of atoms of volumes satisfy the conditions of (532):

$$v_{pc} > a_p \frac{a_{ep}/2 + v_{e_m c}}{a_{ep} - a_p}. \tag{558}$$

where $v_{e_m c}$ is the maximum magnitude of velocity of electrons in atoms of volumes, then both volumes will repel the proton with equal forces, and the resulting force acting on the proton will equal to zero. As the temperature of the first volume rises, velocities of mass centres of atoms in it relatively to the proton will increase. If initial relative velocities of the proton and mass centres of atoms of volumes upon conditions of (558) will be so that the magnitudes of forces of repulsion of the proton by volumes of atoms under the rise of temperatures of volumes will increase, then the magnitude of repulsion force acting on the proton from the side of atoms of hot volume will increase, and the resulting force acting on the proton will be directed from the hot volume to the cold. The hot volume will repel the proton stronger than the cold. Upon the further rise of temperature of hot volume, the magnitude of force acting on the proton from the side of hot volume will reach the maximum, and the resulting force acting on the proton will also possess the maximum value. It will be the result of action of the constant repulsion force of the cold volume and the maximum repulsion force of the hot one. With the further increase of the temperature, the magnitude of force acting from the side of the hot volume will start to decrease, and once this force becomes equal in modulus to the repulsion force acting from the side of cold volume, the resulting force acting on the proton will equal to zero. Further on, as the temperature rises, the force from the hot volume will decrease and the resulting force acting on the proton will change is direction to the opposite. The cold volume will repel the proton stronger than the hot. The proton will be affected by the force acting along the direction from the cold volume to the hot.

If a free charged particle located between two volumes will be affected by an external electromotive force not outgoing from atoms of volumes, then, as the direction of this force is coincident to that of resulting force acting on the free charged particle from the volumes, the kinetic energy of the particle will be the sum of kinetic energies provided to the particle by the external force and by the volumes of atoms. Thus, particles of atoms of the volumes will lose their kinetic energy, and the temperature of volumes will decrease.

If a free charged particle located between two volumes will be affected by an external electromotive force not outgoing from atoms of volumes, then, as the direction of this force is opposite to that of resulting force acting on the free charged particle from the volumes, the kinetic energy of the particle will be the difference of kinetic energies provided to the particle by the external force and by the volumes of atoms. Thus, particles of atoms of the volumes will increase their kinetic energy, and the temperature of volumes will rise.

In common case the resulting force acting on the free charged particle located between two volumes of neutral atoms will depend not only on temperatures of volumes but also on the differences of atoms of the first and second volumes (the number and magnitudes of velocities of particles in atoms), on the orientation of atoms in crystal lattices of the volumes (orientation of rotation vectors of particles in the volume of atoms), and on the distribution of density of atoms in the volumes (gradients of density of atoms in the volumes). This resulting force will also depend on the quantity, density and velocities of free charged particles in the volumes, both relatively to the volumes and relatively to one another. Therefore, the hereinabove description of thermo-electrical phenomena within the frame of PPST is the approximate, qualitative description of these phenomena. Nevertheless, general results of physical experiments related to the thermo-electricity [25, 26] match the PPST conclusions.

Conclusions of PPST are applicable to consideration of thermo-electrical phenomena in superconductors. Based on the description of interaction of the electron and the volumes of atoms at the low relative velocities, when the volumes repel the electron at initial temperatures, one can conclude that the thermo-current at low temperatures should reach the maximum values in the case when the cold volume of atoms repels the electron and the hot one attracts it.

23 Electrification of volumes of neutral atoms

Electrification of volumes of neutral atoms can be both a consequence of thermo-electrical phenomena considered in the previous chapter and a consequence of physical difference of electrifying volumes of atoms (quantities and magnitudes of velocities of particles in atoms, orientation of rotation vectors of particles in the volume of atoms, gradients of density in volumes).

Let us consider the first volume of neutral atoms; it is located in a volume containing free charged particles. We presume that the first volume of neutral atoms upon initial conditions does not contain free charged particles. We also presume that the first volume of neutral atoms attracts free charged particles of the external volume, and as these particles enter the volume of neutral atoms, they are still attracted by the atoms of volume. The number of free particles in the first volume of neutral atoms will increase to the moment until attraction forces between particles of external volume and the first volume of neutral atoms, pressure forces in the volume of free particles entered the first volume of neutral atoms from the external volume, and attraction or repulsion forces between the volume of free particles located inside the first volume of neutral atoms and free particles of external volume, come to equilibrium. From this moment of time the first volume of neutral atoms containing a certain number of charged particles can be considered electrically neutral relatively to the external volume since there will be no electromotive force between the first and the external volumes – the sum of pressure forces, attraction and repulsion forces acting on free charged particles of external volume from the side of first volume of neutral atoms and free charged particles located inside it will equal to zero.

Let us consider the second volume of neutral atoms. We presume that the second volume is located in the same volume as the first one, but the first and the second volumes are at the distance between one another at which interaction forces between them can be counted as equal to zero. Let us assume that the second volume of neutral atoms upon initial conditions does not contain free charged particles. We also presume that the second volume of neutral atoms attracts free charged particles of the external volume, and as these particles enter the volume of neutral atoms, they are still attracted by the atoms of volume. The number of free particles in the second volume of neutral atoms will increase to the moment until the second volume as well as the first one considered hereinabove becomes electrically neutral relatively to the external volume.

Let us bring the first and the second volumes of neutral atoms with certain numbers of free charged particles located inside them as close to one another as their edges contact. If due to some physical process (e.g., changing of temperatures of volumes, changing of their densities, etc.) the balance of forces acting from the side of the volumes of neutral atoms and charged particles inside them on a single free charged particle at the boundary of contact of volumes is disturbed, then an electromotive force will appear at this boundary and will start to move free charged particles from one volume to another. In one volume

the quantity of free charged particles will decrease whereas in another one it will increase. If due to this process the neutrality of volumes regarding the external volume is disrupted, volumes will begin to restore their neutrality. Further on, if we bring the first and the second volumes apart at the initial distance before the moment when the volumes become neutral relatively to external volume, then there will exist electromotive forces between the external volume and separated volumes. The separated volumes in this case will be of two types:
1. the volume with the excess of charged particles relatively to the neutral state with external volume;
2. the volume with the lack of charged particles relatively to the neutral state with external volume.

There will be the electromotive force between the volume with the excess of charged particles and the external volume acting on a free charged particles located in the external volume and directed from the volume with the excess of charged particles to the external volume.

There will be the electromotive force between the volume with the lack of charged particles and the external volume acting on a free charged particles located in the external volume and directed from the external volume to the volume with the lack of charged particles.

Therefore, the process of electrification of two volumes of neutral atoms in PPST is determined by the electromotive force acting on a free charged particle located at the boundary of contact of two volumes of neutral atoms. This electromotive force is the sum of four forces: two forces acting from the volumes of neutral atoms, and two forces acting from the charged particles located inside the volumes of neutral atoms.

24 Interaction between a proton and an electrically neutral volume of particles

Let us consider the interaction between a proton and an electrically neutral volume of particles (the numbers of negative and positive charges in the volume are equal) – it can be either the volume of neutral atoms or the volume of a neutral plasma or the volume containing both neutral atoms and the neutral plasma. Proceeding from the system of equations of motion of particles (7), we obtain the equation of motion of the proton relatively to the mass centre of neutral volume of particles:

$$\frac{Mm_p}{(M+m_p)}\frac{d\vec{v}_{pc}}{dt} = e^2\sum_{n=1}^{N}\left(\frac{\hat{r}_{pp_n}}{r_{pp_n}^2}\left(1-b^{\left(1-(\vec{v}_{pc}-\vec{v}_{p_nc})^2/a_p^2\right)}\right)-\frac{\hat{r}_{pe_n}}{r_{pe_n}^2}\left(1-b^{\left(1-(\vec{v}_{pc}-\vec{v}_{e_nc})^2/a_{ep}^2\right)}\right)\right), \tag{559}$$

where:
N is the number of electrons equal to the number of protons in the neutral volume of particles,
$M = N\,(m_e + m_p)$ is the mass of the neutral volume of particles,
$\vec{r}_{pp_n}$ is the radius vector of position of the proton relatively to a proton No. n of the neutral volume of particles,
$\vec{r}_{pe_n}$ is the radius vector of position of the proton relatively to an electron No. n of the neutral volume of particles,

$\vec{v}_{pc}$ is the velocity of proton relatively to the mass centre of the neutral volume of particles,
$\vec{v}_{p_nc}$ is the velocity of a proton No. n of the neutral volume of particles relatively to the mass centre of the neutral volume of particles,
$\vec{v}_{e_nc}$ is the velocity of an electron No. n of the neutral volume of particles relatively to the mass centre of the neutral volume of particles.

Let us split the volume occupied by the neutral volume of particles into K of smaller volumes each of which containing the number of electrons equal to the number of protons - N_k ($\sum_{k=1}^{K} N_k = N$). From the (559) we emphasise the $\vec{Q}_{pc_k}$ functions which determines the signs of forces and unit vectors of forces acting between the proton and a small volume No. k:

$$\vec{Q}_{pc_k} = \frac{r^2_{pc_k}}{N_k}\sum_{n_k=1}^{N_k}\left(\frac{\hat{r}_{pp_{n_k}}}{r^2_{pp_{n_k}}}\left(1-b^{\left(1-\left(\vec{v}_{pc}-\vec{v}_{p_{n_k}c}\right)^2/a_p^2\right)}\right)-\frac{\hat{r}_{pe_{n_k}}}{r^2_{pe_{n_k}}}\left(1-b^{\left(1-\left(\vec{v}_{pc}-\vec{v}_{e_{n_k}c}\right)^2/a_{ep}^2\right)}\right)\right), \tag{560}$$
$$k = 1, 2, .., K,$$

where $\vec{r}_{pc_k}$ is the radius vector of position of the proton relatively to the mass centre of the small volume of particles No. k, and $\vec{v}_{e_{n_k}c}$ and $\vec{v}_{p_{n_k}c}$ are correspondingly the velocity of an electron No. n and a proton No. n of the volume of particles No. k relatively to the mass centre of the mutual volume of particles including all K smaller volumes. Let us determine the dimensions of small volumes so that the maximum distances between particles in each of K small volumes will be much less than the distances between their mass centres and the proton. Then we can rewrite the (560) as follows:

$$\vec{Q}_{pc_k} = \frac{1}{N_k}\sum_{n_k=1}^{N_k}\left(b^{\left(1-\left(\vec{v}_{pc}-\vec{v}_{e_{n_k}c}\right)^2/a_{ep}^2\right)} - b^{\left(1-\left(\vec{v}_{pc}-\vec{v}_{p_{n_k}c}\right)^2/a_p^2\right)}\right)\hat{r}_{pc_k}, \quad k = 1, 2, .., K. \tag{561}$$

Using the (561), we rewrite the (559) as follows:

$$\frac{Mm_p}{(M+m_p)}\frac{d\vec{v}_{pc}}{dt} = \sum_{k=1}^{K}\frac{N_k e^2}{r^2_{pc_k}}Q_{pc_k}\hat{r}_{pc_k}, \tag{562}$$

$$Q_{pc_k} = \frac{1}{N_k}\sum_{n_k=1}^{N_k}\left(b^{\left(1-\left(\vec{v}_{pc}-\vec{v}_{e_{n_k}c}\right)^2/a_{ep}^2\right)} - b^{\left(1-\left(\vec{v}_{pc}-\vec{v}_{p_{n_k}c}\right)^2/a_p^2\right)}\right), \quad k = 1, .., K. \tag{563}$$

We presume that the following conditions will fulfil for electrons in each of K small volumes at any moment of time:

$$v_{e_{n_k}c} \neq 0, \quad n_k = 1_k, 2_k, .., N_k, \quad k = 1, 2, .., K, \tag{564}$$

and particles in volumes can be grouped so that the following conditions would fulfil as well:

$$0 < v_{e_{1_k}c}a_p - v_{p_{1_k}c}a_{ep} \leq v_{e_{2_k}c}a_p - v_{p_{2_k}c}a_{ep} \leq ... \leq v_{e_{N_k}c}a_p - v_{p_{N_k}c}a_{ep}, \tag{565}$$
$$n_k = 1_k, 2_k, .., N_k, \quad k = 1, 2, .., K.$$

Then conditions at which the proton and small volumes No. k attract will be determined by the inequalities:

$$\frac{v_{e_{s_k}c} - v_{pc}}{a_{ep}} > \frac{v_{p_{s_k}c} + v_{pc}}{a_p}, \quad v_{e_{s_k}c} > v_{pc}, \quad k = 1, 2, .., K, \tag{566}$$

which lead to the following:

$$v_{pc} < \frac{v_{e_{s_k}c}a_p - v_{p_{s_k}c}a_{ep}}{a_{ep}+a_p}, \quad Q_{pc_k} < 0, \quad k = 1,2,..,K. \tag{567}$$

Expressions $v_{e_{s_k}c}a_p - v_{p_{s_k}c}a_{ep}$ in the (567) are the certain parts of inequalities of (565) at which the (567) are fulfilled. In other words, if the following inequalities fulfil for the (563):

$$\sum_{n_k=s_k}^{N_k}\left(b^{\left(1-\left(\vec{v}_{pc}-\vec{v}_{e_{n_k}c}\right)^2/a_{ep}^2\right)} - b^{\left(1-\left(\vec{v}_{pc}-\vec{v}_{p_{n_k}c}\right)^2/a_p^2\right)}\right) < 0, \quad k = 1,2,..,K,$$

$$|\sum_{n_k=s_k}^{N_k}\left(b^{\left(1-\left(\vec{v}_{pc}-\vec{v}_{e_{n_k}c}\right)^2/a_{ep}^2\right)} - b^{\left(1-\left(\vec{v}_{pc}-\vec{v}_{p_{n_k}c}\right)^2/a_p^2\right)}\right)| >$$

$$> |\sum_{n_k=1}^{s_k-1}\left(b^{\left(1-\left(\vec{v}_{pc}-\vec{v}_{e_{n_k}c}\right)^2/a_{ep}^2\right)} - b^{\left(1-\left(\vec{v}_{pc}-\vec{v}_{p_{n_k}c}\right)^2/a_p^2\right)}\right)|,$$

then the conditions of (567) will also fulfil.

Let us presume that each of K small volumes of particles can be grouped at any moment of time as we did it for the (565) so that the following conditions would fulfil:

$$0 < v_{e1_k c}a_p + v_{p1_k c}a_{ep} \le v_{e2_k c}a_p + v_{p2_k c}a_{ep} \le ... \le v_{e_{N_k}c}a_p + v_{p_{N_k}c}a_{ep}, \tag{568}$$

$$n_k = 1_k, 2_k, .., N_k, \quad k = 1,2,..,K.$$

(The numbering of particles in the (568) may not match that of the (565)). Then conditions at which the proton and small volumes of particles No. k repel will be determined by inequalities:

$$\frac{v_{pc} - v_{p_{l_k}c}}{a_p} > \frac{v_{pc} + v_{e_{l_k}c}}{a_{ep}}, \quad v_{pc} > v_{p_{l_k}c}, \quad k = 1,2,..,K. \tag{569}$$

which lead to the following:

$$v_{pc} > \frac{v_{e_{l_k}c}a_p + v_{p_{l_k}c}a_{ep}}{a_{ep}-a_p}, \quad Q_{pc_k} > 0, \quad k = 1,2,..,K. \tag{570}$$

Expressions $v_{e_{l_k}c}a_p + v_{p_{l_k}c}a_{ep}$ in the (570) are the certain parts of inequalities of (568) at which the (570) are fulfilled. In other words, if the following inequalities fulfil for the (563):

$$\sum_{n_k=1}^{l_k}\left(b^{\left(1-\left(\vec{v}_{pc}-\vec{v}_{e_{n_k}c}\right)^2/a_{ep}^2\right)} - b^{\left(1-\left(\vec{v}_{pc}-\vec{v}_{p_{n_k}c}\right)^2/a_p^2\right)}\right) > 0, \quad k = 1,2,..,K,$$

$$|\sum_{n_k=1}^{l_k}\left(b^{\left(1-\left(\vec{v}_{pc}-\vec{v}_{e_{n_k}c}\right)^2/a_{ep}^2\right)} - b^{\left(1-\left(\vec{v}_{pc}-\vec{v}_{p_{n_k}c}\right)^2/a_p^2\right)}\right)| >$$

$$> | \sum_{n_k=l_k+1}^{N_k} \left(b^{\left(1-\left(\vec{v}_{pc}-\vec{v}_{e n_k c}\right)^2/a_{ep}^2\right)} - b^{\left(1-\left(\vec{v}_{pc}-\vec{v}_{p n_k c}\right)^2/a_p^2\right)} \right) |,$$

then the conditions of (570) will also fulfil.

If $v_{e_s c} a_p - v_{p_s c} a_{ep}$ is the minimum value of all $v_{e_{s_k} c} a_p - v_{p_{s_k} c} a_{ep}$ and $v_{e_l c} a_p + v_{p_l c} a_{ep}$ is the maximum value of all $v_{e_{l_k} c} a_p + v_{p_{s_l} c} a_{ep}$ for all K small volumes in the neutral volume of particles, then the following conditions will fulfil:

$$v_{pc} < \frac{v_{e_s c} a_p - v_{p_s c} a_{ep}}{a_{ep} + a_p}, \quad Q_{pc_k} < 0, \quad k = 1, 2, .., K. \tag{571}$$

$$v_{pc} > \frac{v_{e_l c} a_p + v_{p_l c} a_{ep}}{a_{ep} - a_p}, \quad Q_{pc_k} > 0, \quad k = 1, 2, .., K. \tag{572}$$

Based on the (571) and (572), we conclude the following:

1. All small volumes of particles of the neutral volume of particles will attract the proton under conditions of (565) if conditions of (571) fulfil.

2. All small volumes of particles of the neutral volume of particles will repel the proton under conditions of (568) if conditions of (572) fulfil.

3. During the interaction of the proton and the neutral volume of particles under conditions of (565) and (568), within the following range of values of magnitudes of relative velocities of the proton and the mass centre of the neutral volume of particles:

$$\frac{v_{e_s c} a_p - v_{p_s c} a_{ep}}{a_{ep} + a_p} \le v_{pc} \le \frac{v_{e_l c} a_p + v_{p_l c} a_{ep}}{a_{ep} - a_p}, \tag{573}$$

there will exist the values of magnitudes of relative velocities of the proton and the mass centre of the neutral volume of particles at which the magnitude of force acting between them will equal to zero. With the certain value of the magnitude of relative velocity of the proton and the mass centre of the neutral volume of particles less than these values, the proton and the neutral volume of particles will attract whereas at the value greater than these values they will repel.

25 Interaction between neutral atoms

Interaction between neutral atoms at the distances much longer than the radii of atoms in PPST can be the analogue of the intermolecular interaction.

If the volume of particles which motion is described by the equation (7) is split into two interacting volumes for each of which the number of protons is equal to the number of electrons, and presume that the mass centres of volumes are at the distance from one another which is much greater than the largest value of radii of volumes, then we can find a function which determines the acceleration of mass centre of the first volume relatively to the mass centre of the second one:

$$\frac{d\vec{v}_{12}}{dt} = \frac{e^2 \left(M_1 + M_2\right)}{\left(m_p + m_e\right)^2 r_{12}^2} Q_{12} \hat{r}_{12}, \tag{574}$$

$$Q_{12} = \frac{1}{KN} \sum_{k=1}^{K} \sum_{n=1}^{N} \left(b^{1-\left(\vec{v}_{12}+\vec{v}_{e_k 1}-\vec{v}_{p n 2}\right)^2/a_{ep}^2} + b^{1-\left(\vec{v}_{12}+\vec{v}_{p_k 1}-\vec{v}_{e n 2}\right)^2/a_{ep}^2} \right) -$$

$$-\frac{1}{KN}\sum_{k=1}^{K}\sum_{n=1}^{N}\left(b^{1-\left(\vec{v}_{12}+\vec{v}_{e_k 1}-\vec{v}_{en2}\right)^2/a_e^2}+b^{1-\left(\vec{v}_{12}+\vec{v}_{p_k 1}-\vec{v}_{pn2}\right)^2/a_p^2}\right), \quad (575)$$

where:
K is the number of protons equal to the number of electrons in the first volume,
N is the number of protons equal to the number of electrons in the second volume,
M_1 and M_2 are the masses of the first and second volumes,
$\vec{r}_{12}$ is the radius vector of position of the mass centre of the first volume relatively to the mass centre of the second volume,
$\vec{v}_{12}$ is the velocity of the mass centre of the first volume relatively to the mass centre of the second volume,
$\vec{v}_{e_k 1}$ is the velocity of an electron No. k of the first volume relatively to the mass centre of the first volume,
$\vec{v}_{en2}$ is the velocity of an electron No. n of the second volume relatively to the mass centre of the second volume,
$\vec{v}_{p_k 1}$ is the velocity of a proton No. k of the first volume relatively to the mass centre of the first volume,
$\vec{v}_{pn2}$ is the velocity of a proton No. n of the second volume relatively to the mass centre of the second volume.

Let us determine that all particles of considered volumes are bound into atoms. Each volume can contain both a single atom and a set of atoms. We will assume that nuclei of these atoms do not contain neutrons in which the proton and the electron are in the bound unsteady state when the velocity of proton relatively to the mass centre of atom is greater than the halved neutral relative velocity of protons. We will also assume that in the atom of hydrogen as well as in nuclei of all atoms the velocity of proton relatively to the mass centre of atom is less than the halved neutral relative velocity of protons.

Let us consider the Q_{12} function at $v_{12} = 0$ and at the magnitudes of velocities of mass centres of all atoms relatively to the mass centres of volumes of atoms equal to zero, i.e., the case when mass centres of atoms of volumes are motionless relatively to one another:

$$Q_{12}=\frac{1}{KN}\sum_{k=1}^{K}\sum_{n=1}^{N}\left(b^{1-\left(\vec{v}_{e_k 1}-\vec{v}_{pn2}\right)^2/a_{ep}^2}+b^{1-\left(\vec{v}_{p_k 1}-\vec{v}_{en2}\right)^2/a_{ep}^2}\right)-$$

$$-\frac{1}{KN}\sum_{k=1}^{K}\sum_{n=1}^{N}\left(b^{1-\left(\vec{v}_{e_k 1}-\vec{v}_{en2}\right)^2/a_e^2}+b^{1-\left(\vec{v}_{p_k 1}-\vec{v}_{pn2}\right)^2/a_p^2}\right). \quad (576)$$

Let us write down the sum which determines the sigh of function of (576):

$$\sum_{k=1}^{K}\sum_{n=1}^{N}\left(b^{1-\left(\vec{v}_{e_k 1}-\vec{v}_{pn2}\right)^2/a_{ep}^2}+b^{1-\left(\vec{v}_{p_k 1}-\vec{v}_{en2}\right)^2/a_{ep}^2}-b^{1-\left(\vec{v}_{e_k 1}-\vec{v}_{en2}\right)^2/a_e^2}-b^{1-\left(\vec{v}_{p_k 1}-\vec{v}_{pn2}\right)^2/a_p^2}\right). \quad (577)$$

The following statement will be valid for the (577):

If the inequality of (460), i.e., if $a_e > 2a_{ep} + a_p$, then the sum of (577) is negative.

This statement to be proven as follows:

According to conclusions of Chapter 17:

$$v_{e_k 1} > a_{ep} + a_p/2, \quad v_{en2} > a_{ep} + a_p/2, \quad v_{p_k 1} < a_p/2, \quad v_{pn2} < a_p/2,$$

$$n = 1, 2, ...N, \qquad k = 1, 2, ...K, \tag{578}$$

thus:

$$b^{1-\left(\vec{v}_{e_k1}-\vec{v}_{pn2}\right)^2/a_{ep}^2} < 1, \qquad b^{1-\left(\vec{v}_{p_k1}-\vec{v}_{en2}\right)^2/a_{ep}^2} < 1, \qquad b^{1-\left(\vec{v}_{p_k1}-\vec{v}_{pn2}\right)^2/a_p^2} > 1,$$

$$n = 1, 2, ...N, \qquad k = 1, 2, ...K. \tag{579}$$

Then, if:

$$v_{e_k1} = v_{en2} = v_0, \qquad n = 1, 2, ...N, \qquad k = 1, 2, ...K, \tag{580}$$

then, considering the (578) and (580), we will obtain the following inequalities:

$$\left(\vec{v}_{e_k1} - \vec{v}_{pn2}\right)^2 > \left(v_0 - a_p/2\right)^2, \quad \left(\vec{v}_{p_k1} - \vec{v}_{en2}\right)^2 > \left(v_0 - a_p/2\right)^2,$$

$$\left(\vec{v}_{e_k1} - \vec{v}_{en2}\right)^2 \leq 4v_0^2. \tag{581}$$

Let us determine the inequality:

$$\frac{v_0 - a_p/2}{a_{ep}} > \frac{2v_0}{a_e}. \tag{582}$$

Let us transform the (582):

$$v_0 > \frac{a_e a_p}{2\left(a_e - 2a_{ep}\right)}. \tag{583}$$

As follows from the (578), $v_0 > a_{ep} + a_p/2$. Thus, for the value of v_0 less than the minimum possible, from the (583) we will obtain the inequality:

$$a_{ep} + a_p/2 > \frac{a_e a_p}{2\left(a_e - 2a_{ep}\right)}. \tag{584}$$

The (584) is valid for $a_e > 2a_{ep} + a_p$. And thus, the inequality of (582) is also valid under this condition. Based on the (581) and (582), we obtain inequalities:

$$\frac{\left(\vec{v}_{e_k1} - \vec{v}_{pn2}\right)^2}{a_{ep}^2} > \frac{\left(\vec{v}_{e_k1} - \vec{v}_{en2}\right)^2}{a_e^2}, \quad \frac{\left(\vec{v}_{p_k1} - \vec{v}_{en2}\right)^2}{a_{ep}^2} > \frac{\left(\vec{v}_{e_k1} - \vec{v}_{en2}\right)^2}{a_e^2}, \quad v_{e_k1} = v_{en2}. \tag{585}$$

which result to:

$$b^{1-\left(\vec{v}_{e_k1}-\vec{v}_{pn2}\right)^2/a_{ep}^2} < b^{1-\left(\vec{v}_{e_k1}-\vec{v}_{en2}\right)^2/a_e^2}, \qquad b^{1-\left(\vec{v}_{p_k1}-\vec{v}_{en2}\right)^2/a_{ep}^2} < b^{1-\left(\vec{v}_{e_k1}-\vec{v}_{en2}\right)^2/a_e^2},$$

$$n = 1, 2, ...N, \qquad k = 1, 2, ...K, \qquad v_{e_k1} = v_{en2}. \tag{586}$$

We rewrite the (581) as follows:

$$\left(\vec{v}_{e_k1} - \vec{v}_{pn2}\right)^2 > \left(v_{e_k1} - a_p/2\right)^2, \quad \left(\vec{v}_{p_k1} - \vec{v}_{en2}\right)^2 > \left(v_{en2} - a_p/2\right)^2,$$

$$\left(\vec{v}_{e_k1} - \vec{v}_{en2}\right)^2 \leq \left(v_{e_k1} + v_{en2}\right)^2, \quad v_{e_k1} \neq v_{en2}. \tag{587}$$

From the (582) and (587) either the first system of inequalities is following:

$$v_{e_k1} > v_{en2}, \quad \frac{v_{e_k1} - a_p/2}{a_{ep}} > \frac{v_{e_k1} + v_{en2}}{a_e}, \quad b^{1-\left(\vec{v}_{e_k1}-\vec{v}_{pn2}\right)^2/a_{ep}^2} < b^{1-\left(\vec{v}_{e_k1}-\vec{v}_{en2}\right)^2/a_e^2}, \tag{588}$$

or the second:

$$v_{e_n2} > v_{e_k1}, \quad \frac{v_{e_n2} - a_p/2}{a_{ep}} > \frac{v_{e_k1} + v_{e_n2}}{a_e}, \quad b^{1-\left(\vec{v}_{p_k1} - \vec{v}_{e_n2}\right)^2/a_{ep}^2} < b^{1-\left(\vec{v}_{e_k1} - \vec{v}_{e_n2}\right)^2/a_e^2}. \quad (589)$$

As follows from (579), (586), (588) and (589), we can split all parts of the sum (577) into pairs consisting of one negative and one positive part of the sum, so that the negative parts of pairs will be greater in moduli than the positive those. It means that the statement for the sum (577) is valid. Therefore, the value of the Q_{12} function determined in the (575) will be negative at $v_{12} = 0$ and with magnitudes of velocities of mass centres of all atoms relatively to the mass centres of volumes of atoms equal to zero.

Let us consider the (575) under the following conditions:

$$v_{12} >> v_{e_k1}, \quad v_{12} >> v_{e_n2}, \quad n = 1, 2, ...N, \quad k = 1, 2, ...K. \quad (590)$$

In the (590), the velocity of electron in the volume will be compounded of the velocity of motion of electron in the atom and the velocity of motion of atom relatively to the mass centre of the volume. Therefore, the conditions of (590) should be limited with the maximum possible magnitudes of velocities of neutral atoms in the volumes at which atoms do not ionise.
We obtain:

$$Q_{12} = 2b^{1-v_{12}^2/a_{ep}^2} - b^{1-v_{12}^2/a_e^2} - b^{1-v_{12}^2/a_p^2}. \quad (591)$$

With:

$$a_{ep} >> a_p, \qquad a_e >> a_p, \qquad v_{12} >> a_p,$$

the (591) will acquire the following form:

$$Q_{12} = b\left(b^{\frac{\ln 2}{\ln b} - \frac{v_{12}^2}{a_{ep}^2}} - b^{-\frac{v_{12}^2}{a_e^2}}\right). \quad (592)$$

Proceeding from the (592), we determine and consider the inequality:

$$\frac{v_{12}^2}{a_{ep}^2} - \frac{\ln 2}{\ln b} > \frac{v_{12}^2}{a_e^2}, \quad (593)$$

upon fulfilment of which $Q_{12} < 0$. We transform the (593):

$$\frac{v_{12}^2}{a_{ep}^2}\left(1 - \frac{a_{ep}^2}{a_e^2}\right) > \frac{\ln 2}{\ln b}. \quad (594)$$

If $a_e > 2a_{ep}$, then the value of expression enclosed in parentheses in the (594) can be limited by the inequality:

$$\frac{3}{4} < 1 - \frac{a_{ep}^2}{a_e^2} < 1. \quad (595)$$

As follows from conditions of (590), $v_{12} >> a_{ep}$, thus, with $b \geq 2$, the inequality of (594) is valid. Therefore, under conditions of (590) and with $b \geq 2$, Q_{12} tends to zero from the side of minus-infinity.

Based on values of function (575) determined hereinabove for the minimum and maximum values of magnitudes of velocities of mass centres of neutral atoms relatively to one another, we determine the properties of forces acting between the neutral atoms in PPST, proceeding from two possible variants of behaviour of the (575) function, depending on the magnitude of relative velocity of mass centres of volumes and on magnitudes of velocities of mass centres of atoms relatively to mass centres of volumes:

First variant is when the Q_{12} function does not have values equal to zero and its value is always negative.

Second variant is when the Q_{12} function has values equal to zero.

As follows from the first variant:

1. With $b \geq 2$, neutral atoms being at the distances much longer than their radii always attract one another. As the magnitude of relative velocity of mass centres of atoms increases to a certain value, the magnitude of forces acting between them will start to decrease and approach zero.

2. With $b \geq 2$, separated volumes of neutral atoms being at the distances much longer than the maximum radii of volumes always attract one another. As the magnitude of relative velocity of mass centres of volumes of atoms or magnitudes of velocities of mass centres of atoms in volumes increase to certain values at which atoms of volumes do not ionise, the magnitude of forces acting between them will start to decrease and approach zero.

As follows from the second variant:

1. With $b \geq 2$, neutral atoms being at the distances much longer than their radii can attract one another, be neutral, or repel one another, depending on the magnitude of relative velocity of mass centres of atoms. If the magnitude of relative velocity of mass centres of atoms equals to zero, then atoms attract one another. As the magnitude of relative velocity of mass centres of atoms increases, the magnitude of forces acting between them can equal to zero, and the sign of forces can change (attraction can change to repulsion). As the magnitude of relative velocity of mass centres of atoms increases to a certain value, atoms will attract, and with the further increase of the magnitude of their relative velocity the magnitude of attraction forces acting between them will tend to zero.

2. With $b \geq 2$, separated volumes of neutral atoms being at the distances much longer than their radii can attract one another, be neutral, or repel one another, depending on the magnitude of relative velocity of mass centres of volumes and on magnitudes of velocities of mass centres of atoms inside volumes. If the magnitude of relative velocity of mass centres of volumes and magnitudes of velocities of mass centres of atoms inside volumes equal to zero, then the volumes attract one another. As the magnitude of relative velocity of mass centres of volumes and or magnitudes of velocities of mass centres of atoms inside volumes increase, the magnitude of forces acting between them can equal to zero, and the sign of forces can change (attraction can change to repulsion). As the magnitude of relative velocity of mass centres of volumes and or magnitudes of velocities of mass centres of atoms inside volumes increase to a certain value, the volumes will attract, and with the further increase of magnitudes of these velocities the magnitude of attraction forces acting between them will tend to zero.

While determining the properties of interaction of neutral atoms, we did not consider the interaction of particles at the zero velocity. The interaction at the zero velocity will additionally contribute into the attraction of neutral atoms at the low values of magnitudes of relative velocities of atoms since the domains of magnitudes of velocities of protons and electrons in atoms do not intersect. The interaction of electrons and protons at the zero velocity and hence, the repelling contribution into the interaction will be possible at the magnitudes of relative velocities of mass centres of atoms comparable to magnitudes of velocities of motion of electrons in atoms.

Let us consider the interaction of neutral atoms of hydrogen with one another at the distance much longer than their radii and at the following condition:

$$v_p > a_p/2,$$

where v_p is the magnitude of velocity of the proton in the atom of hydrogen relatively to the mass centre of atom.

For the interaction of two atoms of hydrogen at the magnitude of relative velocity of their mass centres equal to zero, from the (577) we obtain:

$$b^{1-(\vec{v}_{e1}-\vec{v}_{p2})^2/a_{ep}^2} + b^{1-(\vec{v}_{p1}-\vec{v}_{e2})^2/a_{ep}^2} - b^{1-(\vec{v}_{e1}-\vec{v}_{e2})^2/a_e^2} - b^{1-(\vec{v}_{p1}-\vec{v}_{p2})^2/a_p^2}. \quad (596)$$

In accordance to the following:

$$m_e\vec{v}_{e1} + m_p\vec{v}_{p1} = 0, \quad m_e\vec{v}_{e2} + m_p\vec{v}_{p2} = 0, \quad (597)$$

we rewrite the (596) as follows:

$$b^{1-\left(\vec{v}_{e1}+\frac{m_e}{m_p}\vec{v}_{e2}\right)^2/a_{ep}^2} + b^{1-\left(\vec{v}_{e2}+\frac{m_e}{m_p}\vec{v}_{e1}\right)^2/a_{ep}^2} - b^{1-(\vec{v}_{e1}-\vec{v}_{e2})^2/a_e^2} - b^{1-m_e^2(\vec{v}_{e1}-\vec{v}_{e2})^2/(m_pa_p)^2}. \quad (598)$$

Let us write down inequalities which will always fulfil:

$$\left(\vec{v}_{e1} + \frac{m_e}{m_p}\vec{v}_{e2}\right)^2 \geq \left(v_{e1} - \frac{m_e}{m_p}v_{e2}\right)^2, \quad \left(\vec{v}_{e2} + \frac{m_e}{m_p}\vec{v}_{e1}\right)^2 \geq \left(v_{e2} - \frac{m_e}{m_p}v_{e1}\right)^2,$$

$$(\vec{v}_{e1} - \vec{v}_{e2})^2 \leq (v_{e1} + v_{e2})^2. \quad (599)$$

From the (598) and (599) we obtain conditions at which the value of the sum of (598) is less than zero:

$$\frac{v_{e1} - \frac{m_e}{m_p}v_{e2}}{a_{ep}} > \frac{v_{e1} + v_{e2}}{a_e}, \quad \frac{v_{e2} - \frac{m_e}{m_p}v_{e1}}{a_{ep}} > \frac{m_e\left(v_{e1} + v_{e2}\right)}{m_pa_p}, \quad \frac{m_e}{m_p} < \frac{v_{e1}}{v_{e2}} < \frac{m_p}{m_e}. \quad (600)$$

With $m_pa_p = m_ea_e$, the (600) provides the following two inequalities:

$$v_{e1} > v_{e2}\frac{a_p + a_{ep}}{a_e - a_{ep}}, \quad v_{e1} < v_{e2}\frac{a_e - a_{ep}}{a_p + a_{ep}}, \quad (601)$$

from which we can determine:

$$\frac{a_p + a_{ep}}{a_e - a_{ep}} < \frac{v_{e1}}{v_{e2}} < \frac{a_e - a_{ep}}{a_p + a_{ep}}. \quad (602)$$

As follows from the (602), with $m_pa_p = m_ea_e$, with $a_e > 2a_{ep}+a_p$, and with the magnitude of relative velocity of mass centres equal to zero, two atoms of hydrogen being at the distances much longer than the maximum radius of interacting atoms will attract if the ratio of magnitudes of velocities of electrons of atoms relatively to mass centres of atoms will lay within the range of (602).

Let us consider the (596) with $m_p a_p < m_e a_e$. In this case the following inequality will be valid:

$$\frac{v_{e1} + v_{e2}}{a_e} < \frac{m_e\left(v_{e1} + v_{e2}\right)}{m_p a_p}. \tag{603}$$

Thus, proceeding from the (600), we can determine that with:

$$\frac{v_{e1} - \frac{m_e}{m_p} v_{e2}}{a_{ep}} > \frac{m_e\left(v_{e1} + v_{e2}\right)}{m_p a_p}, \quad \frac{v_{e2} - \frac{m_e}{m_p} v_{e1}}{a_{ep}} > \frac{m_e\left(v_{e1} + v_{e2}\right)}{m_p a_p}, \quad \frac{m_e}{m_p} < \frac{v_{e1}}{v_{e2}} < \frac{m_p}{m_e}, \tag{604}$$

the sum of (598) will be less than zero. Proceeding from the (604), we obtain the following:

$$\frac{\frac{m_e}{m_p}\left(a_p + a_{ep}\right)}{a_p - \frac{m_e}{m_p} a_{ep}} < \frac{v_{e1}}{v_{e2}} < \frac{a_p - \frac{m_e}{m_p} a_{ep}}{\frac{m_e}{m_p}\left(a_p + a_{ep}\right)}, \quad a_p > \frac{2 m_e a_{ep}}{\left(m_p - m_e\right)}. \tag{605}$$

Therefore, with $m_p a_p < m_e a_e$, with conditions of (605), and with the magnitude of relative velocity of mass centres equal to zero, two atoms of hydrogen being at the distances much longer than the maximum radius of interacting atoms will attract if the ratio of magnitudes of velocities of electrons of atoms relatively to mass centres of atoms will lay within the range determined by the conditions of (605).

Analogously, for $m_p a_p > m_e a_e$, proceeding from the (600), we will have:

$$\frac{\frac{m_e}{m_p} a_e + a_{ep}}{a_e - a_{ep}} < \frac{v_{e1}}{v_{e2}} < \frac{a_e - a_{ep}}{\frac{m_e}{m_p} a_e + a_{ep}}, \quad a_e > \frac{2 m_p a_{ep}}{\left(m_p - m_e\right)}. \tag{606}$$

Thus, with $m_p a_p > m_e a_e$, with conditions of (606), and with the magnitude of relative velocity of mass centres equal to zero, two atoms of hydrogen being at the distances much longer than the maximum radius of interacting atoms will attract if the ratio of magnitudes of velocities of electrons of atoms relatively to mass centres of atoms will lay within the range determined by the conditions of (606).

As follows from (590) - (595), with the magnitude of relative velocity of mass centres of atoms of hydrogen much greater than the largest magnitude of velocity of electron in atoms, the atoms of hydrogen will attract.

Conclusions made hereinabove for the interaction of volumes of neutral atoms in which atoms of hydrogen are in states at which the magnitude of velocity of a proton relatively the mass centre of an atom of hydrogen is less than the halved neutral relative velocity of protons will be also valid for the interaction of volumes of atoms of hydrogen with $m_p a_p = m_e a_e$, with the conditions of (602), with $m_p a_p < m_e a_e$, with the conditions of (605), with $m_p a_p > m_e a_e$, with the conditions of (606), when magnitudes of velocities of protons relatively the mass centre of atom of hydrogen are greater than the halved neutral relative velocity of protons.

26 Interaction between neutral atoms and gravitational forces

Let us rewrite the (574) as follows:

$$\frac{d\vec{v}_{12}}{dt} = \frac{e^2\left(M_1 + M_2\right)}{\left(m_p + m_e\right)^2 r_{12}^2} Q_{12} \hat{r}_{12}, \tag{607}$$

Let us consider the (607) as the interaction of two bodies with masses of M_1 and M_2 at the distances much longer than the maximum radius of these bodies.

Let us represent the Q_{12} function (575) as follows:

$$\frac{(m_p+m_e)^2}{M_1M_2}\sum_{k=1}^{K}\sum_{n=1}^{N}\left(b^{1-\left(\vec{v}_{12}+\vec{v}_{e_k1}-\vec{v}_{pn2}\right)^2/a_{ep}^2}+b^{1-\left(\vec{v}_{12}+\vec{v}_{p_k1}-\vec{v}_{en2}\right)^2/a_{ep}^2}\right)-$$

$$-\frac{(m_p+m_e)^2}{M_1M_2}\sum_{k=1}^{K}\sum_{n=1}^{N}\left(b^{1-\left(\vec{v}_{12}+\vec{v}_{e_k1}-\vec{v}_{en2}\right)^2/a_e^2}+b^{1-\left(\vec{v}_{12}+\vec{v}_{p_k1}-\vec{v}_{pn2}\right)^2/a_p^2}\right), \tag{608}$$

where:

$$\frac{(m_p+m_e)^2}{M_1M_2}=\frac{1}{NK}.$$

The function determined in the (608) being finally calculated does not depend on the masses of interacting volumes and on the quantities of particles in these volumes. This function determines the sum of four arithmetic means, two positive and two negative, each of which is obtained by division of the sum of NK parts depending on magnitudes of relative velocities of particles participating in the interaction by NK. The value of magnitude of this function will be limited by the following inequality:

$$0\le|Q_{12}|\le 2b. \tag{609}$$

Using conditions for the conclusion of (574), considering the (608), we can form the following system of two equations from the system of equations (7):

$$M_1\frac{d\vec{v}_1}{dt}=\frac{e^2M_1M_2}{(m_p+m_e)^2\,r_{12}^2}Q_{12}\hat{r}_{12},$$

$$M_2\frac{d\vec{v}_2}{dt}=\frac{e^2M_2M_1}{(m_p+m_e)^2\,r_{21}^2}Q_{12}\hat{r}_{21}. \tag{610}$$

Joining of two equations of (610) into one provides the (607). If we determine the function for interaction of two neutral atoms as follows:

$$G_m=\frac{e^2Q_{12}}{(m_p+m_e)^2}, \tag{611}$$

then we can rewrite the (610) for the common action of intermolecular and gravitational forces:

$$M_1\frac{d\vec{v}_1}{dt}=-\frac{(G-G_m)\,M_1M_2}{r_{12}^2}\hat{r}_{12},$$

$$M_2\frac{d\vec{v}_2}{dt}=-\frac{(G-G_m)\,M_2M_1}{r_{21}^2}\hat{r}_{21}, \tag{612}$$

where G is the gravity constant.

If we presume that gravitational forces are manifestations of just intermolecular forces, then the (612) will look as follows:

$$M_1\frac{d\vec{v}_1}{dt}=\frac{G_mM_1M_2}{r_{12}^2}\hat{r}_{12},$$

$$M_2 \frac{d\vec{v}_2}{dt} = \frac{G_m M_2 M_1}{r_{21}^2} \hat{r}_{21}, \tag{613}$$

where G_m is not constant.

Therefore, the forces acting between neutral atoms and volumes of neutral atoms in PPST, as analogues of intermolecular forces, either complete the gravitational forces or are the gravitational forces.

27 Nuclear fusion

A nuclear fusion occurs at rather high values of temperature and density of the plasma. The main problem of the nuclear fusion if the overcome of Coulomb potential barrier (the repulsion of positively charged particles at the high values of magnitudes of their relative velocities). According to the generally accepted theory of nuclear forces, the nuclear synthesis should occur according to the following scheme:

The counter motion of two high-energetic, positively charged particles results to their approach to the distance of action of nuclear interaction forces. At that, if nuclear attraction forces become stronger than Coulomb repulsion forces, the positively charged particles form a bound pair.

In the point particles states theory, the nuclear fusion will occur according to the analogous scheme. However, unlike the nuclear forces theory where the change of repulsion to attraction depends on the distance between particles, the change of repulsion to attraction in PPST depends on the magnitude of relative velocity of particles. If the magnitude of relative velocity of approaching particles and the distance between them during their interaction with both one another and other particles will satisfy conditions of bonding of two likely charged particles (414), then the bound pair of particles is forming.

In both cases, initially we have two high-energetic, positively charged particles mowing toward one another. In both cases, as a result of synthesis we obtain the pair of bound positively charged particles. It is impossible to distinguish these events during the nuclear fusion since as the distance between two likely charged particles interacting in accordance with the Coulomb law decrease, the simultaneous decrease of the magnitude of their relative velocity occurs. Therefore, both the decrease of the distance between particles and the decrease of the magnitude of their relative velocity can be the cause of change of the sign of interaction forces between particles.

Thus, the process of nuclear fusion according to the PPST scenario is theoretically possible.

28 Superconductivity

As the temperature of superconductor decreases and the density of electrons in it increase to the values at which magnitudes of relative velocities of electrons and average distances between them begin to satisfy the conditions of (414), electrons bind into pairs forming the condensate. While the temperature decreases, the process of decrease of magnitudes of velocities of electrons of the condensate relatively to atoms and ions of superconductor's lattice also occurs. As magnitudes of their relative values decrease to a certain value, atoms and ions of superconductor's lattice begin to repel electrons of the condensate (please refer to Chapter 21). With the further decrease of the temperature the condensate will be extruded to the surface of superconductor and to **zones in which the common action of inertia forces and repulsion forces of electrons by ions and atoms of the lattice tends to the zero value (zones of the least action of forces)**. Later on we will talk about interaction between the electron condensate and ions of the lattice, referring to it as to the interaction with both ions and neutral atoms.

The motion of electron condensate with no resistance occurs both at the surface of superconductor and at surfaces formed inside the superconductor by zones of the least action of forces; at that, the attraction of bound pairs of electrons to one another does not allow separate pairs of electrons for leaving both the surface of superconductor and zones of the least action of forces.

The destruction of the state of superconductivity should occur in the following cases:

1. Under the increase of magnitudes of relative velocities of electrons of the condensate, or under the increase of average distance between them, when electrons begin to turn into the free state and scatter during the interaction with ions of the lattice once the condition of bonding (414) is violated.

2. Under the increase of magnitudes of velocities of electrons of the condensate relatively to ions of the lattice, when the repulsion of electrons of the condensate by ions of the lattice changes to the attraction (please refer to Chapter 21).

3. Under the localisation of the electron condensate in certain zones of the superconductor during the compression of electron condensate by external magnetic field (please refer to Chapter 14).

4. Under the affection of the radiation determined in Chapter 20 on the electron condensate, when the electron condensate evaporates during the interaction of electrons of the condensate at the zero velocity with particles of the source of radiation.

Therefore, initiation of superconductivity in PPST is the two processes occurring simultaneously:

The first one is the formation of the electron condensate from bound pairs of electrons.

The second one is the extrusion of the electron condensate to the surface of superconductor and to zones of the least action of forces.

Effects of attraction of electrons with one another and repulsion of electrons by neutral atoms are observable in the process of formation of "electron bubbles" in the superfluid helium [10] and in the liquid hydrogen [11].

The existence of energy pseudo-gap in high-temperature superconductors [27] is most likely related to the first process, the formation of the electron condensate from bound pairs of electrons. The condensate is forming but it flows with resistance. With the further decrease of the temperature the second process, the extrusion of the electron condensate to the surface of superconductor and to zones of the least action of forces, begins to realise. And only after that the superconductivity state arises. In superconductors where the pseudo-gap does not appear the second process (the extrusion of free electrons to the surface of superconductor and to zones of the least action of forces) is realised first as the temperature decreases, and then the first one (the formation of the electron condensate from bound pairs of electrons). In this case the energy gap appears simultaneously with the state of superconductivity. As the pressure upon the conductor or the temperature of it is changing, if in the conductor during the process of extrusion of free electrons to the surface of superconductor and to zones of the least action of forces the dynamics of change of both the density of electrons and the temperature of the conductor will be so that conditions of (414) fail to fulfil, then electrons will not bind into pairs and the superconductivity will not appear. The presence of pseudo-gap has been detected in the substance which is not a high-temperature superconductor [28]. Most likely, in this case free electrons initially localise in potential wells formed by strong repulsion forces and the structure of crystal lattice so that in order to maintain the flow of electron condensate formed due to the further decrease of the temperature, the permanent income of the energy is required, forcing the condensate to leave the potential well. Thus, the current in the conductor will experience the resistance, and with a certain minimum of voltage it will disappear. This minimum of voltage should correspond to the potential barrier of the condensate locked in the conductor.

29 Motion of a particle flow through the volume of particles

A group motion of a cylindrical volume of particles similar to the flow of a liquid, with the unit vector of velocity of motion of this cylindrical volume parallel to the axis of cylinder, will be referred to as a motion of particle flow.

In PPST we can determine conditions of motion of particle flow through the volume of particles at which this process will have a property similar to that of superconductors, namely, the transmission of particle flows through their volume with low resistance to the motion of the flow. According to PPST, this property should be possessed by both liquids, and gases, and the plasma, and volumes of like particles, not just by crystal bodies. This process should be determined by velocities of motion of particles in the flow relatively to one another, by velocities of motion of particles in the volume relatively to one another, and by the velocity of motion of the flow relatively to the volume.

Let us consider the volume of like particles fast relatively to one another (please refer to Chapter 14), either protons or electrons, being under a certain pressure created by external forces. If a continuous flow of the same like particles slow relatively to one another (please refer to Chapter 14) will move along the straight line through this volume of particles, then this flow of particles will be able to move under the weak resistance to its motion from the side of particles of the volume. It will be possible in the case if particles in the flow will attract one another and repel particles of the volume through which the flow is moving. Hence, velocities of particles of the volume relatively to particles of the flow should be faster than their neutral relative velocity, whereas velocities of particles of the flow relatively one another should be slower than their neutral relative velocity. As a result of repulsion of particles of the volume by particles of the flow, the flow will be compressed crosswise, and a rarefaction of particles of the volume (a cylindrical area of lower pressure along which axis particles of the flow will be able to move with the weak resistance to their motion) will be formed around the flow. The external pressure of particles of the volume will form a cylindrical area of higher pressure around the area of lower pressure. With a certain sum of moments of momenta of particles in the cylindrical area of higher pressure, a circular motion of particles of the volume around the cylindrical area of lower pressure will appear. Therefore, there will be a channel formed in the volume of like particles along which the flow of particles same as those of the volume is moving with the weak resistance to its motion.

The processes will develop in the same way under the motion of:

- the flow of electron condensate, or electrons slow relatively to one another, through

the volume of proton condensate, or through the volume of protons slow relatively to one another, if velocities of electrons relatively to protons will be slower than the neutral relative velocity of the electron and the proton,
- the flow of proton condensate, or protons slow relatively to one another, through the volume of electron condensate, or through the volume of electrons slow relatively to one another, if velocities of protons relatively to electrons will be slower than the neutral relative velocity of the electron and the proton,
- the flow of electron condensate, or electrons slow relatively to one another, through the volume of neutral atoms, if velocities of electrons relatively to the volume will be less than a certain value (please refer to Chapter 21),
- the flow of neutral atoms which relative velocities are so that atoms in the flow attract one another (please refer to Chapter 25) through the volume of electron condensate, or through the volume of electrons slow relatively to one another, if velocities of electrons of the volume relatively to atoms of the flow will be less than a certain value (please refer to Chapter 21),
- the flow of proton condensate, or protons slow relatively to one another, through the neutral volume of particles (either the volume of neutral atoms or the volume of the neutral plasma), if velocities of protons relatively to the neutral volume of particles will be greater than a certain value (please refer to Chapter 24).
- the flow of neutral atoms which relative velocities are so that atoms in the flow attract one another (please refer to Chapter 25) through the volume of protons, if velocities of protons of the volume relatively to atoms of the flow will be greater than a certain value (please refer to Chapter 24).

30 PPST and magnetic interaction between particles

Forces acting in PPST between the moving electric charges either should complete forces of magnetic interaction of electric charges or should be the forces of magnetic interaction. It arises from conclusions in Chapter 14 concerning the interaction of volumes of condensates and from the following argumentation:

If the magnetic interaction of two flows of condensate of like particles during their motion along parallel channels exists, then with the magnitude of relative velocities of condensate flows greater than a certain value, forces acting in PPST will contribute some repulsion into the magnetic interaction of channels. If the magnitude of relative velocities of condensate flows will be less than a certain value, the attraction will be added to the magnetic interaction.

If the magnetic interaction of two flows of different condensates, the proton and the electron ones, each of which moves along its channel and channels are parallel, exists, then with the magnitude of relative velocities of condensate flows less than a certain value, forces acting in PPST will contribute some repulsion into the magnetic interaction of channels. If the magnitude of relative velocities of condensate flows will be greater than a certain value, the attraction will be added to the magnetic interaction.

All these contributions into strengthening or weakening of magnetic interaction of channels will not depend on condensate flow directions in the preferred coordinate system. The magnitude of relative velocities of condensate flows will be important here.

The interaction forces between the channels in which the condensate flows of like particles have equal magnitudes of velocities, and unit vectors of velocities can be either parallel or antiparallel, can be described by an equation including both magnetic interaction and forces acting in PPST, if it is assumed that magnitudes of relative velocities of particles inside flows are much less than their neutral relative velocity:

$$F = -\frac{\mu_0 I^2 L \cos\phi_{12}}{2\pi r} + \frac{C_{12}^2}{r}\left(1 - b^{1-2v^2(1-\cos\phi_{12})/a^2}\right), \qquad v >> a. \tag{614}$$

Here:
I is a current strength in a single channel;
L is a length of a single channel;
r is a distance between channels;
π is the pi constant;
μ_0 is the magnetic constant;
C_{12}^2 is the interaction constant of channels in PPST;
v is the magnitude of velocity of condensate flows;
a is the neutral relative velocity of either protons or electrons;
ϕ_{12} is an angle between the unit vectors of velocities of condensate flows. It can equal either to 0 or to π.

The first, negative item in the (614) is the magnetic interaction of channels analogous to the interaction of parallel wires under the current. The second one is the interaction of channels in PPST. If we remove the expression enclosed in parentheses from the (614), then the C_{12}^2/r expression will determine the repulsion of like particles of two channels according to Coulomb law, and the (614), ignoring forces acting in PPST, will acquire the following form:

$$F = -\frac{\mu_0 I^2 L \cos\phi_{12}}{2\pi r} + \frac{C_{12}^2}{r}. \tag{615}$$

We obtain from the (614):

$$\phi_{12} = 0, \qquad F = -\frac{\mu_0 I^2 L}{2\pi r} - \frac{C_{12}^2}{r}(b-1). \tag{616}$$

$$\phi_{12} = \pi, \qquad F = \frac{\mu_0 I^2 L}{2\pi r} + \frac{C_{12}^2}{r}. \tag{617}$$

We obtain from the (615):

$$\phi_{12} = 0, \qquad F = -\frac{\mu_0 I^2 L}{2\pi r} + \frac{C_{12}^2}{r}. \tag{618}$$

$$\phi_{12} = \pi, \qquad F = \frac{\mu_0 I^2 L}{2\pi r} + \frac{C_{12}^2}{r}. \tag{619}$$

The (616, 617) and the (618, 619) demonstrate that the forces acting in PPST between two channels of condensate flows of like particles under certain conditions match the forces of magnetic interaction of these channels (617 and 619), but there is also a difference (616 and 618). Proceeding from the (614), ignoring the forces of magnetic interaction of channels of condensate flows, we obtain the following:

$$\phi_{12} = 0, \qquad F = -\frac{C_{12}^2}{r}(b-1). \tag{620}$$

$$\phi_{12} = \pi, \qquad F = \frac{C_{12}^2}{r}. \tag{621}$$

Therefore, we can conclude that the forces acting in PPST between two channels of condensate flows of like particles either are the forces of magnetic interaction (620 and 621) or change them (616 and 617).

If there are two parallel conductors in the plasma with electric currents flowing in the same direction, then the wires will attract. A current sheet will form between them, and the current will flow in it oppositely to the current in the wires. The electric current of the current sheet prevents the wires from the approach [29].

The forces acting in PPST and depending on the magnitude of relative velocity of motion of flows of like particles will also have a certain impact on the formation of the current sheet in the plasma. If the currents in two wires located in the plasma will be caused by two flows of electrons which electrons are slow relatively to one another, then the flows will attract, and both electrons of the plasma fast relatively to electrons of flows and protons of the plasma slow relatively to electrons of flows will be extruded from the plasma towards the current sheet. Electrons of the plasma slow relatively to electrons of flows and protons of the plasma fast relatively to electrons of flows will be removed from the current sheet. Therefore, the current sheet will be a surface of zero action of repulsion forces of electrons of the plasma fast and protons of the plasma slow relatively to electrons of flows by electrons of flows. The bulk of electrons in the current sheet will move oppositely to the unit vectors of velocities of flows relatively to the plasma, whereas the bulk of protons in the current sheet will move in the same direction as the unit vectors of velocities of flows relatively to the plasma. Thus, the electric current oppositely to electric currents in the wires will appear in the current sheet. Electrons of the current sheet will start to repel electrons of flows since they are fast relatively to electrons of flows. Protons of the current sheet will also repel electrons of flows since they are slow relatively to them.

The interaction of flows of protons with one another and with protons and electrons of the plasma will also develop under the analogous scenario. The proton condensate flows will attract if protons of these flows will be slow relatively to one another; at that, protons fast and electrons slow relatively to protons of flows will be extruded from the plasma towards the current sheet. In this case the current sheet with the electric current oppositely to those of the proton condensate will also be formed. Protons and electrons of the current sheet will also repel the flows of the proton condensate. All these effects will mostly strengthen the magnetic interaction of condensate flows if this interaction is considered as the magnetic interaction of wires with the current located in the plasma as described hereinabove.

The role of forces which depend on magnitudes of relative velocities of charged particles in PPST can be significant both in the formation of the pinch effect, or the compression of an electrically conducting filament in the plasma by magnetic forces induced by the current itself, and in the self-focusing of beams of likely charged particles. If magnitudes of relative velocities of electrons in the conducting channel decrease to a certain value with their forced rectilinear motion under the external electric field, then electrons will start to attract and compress the electronic component of the conducting channel (please refer to Chapter 14). Ions of the conducting channel will move oppositely to the motion of electrons, and if they will be fast relatively to electrons, then they will attract by the electronic component of the conducting channel. Therefore, the compression of the conducting channel will begin.

If magnitudes of relative velocities of motion of likely charged particles in the conducting channel will approach zero, then the value of the S_{sN} function (413) for these particles will approach one, and hence, their mass interaction at the zero velocity will occur, which will result to abrupt compression of the conducting channel, both crosswise and lengthwise.

Let us consider the interaction of a charged particle, either electron or proton, with a rotating ring of like particles having the linear density of charge equal to $Q/(2\pi R_c)$ where R_c is the radius of the ring rotating with the angular velocity v_c/R_c. We superpose the origin of the coordinate system with the pivot of the ring, and the plane $\vec{X}, \vec{Y}$ with the rotation plane of the ring. If we presume that at initial moment the particle is in the centre of the ring, the unit vector of its velocity lays within the rotation plane of the ring, and this vector is directed along the $+\vec{X}$ axis and the ring rotates counter-clockwise, then we can determine the force acting on the particle at this moment of time:

$$m\frac{d\vec{v}}{dt} = -\frac{qQ}{2\pi R_c^2}\int_0^{2\pi} \left(\hat{x}\cos(\phi) + \hat{y}\sin(\phi)\right)\left(1 - b^{1-\left(v^2+v_c^2+2vv_c\sin(\phi)\right)/a^2}\right)d\phi, \tag{622}$$

where $\vec{v}$ and m are the velocity and the mass of particle interacting with the charged ring, q is its charge, ϕ is the angle between the $+\vec{X}$ axis and a vector outgoing from the origin of coordinates to the centre of an arbitrary section of the ring. Derivation of the (622) presumed that the radius of the section of the ring is much less than the radius of rotation of the ring.

From the (622) we obtain:

$$m\frac{d^2x}{dt^2} = \frac{qQ}{2\pi R_c^2}\int_0^{2\pi} b^{1-\left(v^2+v_c^2+2vv_c\sin(\phi)\right)/a^2}\cos(\phi)d\phi, \tag{623}$$

$$m\frac{d^2y}{dt^2} = \frac{qQ}{2\pi R_c^2}\int_0^{2\pi} b^{1-\left(v^2+v_c^2+2vv_c\sin(\phi)\right)/a^2}\sin(\phi)d\phi. \tag{624}$$

The (623) and (624) provide the following:

$$\frac{d^2x}{dt^2} = 0, \quad \frac{d^2y}{dt^2} \neq 0, \tag{625}$$

which means that there will be a force normal to the unit vector of particle's velocity and acting on the particle. If the radius of the area of localisation of the trajectory of particle's motion will be much less than R_c, then the particle will rotate with the constant magnitude of velocity, with the constant radius of rotation around a certain point.

Let us consider the (624). We write it down as follows:

$$m\frac{d^2y}{dt^2} = \frac{qQ}{2\pi R_c^2} b^{1-\left(v^2+v_c^2\right)/a^2}\Sigma_{(N,\Delta\phi)}, \tag{626}$$

where the definite integral is transformed into the sum:

$$\Sigma_{(N,\Delta\phi)} = \sum_{n=0}^{N/2} b^{-\frac{2vv_c}{a^2}\sin(n\Delta\phi)}\sin(n\Delta\phi)\Delta\phi + \sum_{n=N/2}^{N} b^{-\frac{2vv_c}{a^2}\sin(n\Delta\phi)}\sin(n\Delta\phi)\Delta\phi, \tag{627}$$

$$\phi = n\Delta\phi, \qquad N\Delta\phi = 2\pi, \qquad N\to\infty, \qquad \Delta\phi\to 0.$$

Or:

$$\Sigma_{(N,\Delta\phi)} = \sum_{n=0}^{N/2} \left(b^{-\frac{2vv_c}{a^2}\sin(n\Delta\phi)} - b^{\frac{2vv_c}{a^2}\sin(n\Delta\phi)} \right) \sin(n\Delta\phi)\Delta\phi. \tag{628}$$

As follows from the (628), $\Sigma_{(N,\Delta\phi)} \leq 0$.

Using the (626) and (628), we can conclude the following: if the ring is formed by electrons, the electron interacting with the ring will rotate oppositely to the ring rotation while the proton interacting with the ring will rotate in the same direction as the ring; if the ring is formed by protons, the proton interacting with the ring will rotate oppositely to the ring rotation while the electron interacting with the ring will rotate in the same direction as the ring. If the magnitude of velocity of the particle or magnitude of rotation velocity of the ring will equal to zero, then the force acting on the particle from the side of the charged ring will equal to zero as well.

Therefore, in PPST there is a force analogous of that of Lorentz, acting on the charged particle in the constant magnetic field.

From this chapter we can conclude the following: forces acting in PPST between the moving electric charges either can complete the magnetic interaction of electric charges or can be the forces of magnetic interaction.

31 Dynamic system of bound condensates (DSBC)

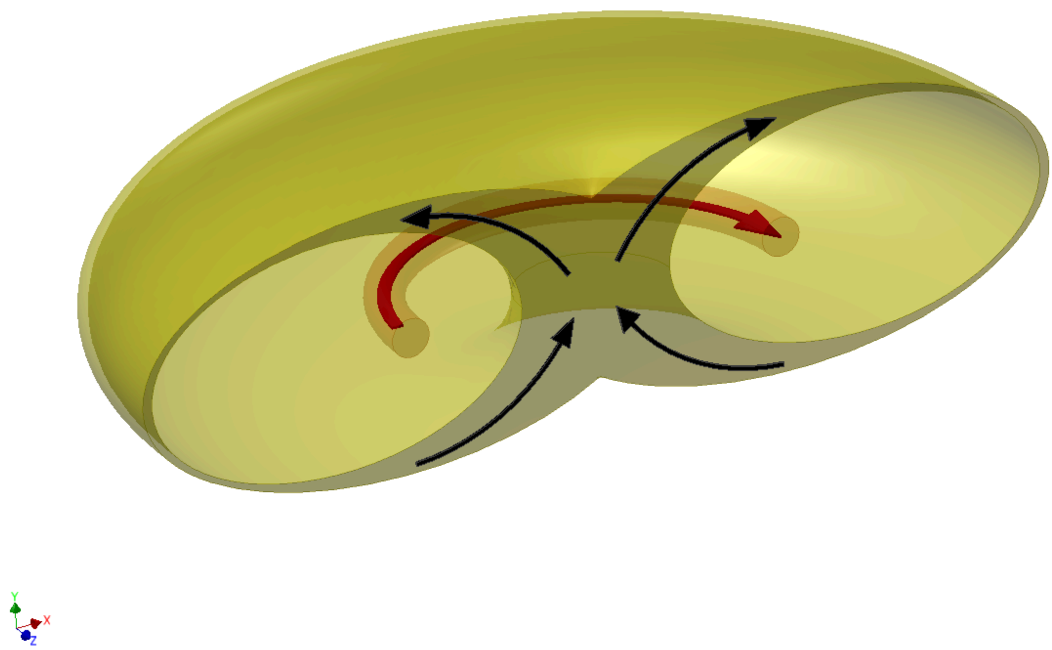

Figure 26: Dynamic system of bound condensates

Within the frame of the point particles states theory, let us obtain a theory of dynamic system of bound condensates. The DSBC theory to be constructed in assumption that conclusions of PPST concerning the existence of free separated volumes of electron and proton condensates are correct.

Figure 26 demonstrates a dynamic system formed by electron and proton condensates. For illustrative purposes the system is demonstrated in cross-section (a half of it). The system consists of a hollow torus of electron condensate formed by bound pairs of electrons (yellow with black arrows) and internal ring of proton condensate formed by bound pairs of protons (reddish with red arrow). Arrows show directions of velocities of flows of condensates. The bound state of condensates of dynamic system should be determined by the values of magnitude of relative velocity of flows of condensates and the distance between them. With the magnitude of relative velocity of flows of condensates greater than a certain value, condensates will attract as oppositely charged fluids (please refer to conclusions at the end of Chapter 14). The positively charged ring is attracted by the negatively charged centre of torus. Inertia forces of rotation of the ring (the flow of condensate) are compensated by attraction forces of protons in the condensate and attraction forces of the centre of torus. In turn, attraction forces of the shell of torus by the ring are compensated by inertia forces of vortex rotation of the electron condensate around the proton condensate. The electron condensate flows into the ring from the one side and flows out from another. Getting around the ring along toroidal surfaces, it flows into the ring again. Therefore, two closed circuits appear, one of them is with the electron current, another is with the proton one, where currents have no resistance. In other words, the dynamic system of bound condensates can be represented as a toroidal vortex of the electron condensate which is held in the stable condition by the internal ring of the proton condensate.

Based on the conclusion at the end of Chapter 14, we can expect that the DSBC will possess rather high stability to dynamic destruction in collision with a substance formed by neutral atoms.

As follows from assumptions made in Chapter 21, the DSBC interacting with volumes of neutral atoms can repel from them. It should occur if the minimum magnitude of velocity of protons in the ring of proton condensate of DSBC relatively the mass centre of DSBC is greater than a certain value while the maximum magnitude of velocity of electrons in the shell of electron condensate relatively the mass centre of DSBC is less than a certain value.

If we consider the interaction of volumes of like particles with neutral atoms analogously to intermolecular forces (please refer to Chapter 25 and Chapter 26), then the interaction of DSBC in the state determined hereinabove with bodies formed by neutral atoms will possibly either weaken the gravitational attraction of these objects or will be the gravitational interaction with the plus sign – i.e., the DSBC and the body will repel. In this case, as the magnitude of velocity of protons in the ring of protons decreases and the magnitude of velocity of electrons in the shell of electrons increases to certain values, the DSBC and the body will attract, i.e., the gravitational repulsion will change to the gravitational attraction.

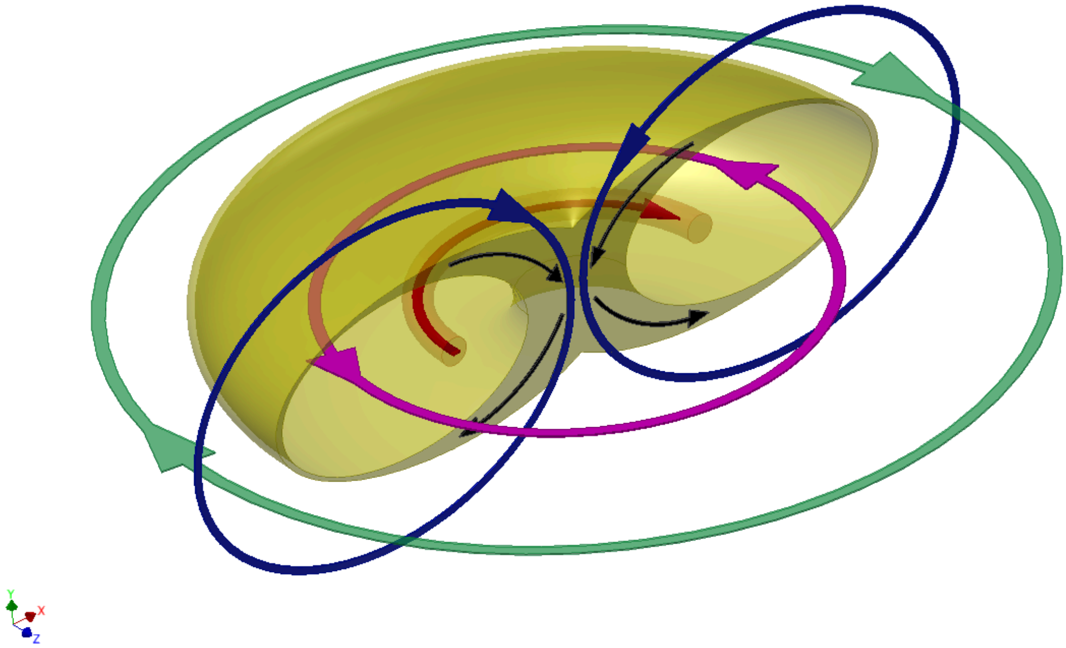

Figure 27: Magnetic fields of DSBC

32 Magnetic fields of DSBC

Closed circuits of the electron and proton currents in the DSBC generate three types of magnetic fields (Figure 27). First type is poloidal (marked with blue at Figure 27), generated by rotation of the ring of proton condensate. Second and third types are toroidal, normal to the first one, generated by the toroidal flow of electron condensate in the external shell. The second field (marked with purple at Figure 27) is locked inside the torus formed by the external shell. The third one (marked with green at Figure 27) is the magnetic field outside the external shell of the DSBC.

While the magnitude and direction of angular rotation velocity of the toroidal shell of electron condensate around the axis of rotation of the ring of proton condensate changes, the magnetic field generated by the ring of proton condensate will either strengthen or weaken, and the poloidal magnetic field of DSBC will be able to change its direction and have the value of magnitude equal to zero.

33 Nuclear synthesis in DSBC

Possibility of the process of nuclear synthesis to occur in DSBC is conditioned by presence of bound pairs of protons in the proton condensate. During the evaporation of electron condensate of toroidal shell, an electron being trapped in the ring of the proton condensate binds to a bound pair of protons. Being bound, two protons and electron form a deuteron. Turning into the bound state, deuterons form alpha particles. Being turned into the bound state both with deuterons and with one another, alpha particles form nuclei of atoms. Therefore, along with the nuclear fusion, a condensate process of nuclear synthesis is also possible in PPST. The process of nuclear synthesis via condensation should be accompanied by stratification of condensates inside the ring under the action of inertia forces on condensates of nuclei synthesised. The nuclear condensate will be formed from the proton one.

Binding free electrons which enter the ring during the process of evaporation of electron condensate, atomic nuclei form neutral atoms. Neutral atoms are also formed when protons and nuclei enter the electron condensate while condensates in the ring evaporate. Thus, the DSBC should synthesise various elements, starting from hydrogen.

34 Formation of DSBC

The process of formation of DSBC can develop in the presence of protons slow relatively to one another in a certain volume where initially there is no electrons. Slow protons will attract compressing the volume and extruding outside protons fast relatively to them. If the magnitude of the sum of moments of momenta of protons slow relatively to one another regarding the mass centre of the volume will have a certain value, then a circular motion of protons of the volume during its compression will begin. Conditions for formation of condensate of protons will appear in the ring of the circular motion, as well as during the motion of like particles in a beam along the closed trajectory (please refer to chapter 14). The ring will expand and contract until the equilibrium between attraction forces of bound pairs of protons in the condensate, centrifugal forces of inertia and repulsion-attraction forces of opposite flows of condensate of rotating ring appears. The ring will start to oscillate around the equilibrium point. If magnitudes of relative velocities of protons in the opposite zones of the ring will be less than the neutral relative velocity of protons, then protons of the opposite zones of the ring will attract, and if at that the ring will contract, then, due to conservation of the sum of moments of momenta of protons relatively to the centre of the ring, the velocity of rotation of the ring will increase. Once magnitudes of relative velocities of protons in the opposite zones of the ring become greater than the neutral relative velocity of protons, forces of repulsion of protons of the opposite zones of the ring will add to centrifugal forces of inertia, and the ring will begin to expand. While the ring is expanding, its rotation velocity will decrease, and the process of expansion will change to that of contraction. Further on, as other particles enter the zone of force interaction with the ring, protons of rotating ring will repel electrons slow relatively to them and protons fast relatively to them and attract protons slow relatively to them and electrons fast relatively to them. In this case, if a toroidal shell of electron condensate appears around the ring of proton condensate, the DSBC is formed.

The ring of proton condensate can form one of two types of DSBC. Both DSBC-A and DSBC-B are shown at Figure 28. They differ by the opposite rotation of vortices of electron condensate relatively to direction of rotation of rings of proton condensate. The synthesis of DSBC can also occur as a process of self-organisation of two DSBCs. Being in the plasma consisting of electrons and protons, DSBC-A and DSBC-B or two similar DSBCs can synthesise the third DSBC on their own.

We will consider the interaction of two DSBCs (DSBC-A and DSBC-B) resulting to formation of the third DSBC in the frame of PPST without analysing these processes as those related to the existence of magnetic fields of DSBC (please refer to Chapter

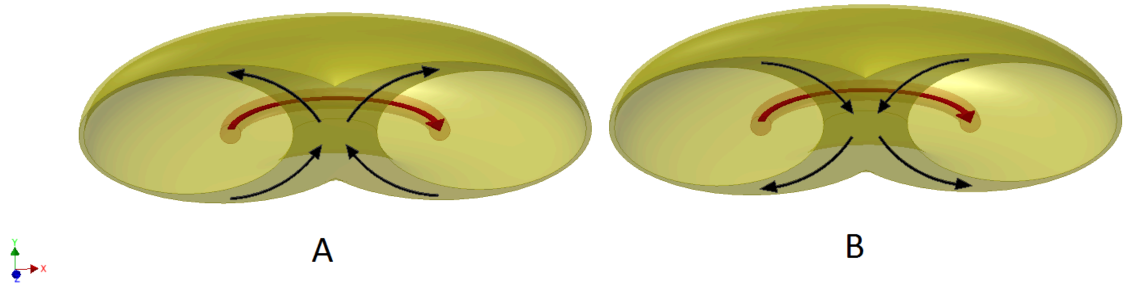

Figure 28: DSBC-A and DSBC-B

32). As it was shown in Chapter 30 and will be shown later, the processes occurring in DSBC either strengthen the magnetic interaction of moving charged particles or are that interaction themselves.

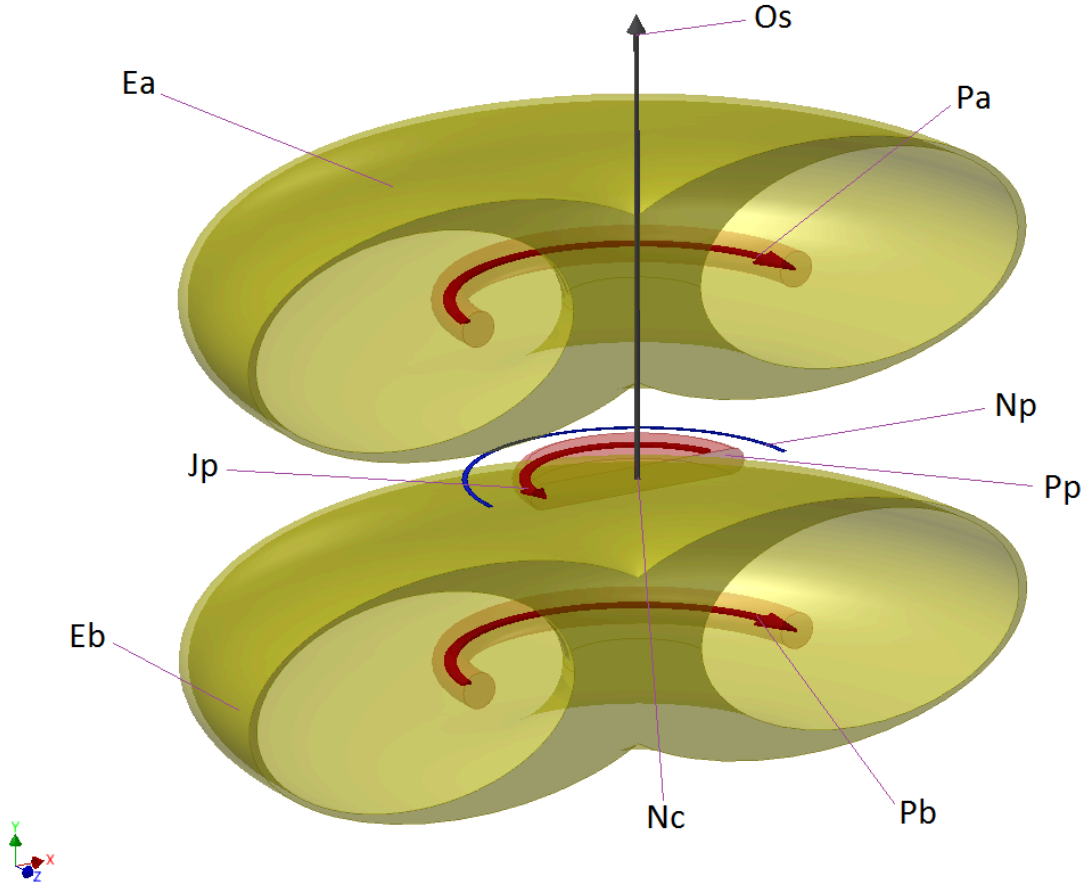

Figure 29: Interaction of DSBC-A and DSBC-B in the plasma

Figure 29 demonstrates one of variants of interaction of DSBC-A and DSBC-B at which a new DSBC can form. The legend of this figure, with pointers (purple lines), contains the following definitions:

Pa is the ring of proton condensate of DSBC-A and its direction of rotation;
Pb is the ring of proton condensate of DSBC-B and its direction of rotation;
Ea is the outer shell of electron condensate of DSBC-A;
Eb is the outer shell of electron condensate of DSBC-B;
Pp is a volume of plasma saturated with protons;
Jp is a direction of rotation of the volume of plasma saturated with protons;
Os is an axis of rotation of rings of DSBCs;
Np is a ring of the zone of zero action of forces of repulsion of protons of plasma by protons of two DSBCs (marked with blue);
Nc is a point of zero action of forces of repulsion of particles of plasma by particles of two DSBCs.

Let us determine the following characteristics of a dynamic system that consists of interacting DSBC-A and DSBC-B (**the system of two DSBCs**) which provide a possibility of formation of a new DSBC:

All geometrical parameters of DSBC-A and DSBC-B coincide one another. Rotation velocities of rings are equal. Rotation axes and directions coincide each other. The number of protons in the proton ring of DSBC-A is equal to that in the ring of DSBC-B. The number of electrons in electron shells is less than the number of protons in the rings (both DSBCs possess equal positive charges). All electrons of electron shells are fast relatively to protons of condensate rings. The value of maximum magnitude of velocities of electrons in the system of two DSBCs relatively to the mass centre of the system is less than the halved value of neutral relative velocity of electrons. The value of the maximum magnitude of velocities of protons of the rings relatively to the mass centre of the system are less than the halved neutral relative velocity of protons.

Being in the plasma formed by electrons and protons, being located relatively one another as demonstrated at Fig. 29, DSBC-A and DSBC-B will attract and approach each other. The attraction will be determined by the following:

First, all protons of the system are slow relatively to one another (all protons of the system attract each other) since the maximum magnitudes of velocities of protons of the rings relatively the mass centre of the system are less than the halved value of neutral relative velocity of protons.

Second, electrons of the system are fast relatively to all protons (all electrons of the system attract all protons of the system).

Third, all electrons of the system are slow relatively to one another (all electrons of the system attract each other) since the value of maximum magnitudes of velocities of electrons in the system of two DSBCs relatively to the mass centre of the system is less than the halved value of neutral relative velocity of electrons.

Protons and electrons of the plasma magnitudes of which velocities lay within certain ranges of values and which have certain directions of unit vectors of their velocities in the coordinate system linked to the mass centre of interacting DSBCs will be extruded from the plasma located between DSBC-A and DSBC-B approaching one another to **a plane, which is formed by forces of repulsion of the plasma particles by particles of the system of two DSBCs, where the forces acting on particles and normal to the plane are lacking, and which will lay midway between DSBCs approaching one another (the plane of zero normal action)**.

The overall electric charge of each DSBC is positive. Positive charge of protons will be located compact in the rings of proton condensate. Negative charge of electrons will be distributed over the whole volume of toroidal shells of DSBC. Hence, we should estimate that protons of rings will mainly act to force particles of plasma in and out of zone of interaction of two DSBCs. Therefore, most of extruded protons of plasma should be fast relatively to protons of rings of DSBCs while most of extruded electrons of plasma should be slow relatively to protons of rings of DSBCs. Electrons of shells of DSBCs will also affect particles of plasma; however, taking into account the distribution of charges in the system and a certain difference in the quantities of charges of rings and shells and hence considering this affection insignificant compared to the action of protons of rings of DSBCs, we can determine conditions of formation of ring-shaped zones of zero action of forces of repulsion of protons and electrons of plasma by protons of two DSBCs. These conditions are determined in Appendix 1 (Chapter 44).

Electrons and protons of plasma are fast relatively to protons of rings of DSBCs, hence, mainly protons of plasma will be extruded to the plane of zero normal action. One part of these protons of plasma located outside the ring-shaped zone of zero action of forces of repulsion of protons of plasma by protons of two DSBCs (Np) will be extruded from the area of approach of two DSBCs. Another part of protons of plasma located inside the ring-shaped zone will be intruded deep inside the ring-shaped zone, to its centre, i.e., to the point of zero action of forces of repulsion of particles of plasma by particles of two DSBCs (Nc). This will be a result of common action of protons of two DSBCs on protons of plasma. Therefore, there will be a certain volume of the plasma saturated by protons, formed within the plane of zero normal action, inside the rung-shaped zone of zero action of forces of repulsion of protons of plasma by protons of two DSBCs. This volume will be forming under the action of centripetal forces appearing due to the action of forces of repulsion of protons of plasma by proton rings of two DSBCs to the area of point of zero action of forces of repulsion of particles of plasma by particles of two DSBCs, under the action of forces extruding protons of plasma to the plane of zero normal action, under the action of inertia forces appearing during the motion of protons of plasma within the limited volume, and under the action of forces of interaction of protons inside the volume.

This process can be represented graphically by consideration of summarised action of forces of repulsion by protons of two rings of DSBCs on a proton of plasma fast relatively to them (Figure 30).

We will consider the action of forces within the plane of a cut of the system of two DSBCs passing through the axis of rotation of the rings of DSBCs (Os). The legend of Figure 30 includes the following definitions:
Os is the axis of rotation of the rings of DSBCs;
Nl is a line of intersection of the plane of zero normal action and the plane of the cut of the system of two DSBCs;
Pa1 is a zone of summarised forces of action of protons of the ring of DSBC-A located to the left from the plane to which Nl is normal and which is passing through the point of location of the proton of plasma on which these forces are acting;
Pa2 is a zone of summarised forces of action of protons of the ring of DSBC-A located to the right from the plane to which Nl is normal and which is passing through the point of location of the proton of plasma on which these forces are acting;
Pb1 is a zone of summarised forces of action of protons of the ring of DSBC-B located to the left from the plane to which Nl is normal and which is passing through the point of location of the proton of plasma on which these forces are acting;
Pb2 is a zone of summarised forces of action of protons of the ring of DSBC-B located to

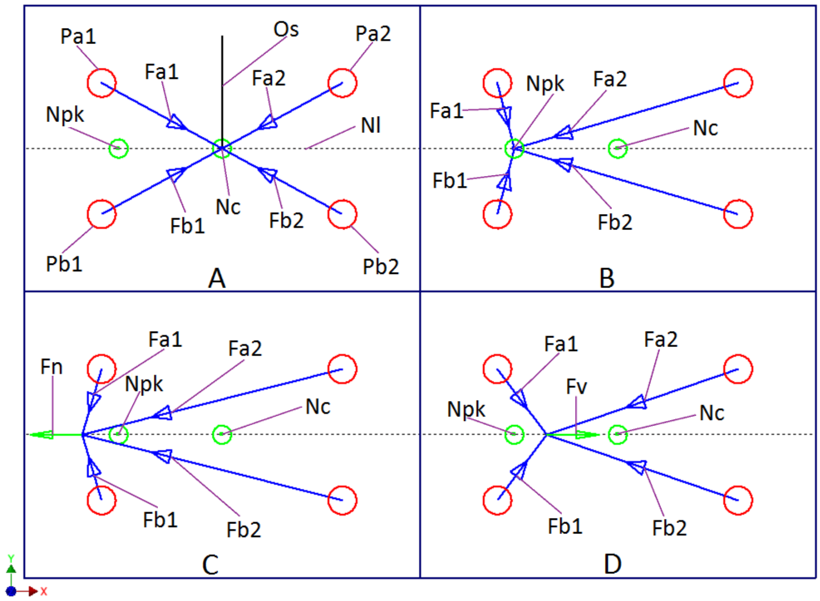

Figure 30: Action of protons of the rings of two DSBCs on the proton of plasma fast relatively to them

the right from the plane to which Nl is normal and which is passing through the point of location of the proton of plasma on which these forces are acting;
Fa1 is a force of action of the Pa1 zone;
Fa2 is a force of action of the Pa2 zone;
Fb1 is a force of action of the Pb1 zone;
Fb2 is a force of action of the Pb2 zone;
Npk is an intersection point of the plane of the cut of the system of two DSBCs and the ring-shaped zone of zero action of forces of repulsion of protons of plasma by protons of rings of two DSBCs;
Nc is the point of zero action of forces of repulsion of particles of plasma by particles of two DSBCs;
Fn is a force of repulsion of the proton of plasma by protons of rings of the system of two DSBCs which extrudes the proton of plasma outside the zone of zero action of forces of repulsion of protons of plasma by protons of two DSBCs;
Fv is a force of repulsion of the proton of plasma by protons of rings of the system of two DSBCs which intrudes the proton of plasma inside the zone of zero action of forces of repulsion of protons of plasma by protons of two DSBCs.

In the sector A (Fig. 30) the sum of Fa1, Fa2, Fb1 and Fb2 forces acting on the proton of plasma located at the Nc point equals to zero. In the sector B (Fig. 30) the sum of Fa1, Fa2, Fb1 and Fb2 forces acting on the proton of plasma located at the Npk point also equals to zero. In the sector C (Fig. 30) the Fn force is the sum of Fa1, Fa2, Fb1 and Fb2 forces acting on the proton of plasma, it is not equal to zero and directed to the left from the Npk point, i.e., to infinity from the Npk point. In the sector D (Fig. 30) the Fv force is the sum of Fa1, Fa2, Fb1 and Fb2 forces acting on the proton of plasma, it is also not equal to zero and directed to the right from the Npk point, i.e., to the Nc point.

While DSBC-A and DSBC-B approach, the pressure upon the localised volume of plasma saturated with protons will increase. Compression of volume, with the presence of a certain sum of moments of momenta of particles in it, will result to the formation of a rotating ring (**the new ring**) produced by this volume. According to conclusion from Chapter 14, protons inside the new ring can attract both along circular trajectories and crosswise them. If the density of protons in the new proton ring reaches a certain value, then the formation of the proton condensate in it will become possible.

Along with the increase of the number of protons coming from the plasma into the new ring where the proton condensate is formed, and while the distance between DSBC-A and DSBC-B decreases, the forces of repulsion of DSBC-A and DSBC-B by the new ring will strengthen. Once the repulsion forces become stronger than those of attraction between two DSBCs so that DSBC-A and DSBC-B begin to scatter (i.e., the distance between them starts to increase), centripetal forces acting in the new ring will start to weaken. The new ring of the proton condensate will start to expand under the action of centrifugal forces. The velocity of rotation of the new ring will begin to slow down. If protons of this ring will be able to turn into the bound unsteady state as protons of the ring formed by protons slow relatively to one another (the process is described at the beginning of this chapter), then the new ring attracting electrons fast relatively to itself will be able to form a new DSBC.

The process of formation of the new ring as described hereinabove is similar to the process of formation of the current sheet by magnetic fields in the plasma. The difference between the formation of the current sheet and the formation of the new ring in PPST is that the current sheet is forming on surfaces of zero values of magnetic fields generated by the motion of charged particles in the plasma, whereas the new ring of the proton condensate should be formed inside the ring-shaped zone of zero action of forces of repulsion of protons of plasma by protons of the system of two DSBCs. As follows from Chapter 30, in other respects the processes are similar.

35 Interaction between two DSBCs without formation of a new DSBC

The process of formation of the dynamic system of bound condensates during the interaction of two DSBCs considered in the previous chapter is greatly simplified, not taking into account many factors which can affect this process negatively.

Let us consider the situation when DSBC-A and DSBC-B having characteristics and interaction conditions as determined hereinabove approach surrounded by the plasma consisting of protons and electrons, then halt and begin to scatter under the action of forces of repulsion of the new ring by the plasma saturated with protons without formation of a new DSBC. In this case the increase of the distance between DSBC-A and DSBC-B will result to the decrease of magnitude of centripetal forces acting of particles of plasma of the new ring, and if centrifugal forces of inertia allow the plasma of the new ring saturated with protons to displace from the internal area of the ring-shaped zone of zero action of forces to its external area, then in the external area the plasma of the new ring will leave the system under the action of inertia forces, repulsion forces between protons of plasma and forces of repulsion by protons of two DSBCs. The process of bremsstrahlung of emitting particles of the new ring during their slowing down in the plasma surrounding the system of two DSBCs will begin. Emitting particles will interact with particles of electron and proton condensates of the system of two DSBCs at the zero velocity. The process of evaporation of condensates will begin (please refer to Chapter 14) and the ejection of protons and electrons from condensates will occur. Then, after ejection of plasma of the new ring and particles during the evaporation of condensates, DSBC-A and DSBC-B will start to approach again. These processes will repeat until either one of DSBCs disintegrates or DSBCs scatter turning into the free state. DSBCs can also merge into one or form the bound system of two DSBCs.

If DSBC-A and DSBC-B will have the moment of momentum relatively their mutual mass centre so that centrifugal forces of inertia will prevent their approach but DSBCs will not turn into the free state, then DSBCs can form the system of two bound DSBCs. In case of termination of the plasma inflow into the zone of approach of DSBC-A and DSBC-B at the moment when DSBC-A and DSBC-B start to approach after scattering again and inertia forces in the new ring will be unable to eject the plasma of the new ring outside the ring-shaped zone of zero action of repulsion forces, DSBCs will start to rotate relatively to their mutual mass centre, and if their state will not be steady, they will begin the oscillatory motion relatively the new ring, i.e., their approach will be changing to scattering and vice versa. If the new ring will be pushed outside the zone of interaction of two DSBCs, DSBCs will begin to rotate relatively to one another under the action of attraction forces and inertia forces without participation of the new ring. Therefore, two DSBCs can form the system of two bound DSBCs either with the new ring or without it.

The process of PPST of ejection of plasma of new rings saturated with protons by two DSBCs from the zone of their interaction is similar to the process of plasma ejection during the magnetic reconnection. The qualitative description of the process of magnetic reconnection with ejection of plasma agrees with the qualitative description of the process of plasma ejection in PPST during the interaction of condensate flows having a certain curvature of their trajectories both between themselves and with particles of plasma.

36 The system of two bound DSBCs

Figure 31 demonstrates the internal structure of the system formed by two DSBCs. Here: 1 is DSBC-A; 5 is DSBC-B; 4 are the rings of proton condensates (marked with red); 6 are toroidal shells of electron condensates (marked with yellow); 8 is the neutral plasma (marked with pink); 2 is the liquid melt (marked with blue); 3 is the crystalline shell (marked with black); 7 is either the zone of the new ring or the zone which structure is close to crystalline (marked with grey).

The model of the system of two bound DSBCs is created upon the assumption that DSBC-A and DSBC-B having the characteristics and conditions of interaction as determined in Chapter 34, being initially joined in the presence of a certain amount of the plasma, begin to rotate relatively to one another and make oscillatory motion around the equilibrium point without any additional income of the plasma to the area of the new ring (please refer to Chapter 35).

During the process of motion of the system of two bound DSBCs in the outer space, the electron condensate due to interaction of particles presented in the space will start to evaporate. The process of evaporation of electron condensate launches the process of nuclear synthesis of various chemical elements in the rings of proton condensate (please

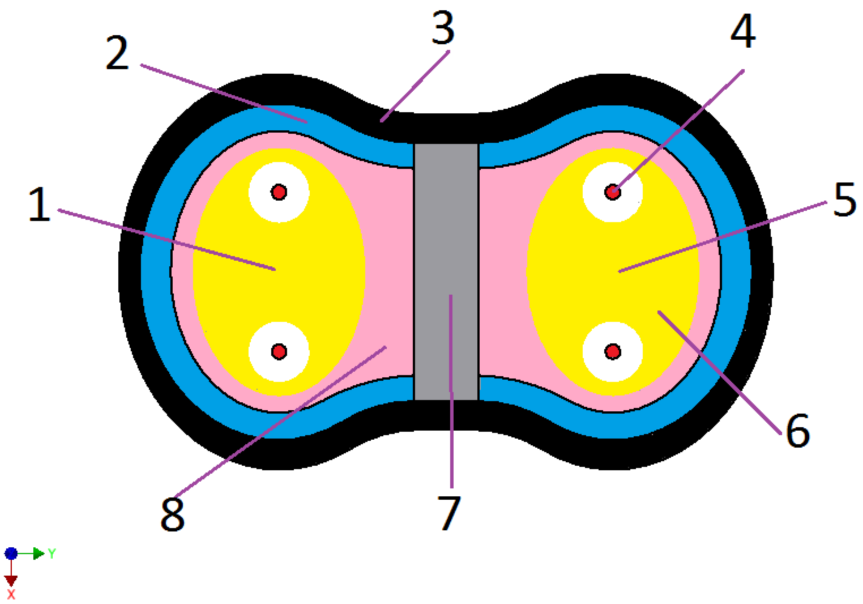

Figure 31: Internal structure of the system of two bound DSBCs

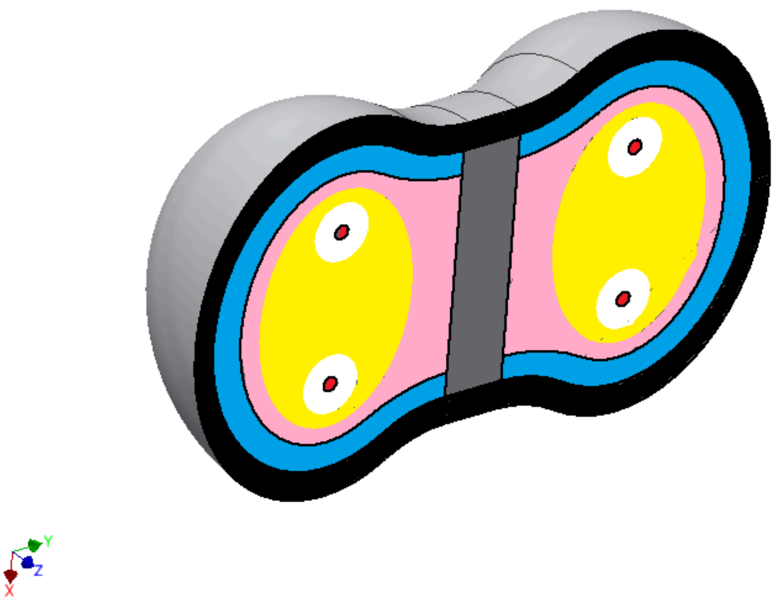

Figure 32: The cut of the spatial model of the system of two bound DSBCs

refer to Chapter 33). Obtained nuclei and atoms along with the cosmic dust form the neutral plasma, liquid melt and crystalline shell around the system of two bound DSBCs. It will be possible if magnitudes of velocities of protons in both DSBCs relatively to the mass centre of the system of two bound DSBCs will not exceed a certain value while magnitudes of velocities of electrons in both DSBCs relatively to the mass centre of the system of two bound DSBCs will be greater than a certain value, when DSBCs attract neutral atoms (please refer to Chapter 21).

Being under the action of inertia forces, nuclei of various chemical elements synthesised in the proton rings will get to the electron shells of DSBCs, forming neutral atoms, and then will be extruded to the surface of the system. Heavy elements will begin to increase the thickness of the crystalline shell whereas light elements being in the gaseous state will leave the system through cracks and pores which they will produce. The process of formation of the crystalline shell of the system of two bound DSBCs is analogous to the process of formation of a planetary crust where volcanoes erupting lava, gases and ashes exist, forming mountains and cracks of the crust.

If during the formation of the system the new ring remains inside the system, then the zone 7 at Fig. 31 will be the zone of the new ring. If the ring leaves the system or disintegrates inside it, the zone 7 will have the structure close to crystalline. Once a crystalline partition between two DSBCs is formed in the zone 7, oscillations of DSBCs relatively to one another will become the minimum. The surface of the crystalline partition will differ from the rest surface of the crystalline shell of the system of two bound DSBCs. There should be less signs of volcanic activity since inertia forces in the proton rings eject synthesised nuclei mainly within the plane of rotation of the rings, and inertia forces arising due to rotation of DSBCs relatively to one another will remove synthesised nuclei away from the crystalline partition.

The magnetic field around the system of two bound DSBCs allows for detection whether there are active DSBCs inside the crystalline shell or not. If the magnetic field exists, then either one or two active DSBCs are there. If there is no magnetic field, then both DSBCs have been disintegrated, and the system will be a porous crystalline formation with caves inside.

Figure 33 demonstrates a photograph of a comet which is more relevant to description of the bound system of DSBCs. Figure 34 shows the Itokawa asteroid which matches the description of crystalline shell inside which the DSBCs have been disintegrated. As it turned out [30], the density of the substance inside the asteroid is varying from 1.75 to 2.85 grams per cubic centimetre. These two characteristic values of density relate to two different parts of the asteroid. However, as it was discovered by the Japanese scientists who researched the samples delivered to the Earth from the surface of asteroid, Itokawa can be considered as a source of ordinary chondrites which density varies from 2 to 3.7 grams per cubic centimetre. This shows that caves and pores inside the Itokawa asteroid can be distributed unevenly.

The MD 2011 asteroid can also be a former comet. Studying this asteroid using the Spitzer orbital telescope, the US National Aeronautics and Space Administration found that the diameter of the asteroid is six metres and its mass is about 100 tons. Due to peculiarities of the structure, the density of asteroid is rather small. Scientists presume that either there are big caves inside the MD 2011 or asteroid consists of discrete rocks held together by the gravity force [31].

Based on the theory of DSBC and the theory of the system of two bound DSBCs,

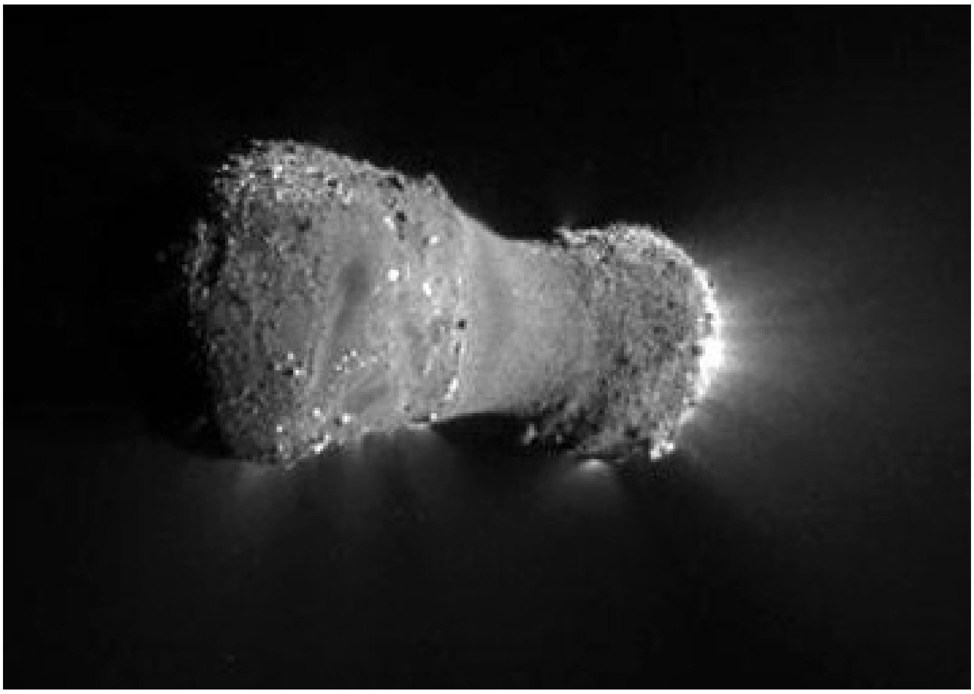

Figure 33: The photograph of the 103P/Hartley comet from November 4th, 2010

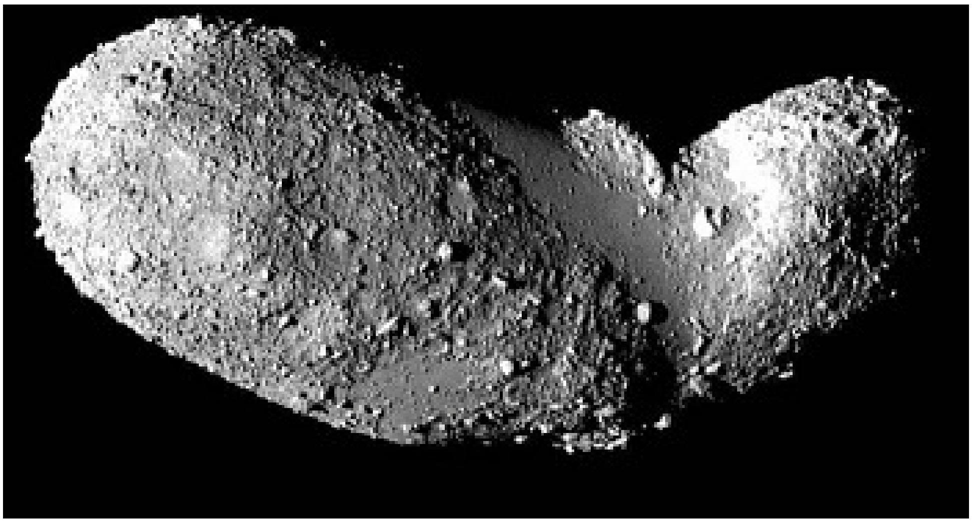

Figure 34: The Itokawa asteroid. Photo by NASA

one can presume that condensates of DSBCs are the main threat during collisions of such objects with the Earth. If we find a way of neutralisation of condensates before collision with the Earth, then only the debris of the crystalline shell can reach the Earth. It concerns active DSBCs but not the case of the Itokawa asteroid. Although asteroids similar to Itokawa, consisting of the crystalline shell with no active DSBCs inside, should disintegrate in the atmosphere of the Earth to rather small debris.

Such debris rather often collides with the Earth. It happens as the Earth passes orbits of comets. Most likely the disintegration of crystalline shells of comets occurs when they pass close to the Sun, entering its atmosphere. The alteration of luminosity of the ISON comet while it approached the Sun in the middle of November, 2013, can be an example of this event (Figure 35).

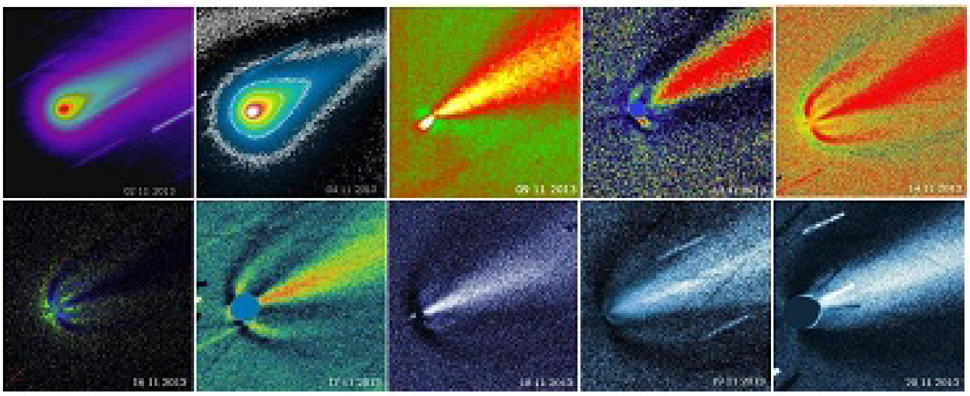

Figure 35: The ISON comet

For a single DSBC moving in the outer space all processes will be analogous to those for the bound system of two DSBCs. Processes related to the new ring will be lacking in the single DSBC.

37 Free volume of the proton condensate

If a certain volume of the proton condensate would exist in the outer space, then in theory it could form the liquid melt and the crystalline shell at its surface. For doing that, it has to accept cosmic electrons which should participate in nuclear synthesis and formation of neutral atoms. If formed nuclei and neutral atoms will be slow relatively to protons of the condensate, then they will attract both the volume of condensate and each other, forming the liquid melt and the crystalline shell. The free volume of the proton condensate surrounded with crystalline shell and formed as a result of this process can have some magnetic field generated by flows of condensate. The free volume of the proton condensate surrounded with crystalline shell will have an excess of slow protons. Free volumes of condensates can be bound. If protons of volumes will be slow relatively to one another, then volumes will attract, having a possibility to turn into the bound state. Hence, comets similar to 103P/Harley (see Figure 33) can be the systems of two bound volumes of the proton condensate.

38 The system of two bound DSBCs in the atmosphere of Earth

What processes happen if a system of two bound DSBCs would enter the Earth's atmosphere at the speed typical for bodies of the Solar System? Based on the theory of the system of two bound DSBCs considered in Chapters 35, 36 and 37, let us determine these processes.

First is heating and destruction of the crystalline shell.

Second is dispersion of liquid melt and plasma in the atmosphere.

Third is interaction between electron condensate of toroidal shells and the atmosphere, and, as a consequence, formation of atmospheric plasma, evaporation of condensates, nuclear synthesis.

Fourth is formation of the new ring consisting of ions of atmospheric plasma and vapours of condensates.

Fifth is ejection of particles of the new ring from the zone of interaction of two DSBCs.

Sixth is bremsstrahlung of particles of the new ring in the atmospheric plasma.

Seventh is ejection of electrons, protons and nuclei during the evaporation of condensates, and, as a consequence, the bremsstrahlung of electrons, protons and nuclei in the atmosphere.

Eighth is repetition of processes from the third to the seventh inclusive.

What can be observed during occurrence of these processes?

1. The change of visible spectrum of object glow along the trajectory.

It appears as a result of the succession of processes: first – second – eighth. Initiation of glow will be determined by the spectrum of radiation during the heating and destruction of the crystalline shell in the atmosphere of the Earth. The second stage of glow is related to dispersion of the liquid melt. The third one is related to the radiation during the ejection of electrons, protons and ions to the atmosphere. And the fourth stage is related to the radiation due to the burning of gases being formed.

2. Coherent radiation.

This is a consequence of the sixth and the seventh processes. The coherent bremsstrahlung appears during the deceleration of electron beams by counter beams of ions [32]. Electrons and protons of evaporating condensates as well as the plasma particles of the new ring can produce the coherent bremsstrahlung on ions in the atmosphere.

3. Pulsing glow of the object.

Appears as a consequence of repetition of the eighth process.

4. Ejections of plasma followed by the decrease of radiation energy of the object.

This is a consequence of the seventh process.

5. Force interaction of isolated objects formed due to all processes.

Attraction and repulsion between DSBCs. Interaction of non-evaporated volumes of condensates remained after the disintegration of DSBCs.

6. Radiation within the radio frequency range which can be registered at the acoustic frequencies (20 Hz – 20 kHz) during the motion of the object.

This phenomenon is analogous to the observation of low-frequency radio waves during either the motion of flows of charged particles or at the moment of appearance of electric discharges in the atmosphere [33], [34]. The ejection of charged particles of the new rings and vapours of condensates into the atmosphere is the process similar both to the motion of flows of charged particles and to atmospheric electric discharges.

7. UV radiation during the glow of the object.

It is related to the bremsstrahlung of fast charged particles in the atmosphere during the ejection of particles of the new rings and particles during the evaporation of condensates.

8. Flows of energetic charged particles.

This is a consequence of evaporation of condensates of DSBCs.

What happens after the completion of these processes?

1. Fallout of debris of a certain mass and size and their certain distribution at the Earth's surface relatively to the flight trajectory and areas of glow along the trajectory.

The destruction of the crystalline shell should occur along cracks and caves through which the synthesised gas has been flown out. Due to the fragility and taking into account the average speed of bodies of the Solar System, the destruction of the crystalline shell should occur rather quickly and at high altitudes above the Earth's surface. The size of large fragments should correspond to the thickness of the crystalline shell. The formation of larger debris is possible within the zone of crystallised new rings.

Knowing parameters of motion, the motion trajectory and coordinates of the point of destruction of the crystalline shell, using formulas and methods described in Appendix 2 (Chapter 45) at the end of this study, one can determine the maximum distances which the debris of a certain mass will cover from the point of destruction.

2. Formation of a dust cloud at the altitude of dispersion of the liquid melt.

Once the crystalline shell is destroyed, the liquid melt and the plasma will begin to disperse under the action of the counter atmospheric airflow. Crystallisation of dispersed liquid melt will form a dust tail which will spread along the trajectory below the altitude of destruction of the crystalline shell and above the starting point of mass ejection of charged particles into the atmosphere.

3. A two-component constituent of dropped fragments and a thin layer of debris' coating.

The existence of two types of dropped fragments is the result of the presence of the crystal structure formed before the shell has been destroyed and formed by the liquid melt after the destruction of the crystalline shell.

The debris of the crystalline shell should be coated with the thin layer of hardened liquid melt during their flight through the liquid melt dispersed by the atmosphere. This coating layer should be lacking in the ruptures appeared after the fragments flew through the liquid melt.

4. Ionospheric changes after the flight of the object.

Ionospheric processes should be periodic. The periodicity is the result of repetition of the eighth process. Probably the periodic process of evaporation of electron and proton condensates will mostly impact ionospheric layers. During the evaporation of condensates due to the action of radiation of a certain energy appearing upon the ejection of particles of the new rings into the atmosphere the velocity of evaporating electrons will be faster than the velocity of evaporating protons. Fast electrons will be the first to enter the Earth's atmosphere. They will form a negative volume charge. Fast protons will enter the atmosphere after electrons, forming a positive volume charge. Electromagnetic pulses appearing during this process will impact the ionosphere in a certain way. The bremsstrahlung within the continuous spectrum from the UV range to the radio range appearing during the motion of charged particles through the atmosphere also contributes into ionospheric phenomena [35].

5. The process of burning and burst of the gas in the trail of the object resulting to formation of the water vapour.

The trail of the object in the Earth's atmosphere below the zone of dispersion of the liquid melt and the plasma of the system of bound DSBCs will be the plasma mainly consisting of nitrogen and oxygen (i.e., the components of the Earth's atmosphere), hydrogen (protons of the condensate of the rings of DSBCs) and ions of chemical elements which nuclei have been synthesised in the proton-nuclear condensate of DSBCs. Depending on the concentration of oxygen and hydrogen, either burning or bursts will occur in the various zones of the trail. The final product of this process is the water vapour. Therefore, the trail of such event below the dust cloud will consist of water vapour, compounds of nitrogen with hydrogen and compounds with the presence of elements synthesised by the pair of bound DSBCs.

6. Formation of zones of increased temperature in the trail of the object in the atmosphere.

As a result of periodic processes of formation and ejection of the new rings followed by evaporations of condensates and ejections of charged energetic particles, some sections of trajectory at which these processes occur will have a higher temperature. As a consequence, these sections of trajectory will have a brighter luminosity compared to that of sections between them. Therefore, the trajectory beyond the dust trail should be an alternation of bright and dark sections.

7. Blast waves from many sources along the flight trajectory.

The blast waves should be generated by the following processes:

1. ejection of electrons, protons and atomic nuclei into the atmosphere during the ejection of the new rings and evaporation of condensates;

2. bursts of the gas (a mixture of hydrogen and oxygen) formed in the trail.

Due to periodicity of ejection of charged particles, the sources of bursts will be located at certain distances from one another along the trajectory of motion of the object. Bursts will occur at some certain intervals of time. Thus, one can observe a lot of acoustic effects from bursts following one another, occurring at different points of the trajectory, some discrete blast waves at a certain distance from the burst epicentres and infrasonic waves generated by these bursts and outgoing from the moving source.

Only three processes would be realised during the entry of a single DSBC into the Earth's atmosphere:

First is heating and destruction of the crystalline shell.

Second is dispersion of liquid melt and plasma in the atmosphere.

Third is interaction between electron and proton condensates and the atmosphere, and, as a consequence, formation of atmospheric plasma, evaporation of condensates, nuclear synthesis.

What would happen during the motion of the free volume of the proton condensate in the atmosphere of the Earth?

First, the crystalline shell will be destroyed.

Second, the liquid melt will be dispersed.

Third, the evaporation of the proton condensate during its interaction with the atmosphere will begin as well as the nuclear synthesis at the surface of the condensate as electrons enter it.

Further on, if the velocity of motion of the proton condensate relatively the atmosphere will be quite slow, then the condensate will be uniformly heated and evenly evaporated. However, if due to the fast velocity of the volume of condensate during its interaction with the Earth's atmosphere the mass process of evaporation of the proton condensate begins at its surface and a deep surface layer of vaporised condensate is formed, then the condensate can start evaporating impulsively. The volume of condensate will eject free protons fast relatively to the condensate from its surface. The expanding sphere of fast protons will enter the atmosphere, simultaneously compressing the volume of remained condensate. If due to compression and radiation caused by fast protons in the atmosphere the temperature of the surface layer of the volume of proton condensate reaches the critical value, the second ejection of condensate will follow the first, the third ejection will follow the second, etc. This pulsed process of evaporation of condensate can be analogous to the process of appearance of the Bragg peak of ionisation of atoms during the transition of the beam of protons through the volume of these atoms (please refer to Chapter 18). Once the magnitude of velocity of first beams of protons relatively the mass centre of remaining condensate due to its deceleration in the atmosphere becomes less than the halved neutral relative velocity of protons, the mass interaction of protons of beams with protons of condensate at the zero velocity will occur, and the new impulse of evaporation will follow. Explosive processes and the counter atmospheric flow can split the condensate into smaller volumes which will attract and fly in groups evaporating either gradually or impulsively.

Therefore, we can conclude the following:

The processes occurring during the motion of the system of two bound DSBCs, or the single DSBC, or the free volume of the proton condensate will result to the same consequences differing very little from one another. Thus, the most complete list of signs of the motion of such objects in the Earth's atmosphere is presented in the analysis of events occurring during the motion of the system of two bound DSBCs. Then the comparison of motion of a space object through the atmosphere of Earth to the theory of the system of two bound DSBCs will also include the comparison to the theory of the single DSBC and to the theory of the free volume of the proton condensate.

According to PPST, in nuclei of atoms there are protons slow relatively to one another and electrons slow relatively to one another. In other words, nuclei of atoms consist of the proton and the electron condensates. During the nuclear blast the evaporation of both proton and electron condensates occurs. Thus, instruments and methods of observation of atmospheric nuclear blasts will be applicable for the observation of processes related to entrance of DSBCs and free volumes of proton condensates into the Earth's atmosphere.

39 Phenomenon of "Chelyabinsk meteor"

Destruction of an object from outer space occurred on 15 February 2013 over Chelyabinsk is the first event in the history of mankind which manifestation has been observed and registered almost fully. In order to study this event, we will compare the information obtained from observations and conclusions based on this information to the theoretical conclusions of Chapter 38.

What has been observed during the motion of the object through the atmosphere of Earth?

1. The change of the visible spectrum of glow of the object along the trajectory.

Figure 36 represents two snapshots of a footage [36] which demonstrate the change of luminosity after the crystalline shell of the pair of two bound DSBCs has been destroyed. Based on this footage, we can conclude that the destruction of the shell occurred approximately at a height of about 50 to 40 kilometres.

Figure 36: The change of luminosity after the destruction of the crystalline shell

2. Coherent radiation.

Figure 37 demonstrates a snapshot of a footage [37] and Figure 38 shows two snapshots of a footage [38].

These two footages have been taken in two different parts of Chelyabinsk City. Perhaps the provided shots captured the interference at car windscreens of coherent bremsstrahlung of beams of electrons or protons during the ejection of particles of the new rings or particles of evaporating condensate in the ionised atmosphere. Various colours of coherent bremsstrahlung (purple and green) can be the consequence of the presence of atoms and molecules of nitrogen and oxygen in the atmosphere of Earth which electrons' perturbation has been registered by video recorders during the interaction of electrons of atoms at the zero velocity with beams of charged particles.

3. Pulsing glow of the object.

As it will be shown later, the intervals between the bursts are very short. Almost all video recorders react differently on the change of glow. Therefore, the detection of this event is quite difficult. However, it is visible at a footage [39].

4. Ejections of the plasma with the further decrease of the radiation energy of the

Figure 37: The interference at the car windscreen

Figure 38: The interference at the car windscreen

object.

The largest ejection of the plasma after which the glow of the object has been interrupted is demonstrated at Figure 39 (a snapshot of a footage [40]).

Figure 39: Ejection of the plasma

Two dark spots at the snapshot are the consequence of shading of light spots (i.e., the brightest zones) by the video recorder. The first, large spot continues its motion while the small one remains where it is, gradually dying down.

5. Force interaction of isolated objects formed due to all processes.

This phenomenon is visible at the large number of footages. Figure 40 demonstrates two snapshots of a footage [41]. As is seen on the snapshots, one object overtakes another. Then they fly along, not outrunning each other. Another snapshot of this footage (Figure 41) shows that later on the objects have split up. Figure 42 demonstrates four snapshots of a footage [42]. Here one can also observe the force approach of objects 5 and 6 (Fig. 42) and their further motion in a pair. Other objects, 1-2 and 3–4, also fly in pairs despite their relative dimensions (one of them is bigger than another). The termination of glow of objects most likely means the completion of the process of evaporation of condensates.

6. Radiation in the radio frequency range which can be registered at the acoustic frequencies (20 Hz – 20 kHz) during the motion of the object.

Figure 43 demonstrates the frequency characteristics of two tracks of a stereophonic audio record (horizontal axis is time in seconds, vertical axis is frequency from 0 to 20 kHz, intensity of radiation is marked with colour) extracted from a video file [43].

Figure 44 shows a cutting from the upper track of audio record. This part of audio file contains outbursts of radio radiation during the glow of object. Figure 45 demonstrates the enlarged cutting of the central part of this radiation. The second channel of the stereophonic record taken by the video recorder contains all sounds whereas the first channel contains the radio noise only. Most likely the microphone of the first channel was defective and worked only as a radio antenna, not as a microphone. Radio interference registered onto the first track presents at the second as well but it is overlapped by audio record. Superposition of audio record from the first track on video records taken by other recorders demonstrates that radio outbursts correspond to periods of glow, to

Figure 40: Interaction of objects

Figure 41: Interaction of objects

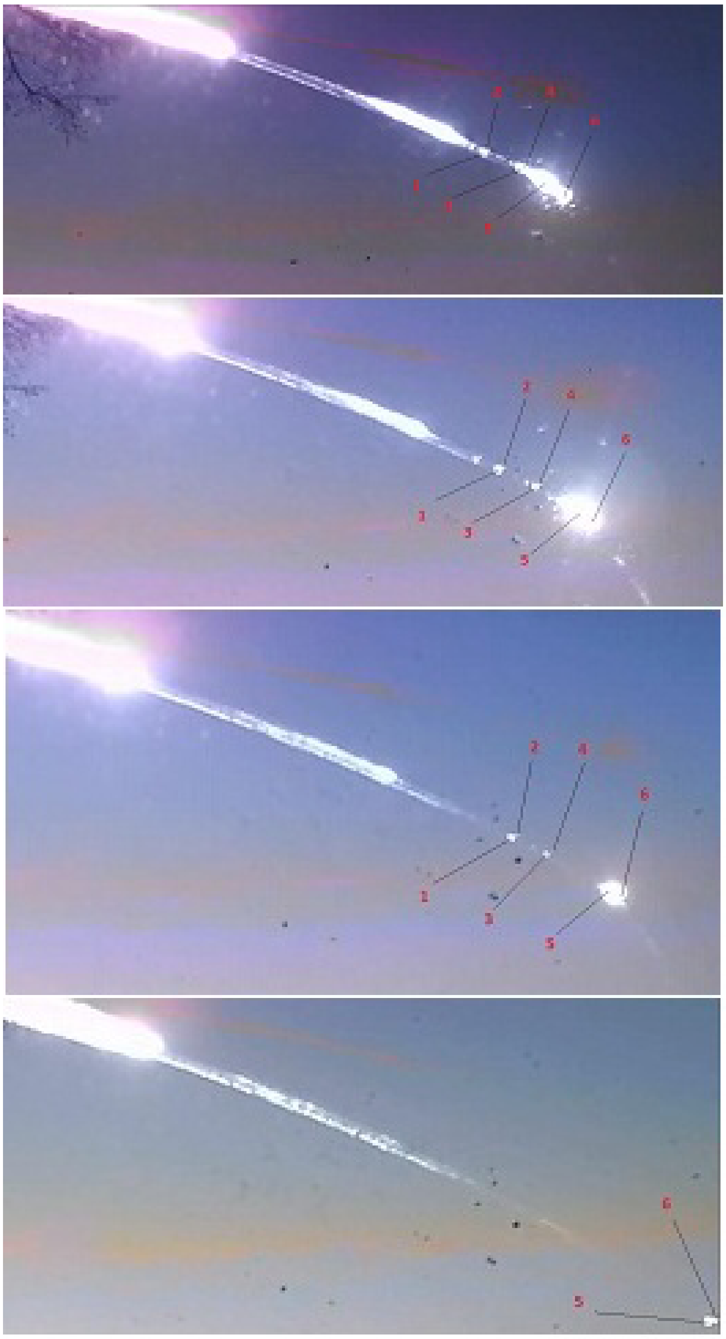

Figure 42: Interaction of objects

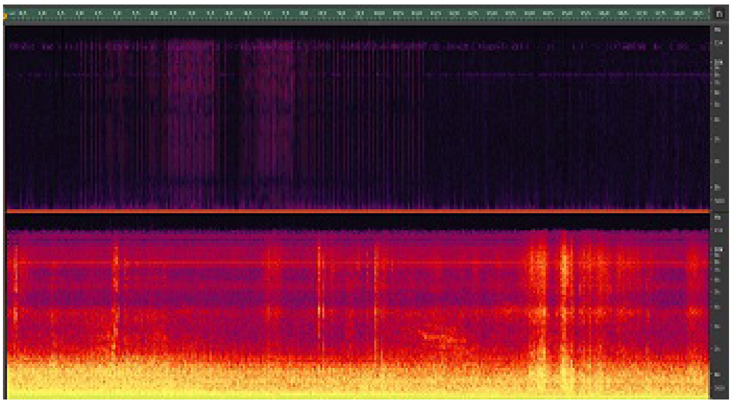

Figure 43: Stereophonic audio record taken by a video recorder

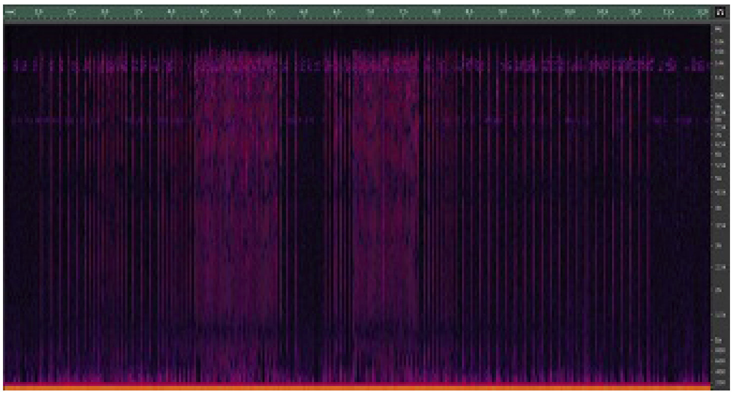

Figure 44: Acoustic frequencies of radio radiation

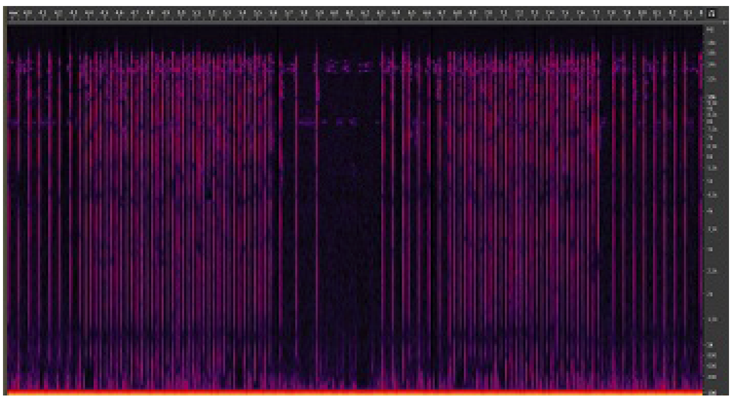

Figure 45: Acoustic frequencies of radio radiation

interruptions of glow, and to termination of glow of objects formed during the process of destruction of the main object. Probably radio outbursts coincide with the moments of bursts of radiation from the object along the trajectory. Time periods between radio outbursts fluctuate from 0.03 to 0.08 seconds average. This is a reason why it is quite difficult to detect the pulsing radiation. The first radio outburst follows the termination of the process of dispersion of the liquid melt.

Analysing frequencies of radio outbursts presented at Figure 45, one can conclude that the spectrum of this radiation is discrete to a certain extent. The decrease of bandwidths of radiation frequencies while the frequency increases attracts attention. Perhaps in the range of higher frequencies which have not been registered by the video recorder bands are narrow, similar to those in the spectra of radiation of atoms. On the other hand, such discreteness can be either a consequence of absorption of certain frequencies in continuous spectrum of bremsstrahlung of particles or a consequence of some peculiarities of receiver of radiation (audio recording system of the video recorder). If we ascribe outbursts and discreteness of the radio radiation at acoustic frequencies during the flight of the object to its glow, then we can ascribe the discreteness of spectrum of this radiation either to processes of emission or absorption upon the transition of bound pairs of like particles of condensates during their evaporation into the free state or to the radio radiation by protons of neutrons of atoms of atmosphere upon the transition of protons and electrons of these neutrons into the unsteady state during the interaction of beams of particles of evaporating condensates (please refer to Chapters 18 - 20).

Another object which trigger of radio radiation is the radiation of glowing object on higher frequencies could also be the source of radiation outbursts.

Perhaps it is just an accidental coincidence of two different processes. There is a probability this radio interference has another origin. However, the probability of it to be a result of glow of the object over Chelyabinsk is very high.

7. UV radiation during the glow of the object.

Some eyewitness accounts indicate the impact of the UV radiation and its consequences. Somebody felt a fierce heating, many people were flushed with heat, some of them have got insignificant sunburns. There is no data about registration of the UV radiation instrumentally or by sensors.

8. Flows of energetic charged particles.

On 15 February 2013 some flows of heavy charged particles which characteristics differed from those of the background radiation have been registered 1-3 hours before and after the meteoroid exploded. Sources which could emit these flows have not been detected. The probability of fortuitousness of this event is evaluated equal to 9 per cent [44].

What happened after the completion of these processes?

1. Fallout of debris of a certain mass and size and their certain distribution at the Earth's surface relatively to the flight trajectory and areas of glow along the trajectory.

A map demonstrated at Figure 46 is one of the most complete maps of debris fallout locations [45]. Figure 47 illustrates the theoretical calculation of locations of the maximum fallout of fragments of certain masses. It is meant that a fragment of a certain mass could not fly farther than the circle indicating this mass. Red circles are settlements according to the map. Yellow circles illustrate the calculation for instant destruction at the altitude of 50 km. Magenta circles are the results of calculation for instant destruction at the height of 40 km. The calculation was performed based on the formulas (674-683) of Appendix 2

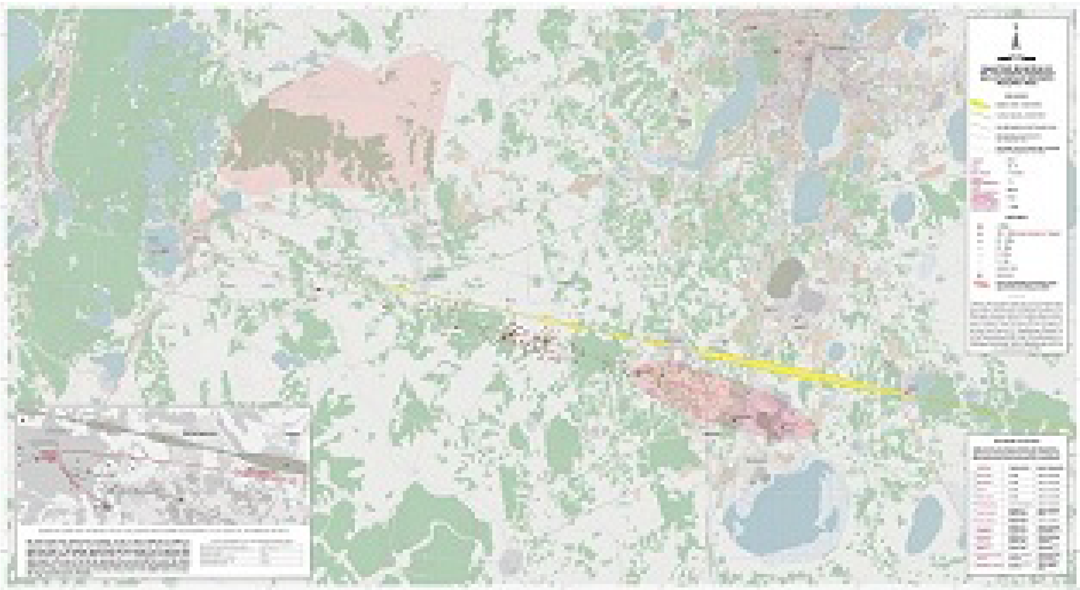

Figure 46: Debris fallout map

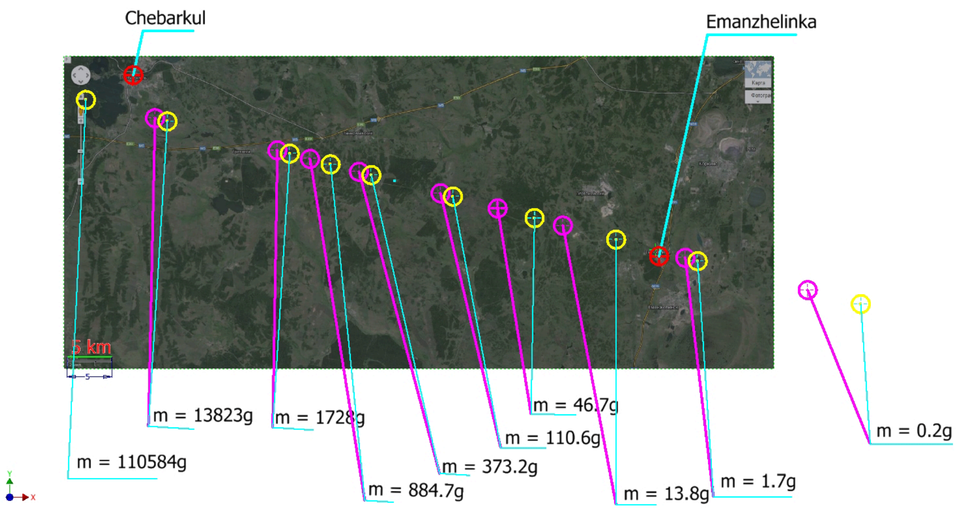

Figure 47: Theoretical calculation of fallout of debris

(Chapter 45) under the following values of constants:
$v_0 = 19\ km/s$ which is an initial velocity of a fragment;
$C_d = 0.3$ which is the drag coefficient;
$P_0 = 1.225\ kg/m^3$ which is a density of the atmosphere at the Earth's surface level;
$H = 7500\ km$ which is a characteristic scale of altitudes;
$P_m = 3.3\ g/cm^3$ which is a density of the fragment;
$C_0 = 18.5\ deg.$ which is an angle between the trajectory and the Earth's surface.

The altitude of trajectory over Yemanzhelinka village is 23 kilometres. The projection of trajectory on the Earth's plane is directed from Yemanzhelinka to Lake Chebarkul.

Comparison of the data according to the map (Figure 46) and results of calculation (Figure 47) does not allow for unambiguous conclusion about the altitude at which the destruction of the crystalline shell had occurred. Calculations of debris fallout after the theoretical destruction of the shell at the height of 50 and 40 kilometres generally correspond to the data of the map. Judging from the size of fragments being found, the thickness of the crystalline shell was not more than 0.2 metres.

2. Formation of the dust cloud at the altitude of dispersion of the liquid melt.

As a result of Chelyabinsk event, a sustainable aerosol cloud has been formed at the height of 34–38 km, consisting of fragments of meteor substance before ignition during the entry into the dense atmosphere [44]. Three photographs (Figure 48) taken by MTSAT-2 satellite on 15 February 2013 at 3:32am UTC, at 5:01am UTC and at 6:32am UTC in the visible spectral range allow to see the formation and displacement of an aerosol cloud in the stratosphere and mesosphere which has developed from the initial part of object's trail [46]. This cloud of dust can be a consequence of dispersion of the liquid melt by the atmosphere of Earth after the crystalline shell has been destroyed.

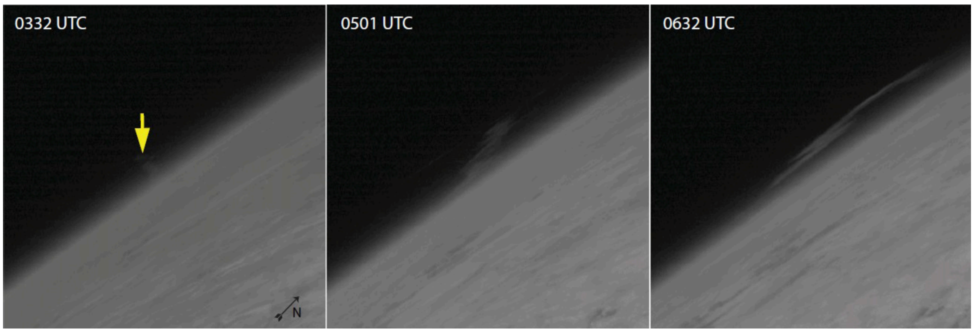

Figure 48: Displacement of a dust cloud in the stratosphere and mesosphere registered by MTSAT-2 satellite (0.73 μm visible) on 15 February 2013 at 3:32am UTC, at 5:01am UTC and at 6:32am UTC

3. The two-component constituent of dropped fragments and a thin layer of debris' coating.

As is written in the statement [47], the most of researched fragments of Chelyabinsk meteorite have the light colour of the central part and a dark crust. Authors have investigated one sample different from others. This fragment is characterised with the dark grey colour of the central part, macroscopically visible difference between the coarse-grained (primary) and fine-grained (recrystallized) aggregates and the presence of multiple spherical caves (bubbles) in the fine-grained aggregate. It gave authors a reason to mark out a specific type (intensively melted) for the fragments of Chelyabinsk meteor. "Intensively melted" debris could also be formed during the crystallisation of the liquid melt.

The surface of dropped meteorite debris is coated with a black glassy substance with pores and drop-shaped inclusions of sulphides and metals [48]. This coating could appear due to dispersion of the liquid melt and passage of debris of the crystalline shell through it.

4. Ionospheric changes after the flight of the object.

Observations of ionospheric changes have been described in the work [44]. Based on them, two conclusions were made:

- Narrow beams of perturbations have been detected on the vertical cuts of ionosphere over the European part of Russia few hours after the blast (Figure 49). One can presume

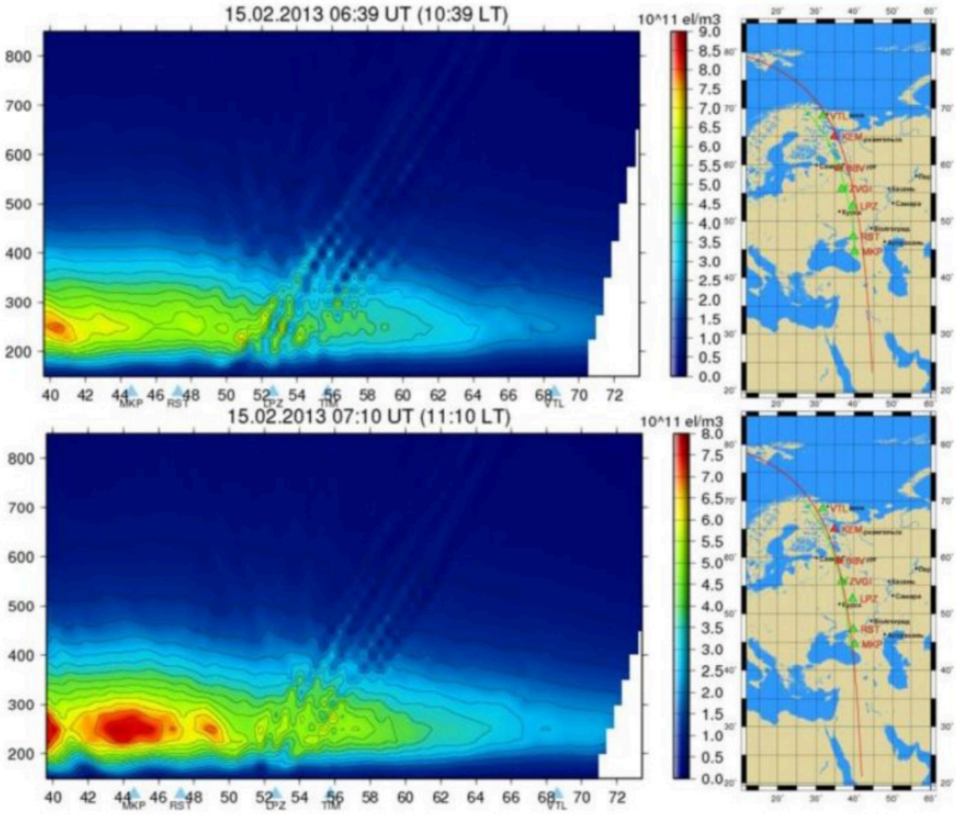

Figure 49: Restored cuts of the ionosphere from 15 February 2013

that the ionospheric perturbation related to the entry of meteoroid have spread in the form of waves similar to narrow beams gradually expanding westward within the solid angle equal to 15°–17°. The direction of their displacement corresponded to prolonged trajectory of motion of meteoroid before the moment of its blast;

- An effect of regional drawdown of the ionosphere has been registered at the altitudes up to 250 km few hours after the blast of meteoroid.

Narrow beams of perturbations on the vertical cuts of ionosphere can be the result of periodic processes of ejection of charged particles during the evaporation of condensates.

5. The process of burning and burst of the gas in the trail of the object resulting to formation of the water vapour.

After 15 February 2013, an increased concentration of water vapour has been registered at the altitudes of 700 km which was confirmed by various types of observations (satellite observations: in the absorption band of water vapour (6.8 μm) and also using the radio frequency mass spectrometer). As authors of the study mention, the detection of traces of molecules of water is the evidence of that the origin of meteoroid can be cometary [44].

Figure 50: Burning of gases in the trail

Figure 51: The raise of the heated gas after its burning and explosion

The process of burning and explosion of gas can be observed on many footages and photographs (e.g., Figure 50). Locations of explosions and burning of gas along the trajectory can be detected by raising of gas clouds (Figure 51). Based on the analysis of photographs (Figure 52 and Figure 53) taken by FY-2D satellite ten minutes after the entry of the object into the troposphere [49], we can conclude that the main cloud of water vapour has been formed during the brightest burst after which the glow of the object has been interrupted. This cloud is also visible at the photograph (Figure 51).

6. Formation of zones of increased temperature in the trail of the object in the atmosphere.

Formation of zones of increased temperature in the trail of the Chelyabinsk event is visible at Figur 54 (snapshots of a footage [36]) and at Figure 55 (snapshots of a footage [41]). Figure 56 demonstrates snapshots of a footage [50] which recorded an atmospheric

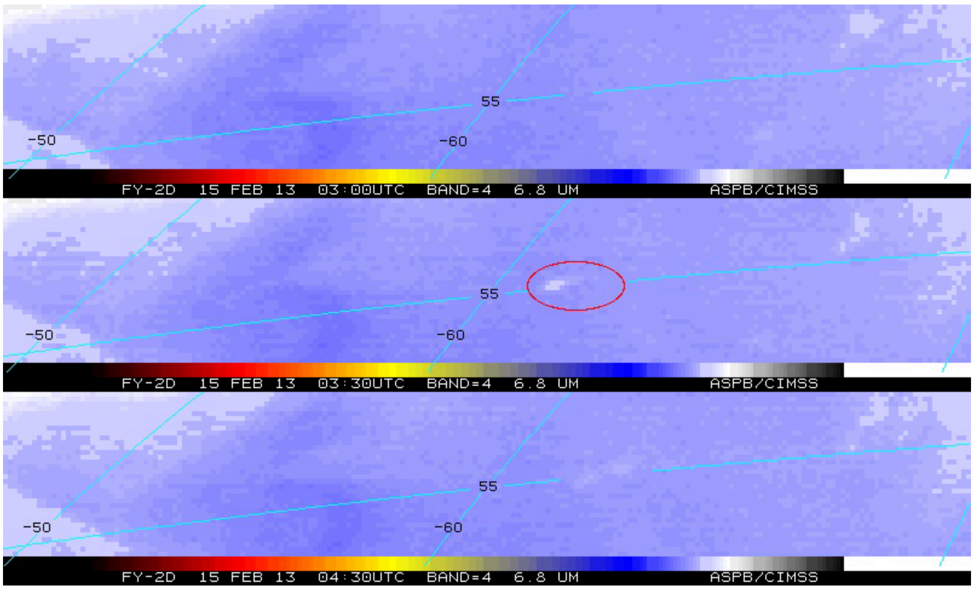

Figure 52: The cloud of water vapour (6.8 μm) above the point of major blast registered by FY-2D satellite on 15 February 2013 at 3:30am UTC

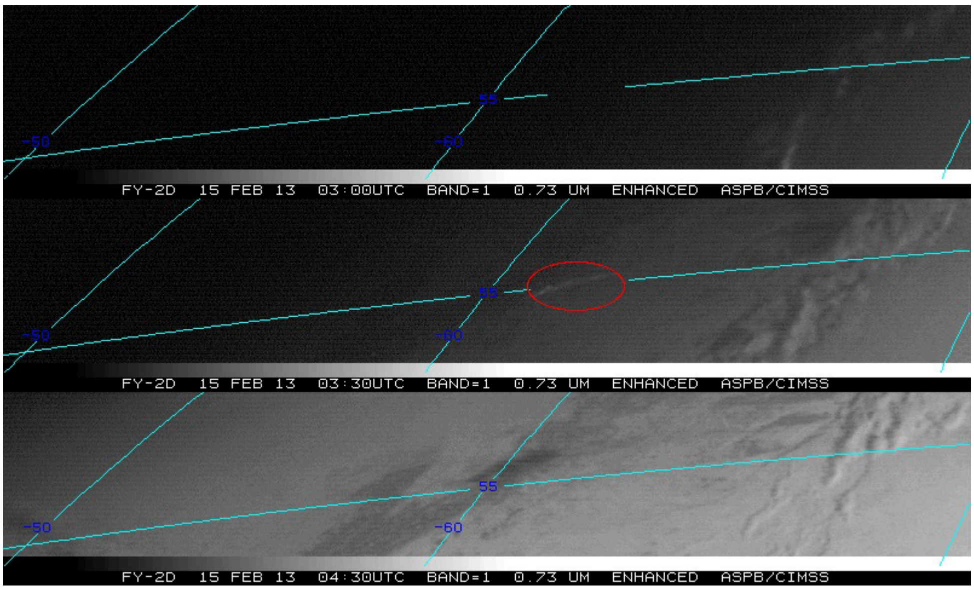

Figure 53: The trail of object (0.73 μm visible) registered by FY-2D satellite on 15 February 2013 at 3:30am UTC

Figure 54: Zones of increased temperatures in the trail of the Chelyabinsk event

Figure 55: Zones of increased temperatures in the trail of the Chelyabinsk event

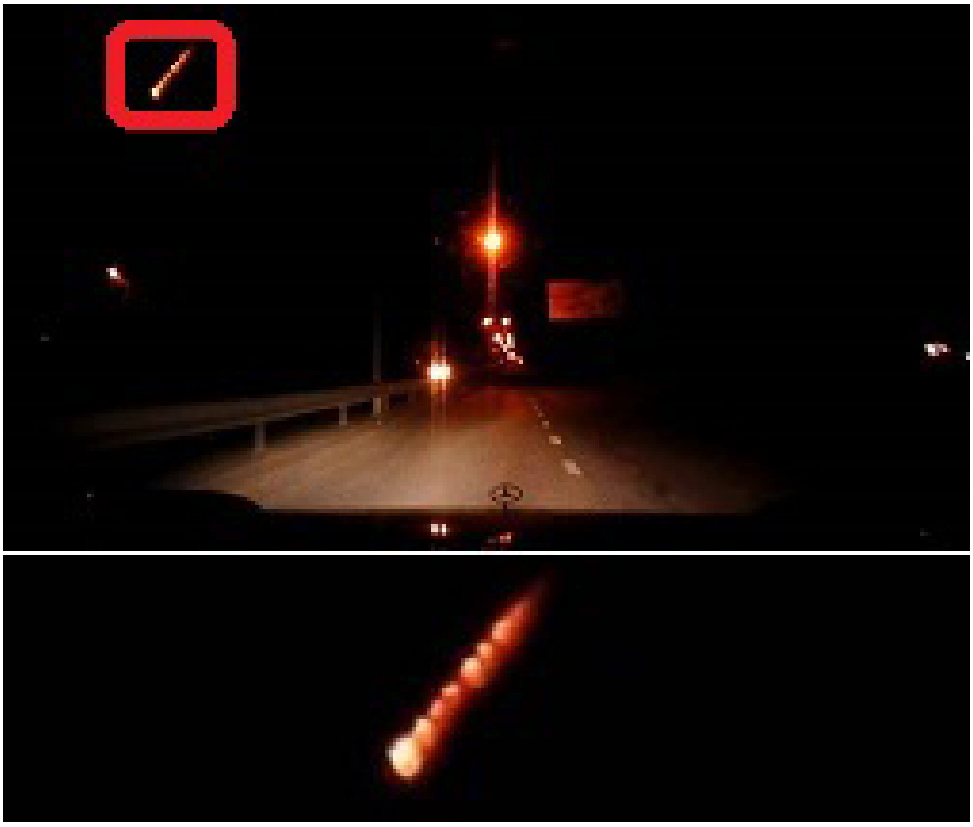

Figure 56: Zones of increased temperatures in the trail of the Crimea event

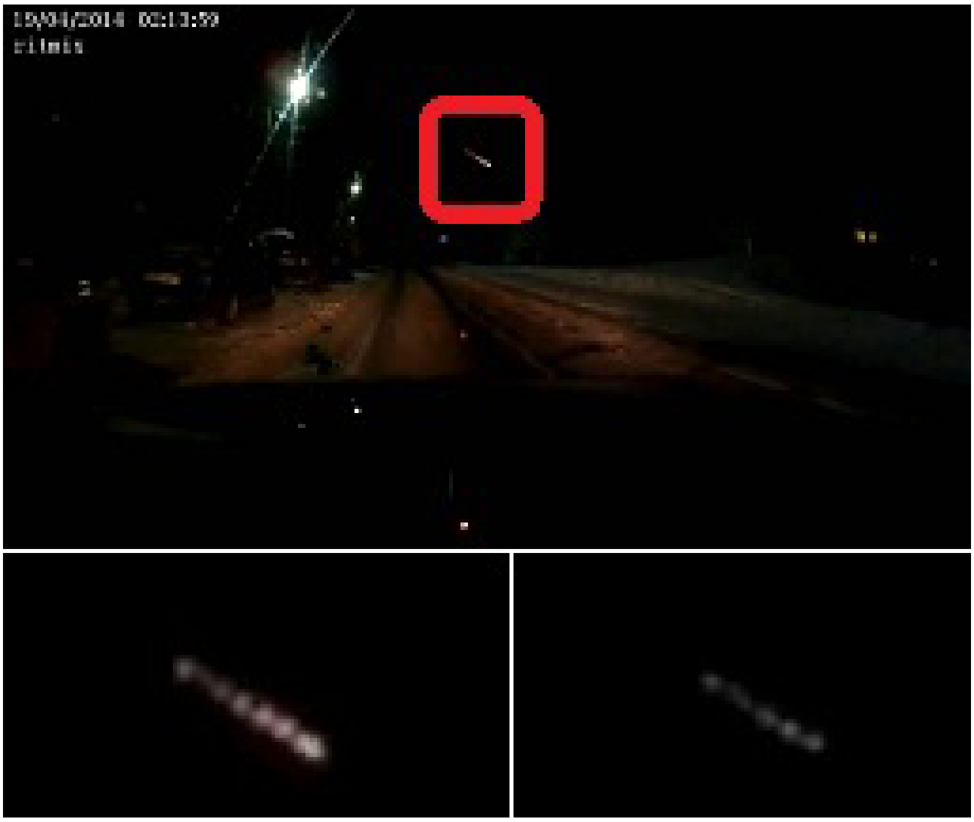

Figure 57: Zones of increased temperatures in the trail of the Murmansk event

trail of the Crimea event (21 November 2013), Figure 57 presents snapshots of a footage [51] of the Murmansk event (19 April 2014).

Glowing zones in the trails of all three objects are almost identical. The zones of increased temperature in the trails of the Crimea and Murmansk events are visible more clearly in the night sky. The processes of glow and destruction of all three objects are similar. Time intervals between the flashes forming the glowing zones are about 0.03–0.08 seconds for all these events.

7. Blast waves from many sources along the flight trajectory.

A nuclear blast in the atmosphere generates low-frequency acoustic oscillations (infrasonic waves). Nuclear test detecting stations have registered the source of infrasonic waves around Chelyabinsk on 15 February 2013. The source of infrasound was transient, not stationary [52], [53]. The stationary nuclear blast generates a broad spectrum of pressure waves which frequencies cover the ranges from the audible sound to 0.02 Hz. Waves are spreading from their source at about the speed of sound in the air. At the distance of a thousand kilometres and more the spectrum becomes much more narrow and the highest distinct frequency is only about 0.03 Hz [54], [55].

It is most likely that the process generating the low-frequency acoustic waves is the process of pulsing evaporation of condensates, both during the nuclear blast and during the destruction of DSBC in the Earth's atmosphere or during the evaporation of the free volume of proton condensate.

The frequencies of formation of flashes during the Chelyabinsk, Crimea and Murmansk events lay within the range from 12 Hz to 33 Hz. It is very probably that particularly this frequency of bursts during the Chelyabinsk event formed the low-frequency acoustic waves which have been registered by nuclear blast detecting stations as waves from the transient source. And the audio record of radio interference captured by a video recorder of a car during the Chelyabinsk event can be the real-time record of bursts since the frequencies of formation of flashes and frequencies of pulsations of the radio noise lay within the same range.

Correspondence of flashes to outbursts of radio radiation during the Chelyabinsk event can be detected on two photographs at Figure 58: the upper image is a snapshot of a footage [41]; the lower one is a cut of the time-frequency characteristics of the audio file extracted from the footage [43]. Glowing zones 1, 2, 3 at the upper photograph can correspond to three radio outbursts 1, 2, 3 at the lower image. A big gap 4 between radio outbursts at the lower photograph can correspond to the interrupted glow 4 at the upper picture. The brightest flash formed the glowing zone 3 and after that the longest interruption in formation of flashes occurred while the longest gap between the radio outbursts appeared.

Audio effects and blast waves from the sequence of bursts have been registered by cameras which have been located close to the epicentres of bursts. A reflection of blast waves following one another from the surface of earth is observable as double waves on the footage recorded at the height of a column crane [56]. One can detect the presence of small bursts before the formation of the most powerful blast from the soundtrack of a footage [57].

From this chapter we will conclude the following:

Comparison of theoretical presumptions about the process of entry of the system of two bound DSBCs into the atmosphere of Earth and real events (Chelyabinsk on 15 February 2013, Crimea on 21 November 2013, Murmansk on 19 April 2014) provides a

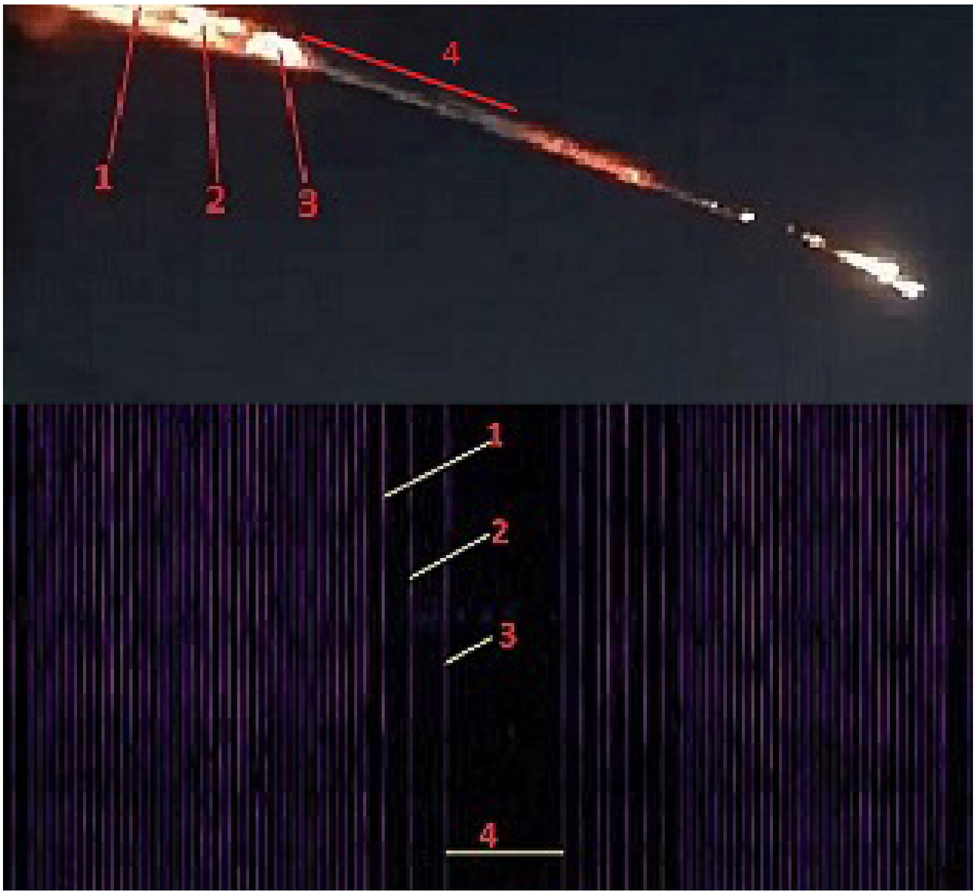

Figure 58: Correspondence of flashes to radio outbursts

high degree of probability that the objects caused these events were either the systems two bound DSBCs or the single DSBCs or the free volumes of proton condensate.

40 Processes at the Sun and in the solar atmosphere

Periods of solar activity while magnetic fields of the Sun are changing can be considered using the theory of the system of two bound DSBCs and presuming that the core of the Sun is a system of two bound DSBCs. Periods of oscillation of rings of proton condensate of two DSBCs relatively to the new ring (convergence and divergence) with the changing of the Solar magnetic field will correspond in this case to periods of solar activity. Appearance and disappearance of sunspots can be a consequence of displacement of proton rings of two DSBCs relatively one another and their activity resulting to ejection of the proton condensate to the surface of the Sun. The decreased temperature in the sunspots should be a result of extrusion of the proton condensate to the surface as the temperature of condensate is less than that of the Solar surface. The process of evaporation of condensate into the atmosphere of the Sun should cause the increase of the temperature of atmosphere above the Solar surface forming the solar corona. Therefore, the temperature inside the Sun should generally match the temperature of the proton condensate. Then, there should exist an area with the temperature equal to that of evaporation of condensate, an area of increased temperature containing high-energy particles of vaporised condensate should lay above it.

Ejections of large volumes of plasma by the Sun can be related to ejection of either fragments of the new ring or fragments of proton rings during the mass evaporation of the condensate. If we presume that the process of formation of the solar wind after the Sun has ejected its protons into its atmosphere is generally determined by the process of PPST, i.e., the process of interaction of the proton and the electrically neutral volume of particles (please refer to Chapter 24), then the solar wind should consist of protons with magnitudes of their velocities relatively to the mass centre of the Sun greater than a certain value at which protons of the solar wind and the volume of protons and electrons of the Sun (if we consider it electrically neutral) are in the neutral state. Protons with the neutral velocity which value is the minimum in the flow of the solar wind will be neither attracted nor repelled by the Sun. Protons which velocities are faster than this neutral velocity will be repelled by the volume of particles of the Sun, forming the Solar atmosphere which is expanding along the radial direction. And protons with slower velocities will be attracted by the Sun.

The synthesis of deuterium, helium and other elements presenting at the Sun can occur both in the rings of proton-nuclear condensates of DSBCs and in the proton condensate extruded from these rings to the surface of the Sun.

Flares on the Sun can be considered within the frame of PPST if a separate solar arc is pretended as a DSBC not formed yet. It will be a flow of either proton condensate or protons slow relatively to one another; the flow is moving along the ring-shaped trajectory through a channel formed in the plasma of the solar atmosphere (please refer to Chapter 29) and partly submerged beneath the surface of the Sun. Protons of the flow slow relatively to one another will attract each other and repel the neutral plasma of the solar atmosphere which surrounds the flow if the magnitude of velocity of the flow of protons relatively to the plasma of the solar atmosphere will be greater than a certain value (please refer to Chapter 24). As a result, the flow of the proton condensate will move along the channel of rarefied plasma where the resistance to its motion from the side of fast protons and ions of the plasma will be the minimum. Therefore, the ring of the proton condensate will exist in the plasma environment within a certain period of time. The interaction of two solar arcs will occur according to scenario of interaction of two DSBCs (please refer to Chapter 34 and 35). During the process of approach and halts of interacting arcs without formation of a new arc by them, the new rings of protons of solar plasma will be forming with the further ejection of the plasma formed by the new rings from the zone of interaction of arcs. As a result, the pulsing radiation with ejection of the plasma and a flow of high-energy charged particles will be registered, where the particles of the flow mostly will be the protons of the proton condensate of rings of arcs and those of the new ring since free protons after the evaporation of condensate in arcs and in the new rings will repel from the zone of evaporation with the force proportional to the quantity of the proton condensate in the zone of evaporation.

41 The Sun and the formation of planetary cores and cometary nuclei

It is very likely that the solar arc formed by the ring of proton condensate surrounded by fast electrons can create a DSBC. Then, if these formed DSBCs could leave the Sun during the solar bursts, they in turn would be able to form cometary nuclei and cores of planets of the Solar System. Formation of cometary nuclei and planetary cores is also possible during the process of ejection by the Sun of a free volume of proton condensate or a volume of protons slow relatively to one another which then will form either a free volume of the proton condensate or a DSBC (please refer to Chapter 34).

Therefore, along with the process of formation of planets by the gravitational contraction, the secondary process of formation of these objects in the space is possible in PPST. The matter of injection of formed cometary nuclei and planetary cores into elliptical orbits relatively to the Sun needs to be reviewed separately. Comets hitting the Sun can be the objects completed the first turn (i.e., returned to where they flew from). Comets “grazing” the Sun (the sun-grazing comets) can change their orbit at the first turn and pass by the Sun, later on gradually increasing perihelia of their orbits. Intermolecular forces which connection to gravity forces was described in Chapter 26 will probably participate this process. A comet moving relatively the Sun will change its velocity and temperature, which in accordance to PPST will result to changing of attraction force between the comet and the Sun. This effect along with the complex interaction between the comet and bodies of the Solar system, the solar wind and the solar radiation can allow some comets to increase the maximum distances of their motion trajectories relatively to the centre of the Sun while returning to the Sun. The 2P/Encke comet which has the shortest known orbital period can be such comet; parameters of its circumsolar trajectory are permanently changing [58].

42 Processes in the atmosphere of Earth, in the earth's crust, in the mantle and in the circum-terrestrial space

The highest temperature at which the phenomenon of superconductivity at high pressure has been registered is $203K$ (–70°C) [59]. If we go back to Chapter 28 ("Superconductivity") and Chapter 14 ("Formation and evaporation of condensate consisting of bound pairs of like particles"), then, based on the (419), we can presume the following:

The temperature of a substance in which the repulsion of free electrons between one another changes to attraction is higher than $203K$.

The temperature in the Earth's atmosphere can drop down below $203K$. Thus, the atmosphere can acquire some properties of superconductors, e.g., electrons in the atmosphere can attract one another and repel from neutral atoms and ions (please refer to Chapter 21). It can explain the fast concentration of electric charges in the large volumes of atmosphere.

Interaction between two volumes of electron condensate located in the atmosphere should occur according to the following scenario:

A small volume of condensate will accelerate toward a bigger one until a certain magnitude of velocity relatively to the mass centre of the large volume is reached, which will be less than the velocity of the neutral state of small and large volumes of condensate. It will simultaneously decelerate due to interaction with atoms of the atmosphere. Being braked, the condensate will start to accelerate again. As a result, its motion will occur impulsively, jerkily, until attracted condensate either evaporates or combines with attracting volume. This process can determine the dynamics of lightning leaders in PPST.

Interaction between volumes of electrons slow relatively to one another and a volume of atoms which contains a large number of ions will be determined by the following dynamics:

If velocities of electrons slow relatively to one another in regard to the volume of ions will be less than a certain value, then volumes will repel and the charges will be separated. If velocities of electrons slow relatively to one another in regard to the volume of ions will be greater than a certain value, then the volume of ions will attract electrons, and they will accelerate towards the volume of ions, i.e., an electric discharge will occur. In this case the discharge should be mainly continuous, without any lightning leaders, since while accelerating towards the volume saturated with ions, starting from the certain value of magnitude of velocity relatively to the volume of ions, electrons will start to accelerate continuously according to the Coulomb law. Electrons fast relatively to the volume of electrons which are slow relatively to one another can also accelerate continuously while repelling from it according to the Coulomb law. This process can describe a secondary lightning discharge from the Earth to the atmosphere. Once the flow of electrons slow relatively to one another, which propagates downward from the atmosphere to the Earth following lightning leaders, forms a channel of plasma to the large volume of slow electrons at the Earth, the large volume of slow electrons at the Earth will eject electrons of the channel fast relatively to this volume upward to the atmosphere along the channel being formed, and these electrons will continuously accelerate upward.

Gradients of the temperature in the atmosphere created by flows, storm-clouds, dust, solar radiation, etc., should generate electromotive forces acting on charged particles of the atmosphere during the electrification of volumes of neutral atoms of the atmosphere (please refer to Chapter 23) between which atmospheric discharges will occur. In this case electrons of the discharge will move from the volume of neutral atoms of atmosphere which has the excess of electrons to the volume of neutral atoms with the shortage of electrons.

In the previous chapter we presumed that the Earth's core can be either a DSBC or a bound pair of DSBCs or a free volume of the proton condensate. If this presumption represents the facts, then electric charges between the volumes of atmospheric condensates and condensates of the Earth's core should occur in the points of the least electric resistance of the Earth's crust and mantle. Such charges often occur during volcanic eruptions and earthquakes. Explosions of large volumes of condensate of likely charged particles in the mantle, beneath the Earth's crust and in the crust can accompany ejections of such volumes from the Earth's core. Therefore, based on PPST, we can presume that certain types of earthquakes (e.g., deep-focus earthquakes) can be the consequences of fast evaporation of volumes of condensates of likely charged particles ejected from the Earth's core. Powerful explosive volcanic eruptions can also be the results of extrusion to the surface of Earth and further fast evaporation of large volumes of condensates of charged particles.

Electrons magnitudes of which velocities relatively to the Earth are less than a certain value and protons magnitudes of which velocities relatively to the Earth are greater than a certain value will be repelled by the mass of neutral atoms of Earth into the upper atmosphere while electrons with greater magnitudes of velocities and protons with lesser magnitudes of velocities will attract to Earth (please refer to Chapter 21). It is very probably that large volumes of atmospheric electrons fast relatively to neutral atoms of Earth, while being focused by the Earth's magnetic field and attracted by neutral atoms of Earth, concentrate at the surface around the North and South Poles. At that, while electrons fall down onto the poles, they interact at the zero velocity with electrons of atoms of the atmosphere producing aurorae polaris. Losing their kinetic energy during this process and decreasing their temperature after the interaction with the cold surface of the poles, electrons form volumes of electrons slow relatively to one another and begin to move from the cold areas of the Earth's crust toward the hot zones of it (please refer to Chapter 22) producing the lack of electrons (Chapter 23) on the poles which is compensated by the inflow of electrons from the atmosphere. Therefore, the thermocurrent of electrons in the Earth's crust appears from the poles to the equator and to the hot surface of the Earth's mantle. The electromotive force in the Earth's crust is directed to faults of the Earth's crust where the extrusion of mantle increases the temperature. Thus, the flows of electron condensate will encounter in the faults of the Earth's crust and in the local zones of increased temperature. Electric discharges and bursts during the evaporation of large volumes of condensate can occur in these zones and can be registered either as earthquakes or as lightnings during volcanic eruptions.

The process of formation of a whirlwind and its dynamics can be explained by ejection of electrons slow relatively to one another by the volume of neutral atoms of Earth into the atmosphere. Whirlwind and other similar atmospheric phenomena can be the manifestation of superconductive properties of the Earth's atmosphere. When a large enough volume of electrons slow relatively to one another and slow relatively to neutral atoms of Earth begins to outflow from the surface of Earth upward to the atmosphere, the flow of electrons forms a channel in which electrons attract one another and repel neutral atoms of Earth and the atmosphere (please refer to Chapter 29). At that, as electrons leave the surface of Earth repelling from atoms of its volume, they provide momenta to neutral atoms located at the surface of Earth and in its atmosphere upward from Earth and across the flow formed by electrons. At that, the maximum possible velocity of the flow of electrons relatively to Earth will be slower than that of the neutral state of the flow of electrons slow relatively to one another and the volume of neutral atoms of Earth. The repulsion of atoms of atmosphere by the flow of electrons results to the rarefaction of the atmosphere. The atmospheric pressure compresses the area surrounding the channel. Due to the presence of a certain moment of momentum of atoms in the volume of atmosphere being compressed, the rotation of atoms of atmosphere and atoms ejected from the surface of Earth begins around the rarefied area of channel along which the flow of electrons moves with the small resistance to its motion, like the current in a superconductor. Formation of the whirlwind can be initiated by the large volume of slow electrons located in the atmosphere above the surface of Earth which will attract the volume of slow electrons of Earth and pull it out from Earth. The motion of slow electrons can also occur downward, from the atmosphere to Earth, if a large volume of slow electrons which is able to pull towards itself the flow out from the atmospheric volume of slow electrons is formed at the surface of Earth. Formation of atmospheric whirlwinds above the water sheet can start from the thermo-current of electrons during the generation of electromotive force acting on electrons from the volumes of cold water toward the volumes of warm water (please refer to Chapter 22), i.e., bottom-up, from the bottom of water body to its surface.

Simultaneous appearance of a large number of powerful atmospheric whirlwinds (tornadoes) in the so-called Tornado Alley in the USA can be explained within the frame of PPST by the presence of currents of electrons slow relatively to one another in the Earth's crust. Perhaps in this area, close to the surface of Earth, there are some channels along which large volumes of electron condensate are moving. The electron condensate of storm-clouds pulls the condensate of these currents out from Earth to the surface while Earth extrudes it to the atmosphere, creating a tornado. High currents of electrons slow rela-

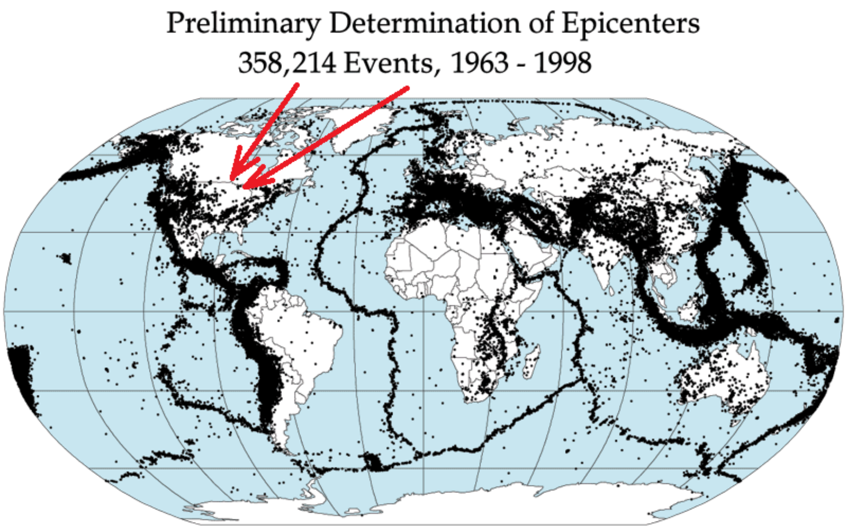

Figure 59: The map of earthquake epicentres in 1963–1998. Black dots are epicentres of earthquakes [60]. Red arrows are presumed flows of volumes of slow electrons.

tively to one another in the earth's crust of the North America can be the thermo-currents from the North Pole to the areas of seismic activity, i.e., zones of increased temperatures in the faults of the earth's crust on the west and south of the North American continent. One can see at Figure 59 that there is no seismically active zones on the way of this thermo-current which could neutralise the volumes of electron condensate by evaporating it and preventing it from transition to the zone of formation of tornado.

Therefore, both whirlwind and atmospheric discharge can arise from the motion of electrons in group. The difference of these atmospheric phenomena is in the velocities of motion of flows of electrons relatively to atoms of the atmosphere. If the velocity of motion of the flow of electrons slow relatively to one another regarding atoms of the atmosphere will be less than a certain value then a whirlwind will form; if this velocity is greater than a certain value then either a weak electric discharge or a lightning occurs. Snapshots (Figure 60 and Figure 61) extracted from a footage [61] demonstrate the transient state of an atmospheric phenomenon: the whirlwind and the lightning (the weak electric discharge).

Figure 60: The transient state: the whirlwind and the lightning

Figure 61: The transient state: the whirlwind and the lightning

Analogous to whirlwinds, there can be two types of discharges occurring between Earth and the atmosphere, striking upward and downward. If a discharge is formed as a result of interaction of two volumes of slow electrons, then the direction of lightning will be determined, first, by masses and quantities of charges in the volumes (electrons of the small volume move toward the large), and second, by the shapes of volumes (the extraction of electrons from an extended part of the large volume is possible).

Protons flying from the side of the Sun should decelerate while approaching Earth if magnitudes of their velocities relatively to Earth will be greater than a certain value when the neutral volume of particles of Earth repels protons (please refer to Chapter 24). This process will result to deceleration and scattering of solar protons having a certain kinetic energy at a certain distance from Earth. Formation of a frontal shock wave between Earth and the Sun created by the solar wind can start from this process. As follows from the presumption that deceleration of solar protons by the volume of neutral atoms of Earth is one reason why the shockwave between Earth and the Sun starts forming, all bodies of the Solar System, either consisting of neutral atoms or having equal numbers of positive and negative charges, being under the action of the solar wind, which has a certain density of protons and a certain velocity relatively to these bodies, should provide conditions for the formation of a frontal shock wave between themselves and the Sun analogous to the wave between Earth and the Sun. Processes similar to those occurring in the frontal shockwave between Earth and the Sun occur between the Moon and the Sun at the distance about 10,000 km from the Moon [62].

If we consider parameters of the solar wind coming to the Earth and Moon as the same and both Earth and the Moon as neutral volumes of particles (they can be either the volumes of neutral atoms or the volumes of neutral plasma or the volumes of containing both neutral atoms and the neutral plasma) which decelerate solar protons, then, based on the following argumentation, we can determine the distance at which the frontal shockwave between the Moon and the Sun should form:

If parameters of dynamics of solar protons, e.g., their density and velocity relatively to Earth and the Moon, will be the same, then distances from Earth and from the Moon at which frontal shockwaves are forming will be determined by the equality of forces acting on solar protons both from the side of Earth and from the side of the Moon.

Let us rewrite the equation (559) of interaction between the proton and the neutral volume of particles:

$$\frac{Mm_p}{(M+m_p)}\frac{d\vec{v}_{pc}}{dt} = e^2 \sum_{n=1}^{N} \left(\frac{\hat{r}_{pp_n}}{r^2_{pp_n}} \left(1 - b^{\left(1-(\vec{v}_{pc}-\vec{v}_{p_nc})^2/a_p^2\right)}\right) - \frac{\hat{r}_{pe_n}}{r^2_{pe_n}} \left(1 - b^{\left(1-(\vec{v}_{pc}-\vec{v}_{e_nc})^2/a_{ep}^2\right)}\right)\right), \tag{629}$$

where:

N is the number of electrons equal to the number of protons in the neutral volume of particles,

$M = N\,(m_e + m_p)$ is the mass of the neutral volume of particles,

$\vec{r}_{pp_n}$ is the radius vector of position of the proton relatively to a proton No. n of the neutral volume of particles,

$\vec{r}_{pe_n}$ is the radius vector of position of the proton relatively to an electron No. n of the neutral volume of particles,

$\vec{v}_{pc}$ is the velocity of proton relatively to the mass centre of the neutral volume of particles,

$\vec{v}_{p_nc}$ is the velocity of a proton No. n of the neutral volume of particles relatively to the

mass centre of the neutral volume of particles,
$\vec{v}_{enc}$ is the velocity of an electron No. n of the neutral volume of particles relatively to the mass centre of the neutral volume of particles.

If we assume the existence of the following approximate equalities:

$$\vec{r}_{pp_n} \approx \vec{r}_{pc}, \quad \vec{r}_{pe_n} \approx \vec{r}_{pc}, \quad n = 1, 2, .., N, \tag{630}$$

where $\vec{r}_{pc}$ is the radius vector of position of the proton relatively to the mass centre of the neutral volume of particles. Then the (629) can be determined as follows:

$$\frac{Mm_p}{(M + m_p)} \frac{d\vec{v}_{pc}}{dt} = \frac{Ne^2}{r_{pc}^2} Q_{pc} \vec{r}_{pc}, \tag{631}$$

$$Q_{pc} = \frac{1}{N} \sum_{n=1}^{N} \left(b^{\left(1-(\vec{v}_{pc}-\vec{v}_{e_n c})^2/a_{ep}^2\right)} - b^{\left(1-(\vec{v}_{pc}-\vec{v}_{p_n c})^2/a_p^2\right)} \right). \tag{632}$$

Using (631), (632) and presumption of equality of forces which provide conditions for the formation of frontal shockwaves near Earth and the Moon, taking into account that:

$$M >> m_p, \quad \frac{Mm_p}{(M + m_p)} \approx m_p,$$

we can write down the equation for determination of the distance from the Moon to its frontal shockwave:

$$\frac{M_z}{r_{pc_z}^2} Q_{pc_z} = \frac{M_l}{r_{pc_l}^2} Q_{pc_l}, \tag{633}$$

where:
M_z is the mass of the neutral volume of particles of Earth,
M_l is the mass of the neutral volume of particles of the Moon,
r_{pc_z} is the distance from the proton in the frontal shockwave of Earth to the mass centre of Earth,
r_{pc_l} is the distance from the proton in the frontal shockwave of the Moon to the mass centre of the Moon,
Q_{pc_z} is the function (632) for interaction between the proton and the neutral volume of particles of Earth,
Q_{pc_l} is the function (632) for interaction between the proton and the neutral volume of particles of the Moon.

As follows from the presumption that Earth and the Moon repel solar protons with the same values of velocities relatively to themselves, and greater to a certain value in moduli:

$$Q_{pc_z} > 0, \quad Q_{pc_l} > 0.$$

Then, if we presume that average velocities of electrons and protons in the volumes of Earth and the Moon relatively to their mass centres coincide, then we can determine an approximate equality:

$$Q_{pc_z} \approx Q_{pc_l}. \tag{634}$$

Using (634) and (633), we obtain the approximate value of distance from the mass centre of the Moon to the location of formation by the solar wind of frontal shockwave near the Moon:

$$r_{pc_l} \approx r_{pc_z} \left(\frac{M_l}{M_z} \right)^{1/2}. \tag{635}$$

Using the value $r_{pc_z} \approx 14r_z$ from [63], where r_z is the radius of the Earth, we will obtain $r_{pc_l} \approx 9908$ km which, considering the approximate nature of calculation, corresponds quite good with the value in [62] (10,000 km).

Therefore, frontal shockwaves formed by the Solar wind near Earth and near the Moon, can begin from the process of PPST, i.e., deceleration and scattering of solar protons by the neutral volume of particles.

43 Conclusion

The point particles states theory is a falsifiable theory. Nowadays there are technologies which can help test experimentally conclusions and predictions of PPST.

The set of physical phenomena which modelling can be performed using the point particles states theory and the theory of dynamic system of bound condensates based on it, is rather wide. Let us draw a list of phenomena which links to PPST were denoted in this work:

1. Formation and evaporation of condensates of bound pairs of like particles.
2. Processes occurring in the condensate of bound pairs of like particles in the external magnetic field.
3. The nucleus and electron shells of atoms.
4. Chemical bonds of atoms in molecules.
5. Emission and absorption of the energy quanta by particles.
6. Decay of a free neutron and decay of a neutron in the atomic nucleus.
7. Neutron emission.
8. The two-proton decay.
9. Radiation of atoms.
10. Bremsstrahlung of particles.
11. Scattering of particles and atoms in the substance.
12. Interaction of Rydberg atoms.
13. Correlation of gamma radiation, radio radiation and the flow of neutrons during the atmospheric and artificial electric discharges.
14. Sources and receivers of the terahertz radiation.
15. The Bragg peak of ionisation of atoms during the transition of a beam of heavy charged particles through a volume of atoms and molecules.
16. Explosive destruction of conductors by electric current.
17. The Ramsauer effect.
18. Thermo-electrical phenomena.
19. Electrification of volumes of neutral atoms.
20. Intermolecular interaction.
21. Gravitational interaction.
22. Magnetic interaction of flows of particles.
23. The Lorentz force acting on a charged particle in the constant magnetic field.
24. Formation of current sheets in the plasma.
25. The plasma ejection during the magnetic reconnection.
26. Nuclear fusion.
27. Superconductivity.
28. Cometary nuclei and planetary cores.

29. Motion of comets in the atmosphere of Earth.
30. The core of the Sun and processes in the solar atmosphere.
31. Solar flares.
32. Atmospheric discharges.
33. Earthquakes.
34. Explosive volcanic eruptions.
35. Formation and dynamics of the atmospheric whirlwind.
36. The solar wind.
37. Frontal shockwaves formed by the flow of positively charged particles during the interaction of celestial bodies.

If the hypothesis of properties of modified Coulomb forces is confirmed, then the theoretical study of all these phenomena within the frame of PPST will be possible at the definition of exact form of equations (7) and at the determination values of all constants included in these equations. Therefore, all mathematic conclusions provided in this work should be considered only as examples of what can be obtained within the frame of the point particles states theory and how it can be done.

The main criterion of consistency or inconsistency of the point particles states theory should be either proof or disproof of existence of neutral relative velocities of particles a_p, a_{ep}, a_e, since PPST is based on the hypothesis of existence of these velocities.

44 Appendix 1

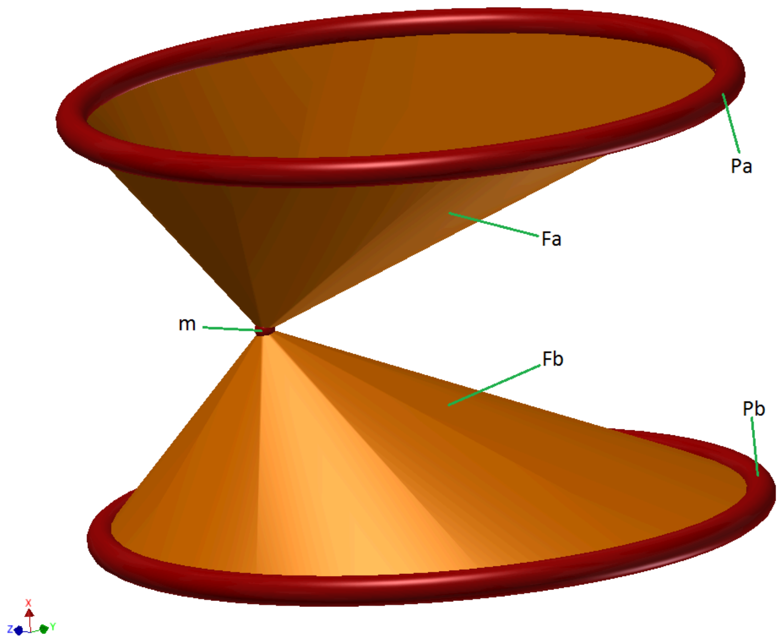

Figure 62: Interaction of a particle of the plasma and protons of rings of the system of two DSBCs

Figure 62 demonstrates the interaction of a particle of the plasma and protons of rings of the system of two DSBCs without considering the forces acting from the side

of electron shells of DSBCs. Dynamical and geometrical parameters of interaction are analogous to those determined in Chapter 34. Here are the following definitions:
m is a particle of the plasma, either a proton or an electron;
Pa is the ring of the proton condensate of DSBC-A;
Pb is the ring of the proton condensate of DSBC-B;
Fa is a surface on which unit vectors of forces of action of protons of the ring of DSBC-A on a particle of the plasma are laying;
Fb is a surface on which unit vectors of forces of action of protons of the ring of DSBC-B on a particle of the plasma are laying.

We will assume that forces acting from the side of proton rings of the system of two DSBCs on the particle of the plasma are coming from the circles formed by centres of infinite set of cross-sections of the proton rings (the circular cross-sections of rings are the same). The axes of the $\vec{X}$ and $\vec{Y}$ coordinate system in which the interaction is reviewed are laying in the plane of zero normal action (please refer to Chapter 34). The positive axis $\vec{Z}$ is coming from the projection point of rotation axis of proton rings to the plane of zero normal action and directed toward the DSBC-A. Coordinates of the centre of the circle of the ring of DSBC-A are $(0, 0, h)$ (the coordinate definition order is (x, y, z)). Coordinates of the centre of the circle of the ring of DSBC-B are $(0, 0, -h)$. Coordinates of the location of the particle of plasma are (x_m, y_m, z_m).

In order to determine the equation of forces acting on the particle of the plasma in the system, we will use the following variables and constants:
m is the mass of a particle of the plasma, either a proton or an electron;
$\vec{R}_m$ is the radius vector of position of the particle of plasma;
$\vec{r}_m = \vec{x}_m + \vec{y}_m$;
q is an electric charge of the particle of plasma (either a proton or an electron);
Q is a cumulative electric charge of one proton ring;
b is a constant of interaction of either protons or the proton and the electron;
a is the neutral relative velocity of either protons or the proton and the electron;
$\vec{v}_m$ is a velocity of the particle of the plasma (either the proton or the electron) in the $\vec{X}, \vec{Y}, \vec{Z}$ coordinate system;
$\vec{R}_{a0}$ is a vector coming from the centre of the circle formed by centres of infinite set of cross-sections of the proton ring of DSBC-A to the point on this circle;
$\vec{R}_{b0}$ is a vector coming from the centre of the circle formed by centres of infinite set of cross-sections of the proton ring of DSBC-B to the point on this circle;
$R_{a0} = R_{b0} = R_0$;
$\vec{R}_{ma}$ is a vector issued from the point of the circle formed by centres of infinite set of cross-sections of the proton ring of DSBC-A and where the $\vec{R}_{a0}$ vector comes to, to the point of location of the particle of plasma;
$\vec{R}_{mb}$ is a vector issued from the point of the circle formed by centres of infinite set of cross-sections of the proton ring of DSBC-B and where the $\vec{R}_{b0}$ vector comes to, to the point of location of the particle of plasma;
α_a is an angle between the vectors $-\vec{Z}$ and $\vec{R}_{ma}$;
α_b is an angle between the vectors $\vec{Z}$ and $\vec{R}_{mb}$;
γ_a is an angle between the vectors $\vec{r}_m$ and $\vec{R}_{a0}$;
γ_b is an angle between the vectors $\vec{r}_m$ and $\vec{R}_{b0}$;
β_a is an angle between the projection of the $-\vec{R}_{ma}$ vector to the $\vec{X}, \vec{Y}$ plane and the $\vec{r}_m$ vector;

β_b is an angle between the projection of the $-\vec{R}_{mb}$ vector to the $\vec{X}, \vec{Y}$ plane and the $\vec{r}_m$ vector;
$\vec{\omega}_m$ is an angular rotation velocity of $\vec{r}_m$;

Let us consider the modifying function:

$$\Upsilon_{ms} = 1 - b^{1-(\vec{v}_m - \vec{v}_s)^2/a^2}, \tag{636}$$

where $\vec{v}_s$ is the velocity of an arbitrary proton of the proton rings in the $\vec{X}, \vec{Y}, \vec{Z}$ coordinate system. Then components depending on the magnitude of relative velocity of the proton of plasma and the proton of the ring for the function of forces acting on the proton of plasma from the side of each proton of the rings at the following conditions:

$$v_s < a_p/2, \quad v_m >> a_p, \tag{637}$$

will be expressed by the function:

$$\Upsilon_m = 1 - b^{1-v_m^2/a_p^2}, \quad \Upsilon_m > 0. \tag{638}$$

Components depending on the magnitude of relative velocity of the electron of plasma and the proton of the ring for the function of forces acting on the electron of plasma from the side of each proton of the rings at the following conditions:

$$v_s < a_p/2, \quad a_p << v_m < a_{ep}, \tag{639}$$

will be expressed by the function:

$$\Upsilon_m = 1 - b^{1-v_m^2/a_{ep}^2}, \quad \Upsilon_m < 0. \tag{640}$$

Then we will consider the interaction of particles of plasma and protons of rings of the system of two DSBCs at the conditions of (637) - (640).

In order to review forces acting on the particle of plasma from the side of proton rings of the system of two DSBCs as forces coming from circles formed by centres of infinite set of cross-sections of the proton rings, the compliance to the conditions of $R_{ma} >> r_s$ and $R_{mb} >> r_s$ is necessary, where r_s is the radius of the cross-section of the proton ring.

Using the system of equations (7), let us write down the equation of a force acting on the particle of plasma from the side of proton rings of the system of two DSBCs:

$$m\frac{d^2\vec{R}_m}{dt^2} = \frac{qQ\Upsilon_m}{2\pi}\int_0^{2\pi}\frac{\vec{R}_{ma}}{R_{ma}^3}d\gamma_a + \frac{qQ\Upsilon_m}{2\pi}\int_0^{2\pi}\frac{\vec{R}_{mb}}{R_{mb}^3}d\gamma_b, \tag{641}$$

where:

$$\vec{R}_{ma} = \vec{r}_m + \vec{z}_m - \vec{R}_{a0} - h\hat{z}, \quad \vec{R}_{mb} = \vec{r}_m + \vec{z}_m - \vec{R}_{b0} + h\hat{z}. \tag{642}$$

Integration in the (641) is performed with respect to γ_a and γ_b variables with the constants R_0, $\vec{R}_m$, h, and variables $\vec{R}_{ma}$, $\vec{R}_{mb}$, α_a, α_b, β_a, β_b.

Geometry of interaction of the proton rings and the particle of plasma provides two systems of equations.

The first one is:

$$R_{ma}\cos(\alpha_a) = h - z, \quad R_{ma}\sin(\alpha_a)\sin(\beta_a) = R_0\sin(\gamma_a),$$

$$R_{ma}\sin(\alpha_a)\cos(\beta_a) = R_0\cos(\gamma_a) - r_m. \tag{643}$$

The second one is:

$$R_{mb}\cos(\alpha_b) = h + z, \quad R_{mb}\sin(\alpha_b)\sin(\beta_b) = R_0\sin(\gamma_b),$$

$$R_{mb}\sin(\alpha_b)\cos(\beta_b) = R_0\cos(\gamma_b) - r_m. \tag{644}$$

Proceeding from the system of equations (643), we obtain:

$$\sin(\gamma_a) = f_a\sin(\beta_a), \quad \frac{R_{ma}^2}{R_0^2} = k_a^2 + f_a^2. \tag{645}$$

$$f_a = \left(1 - g^2\sin^2(\beta_a)\right)^{1/2} - g\left(1 - \sin^2(\beta_a)\right)^{1/2}, \quad -\pi/2 \le \beta_a \le \pi/2. \tag{646}$$

$$f_a = \left(1 - g^2\sin^2(\beta_a)\right)^{1/2} + g\left(1 - \sin^2(\beta_a)\right)^{1/2}, \quad \pi/2 \le \beta_a \le 3\pi/2. \tag{647}$$

$$g = \frac{r_m}{R_0}, \quad k_a = \frac{h - z}{R_0}, \quad |\sin(\beta_a)| \le \frac{R_0}{r_m}. \tag{648}$$

And proceeding from the system of equations (644), we obtain:

$$\sin(\gamma_b) = f_b\sin(\beta_b), \quad \frac{R_{mb}^2}{R_0^2} = k_b^2 + f_b^2. \tag{649}$$

$$f_b = \left(1 - g^2\sin^2(\beta_b)\right)^{1/2} - g\left(1 - \sin^2(\beta_b)\right)^{1/2}, \quad -\pi/2 \le \beta_b \le \pi/2. \tag{650}$$

$$f_b = \left(1 - g^2\sin^2(\beta_b)\right)^{1/2} + g\left(1 - \sin^2(\beta_b)\right)^{1/2}, \quad \pi/2 \le \beta_b \le 3\pi/2. \tag{651}$$

$$k_b = \frac{h + z}{R_0}, \quad |\sin(\beta_b)| \le \frac{R_0}{r_m}. \tag{652}$$

Different values of f_a and f_b functions are because of $|\left(1 - \sin^2(\beta)\right)^{1/2}| = |\cos(\beta)|$ but if β is changing, $\cos(\beta)$ is changing its sign while $\left(1 - \sin^2(\beta)\right)^{1/2}$ is not.

Let us split the force (641) into three components:

$$m\left(\frac{d^2\vec{R}_m}{dt^2}\cdot\vec{r}_m\right) = \frac{qQ\Upsilon_m}{2\pi}\int_0^{2\pi}\frac{\left(\vec{R}_{ma}\cdot\vec{r}_m\right)}{R_{ma}^3}d\gamma_a + \frac{qQ\Upsilon_m}{2\pi}\int_0^{2\pi}\frac{\left(\vec{R}_{mb}\cdot\vec{r}_m\right)}{R_{mb}^3}d\gamma_b. \tag{653}$$

$$m\left(\frac{d^2\vec{R}_m}{dt^2}\cdot\vec{z}_m\right) = \frac{qQ\Upsilon_m}{2\pi}\int_0^{2\pi}\frac{\left(\vec{R}_{ma}\cdot\vec{z}_m\right)}{R_{ma}^3}d\gamma_a + \frac{qQ\Upsilon_m}{2\pi}\int_0^{2\pi}\frac{\left(\vec{R}_{mb}\cdot\vec{z}_m\right)}{R_{mb}^3}d\gamma_b. \tag{654}$$

$$m\left(\frac{d^2\vec{R}_m}{dt^2}\times\vec{r}_m\right) = \frac{qQ\Upsilon_m}{2\pi}\int_0^{2\pi}\frac{\left(\vec{R}_{ma}\times\vec{r}_m\right)}{R_{ma}^3}d\gamma_a + \frac{qQ\Upsilon_m}{2\pi}\int_0^{2\pi}\frac{\left(\vec{R}_{mb}\times\vec{r}_m\right)}{R_{mb}^3}d\gamma_b. \tag{655}$$

Let us consider the (653) - (655) under the following conditions:

$$z_m = 0, \quad \frac{d\vec{z}_m}{dt} = 0, \quad \frac{d^2\vec{z}_m}{dt^2} = 0. \tag{656}$$

Being converted, the (653) - (655) with respect to the (656) provide the following:

$$\frac{1}{2}\frac{d^2 r_m^2}{dt^2} - \left(\frac{d\vec{r}_m}{dt}\right)^2 = \frac{qQ\Upsilon_m r_m}{\pi m}\int_0^{2\pi}\frac{(r_m - R_0\cos(\gamma))}{R^3}d\gamma. \tag{657}$$

$$\frac{d\left(r_m^2\omega_m\right)}{dt} = -\frac{qQ\Upsilon_m r_m}{\pi m}\int_0^{2\pi}\frac{R_0\sin(\gamma)}{R^3}d\gamma. \tag{658}$$

In the (657) and (658):

$$R_{ma} = R_{mb} = R, \quad \gamma_a = \gamma_b = \gamma, \quad \alpha_a = \alpha_b = \alpha, \quad \beta_a = \beta_b = \beta. \tag{659}$$

Proceeding from the (643) and (644), under conditions of (656) and (659), we obtain the following:

$$R = \left(R_0^2 + h^2 + r_m^2 - 2R_0 r_m\cos(\gamma)\right)^{1/2}. \tag{660}$$

Using the (660), we convert the (658):

$$\frac{d\left(r_m^2\omega_m\right)}{dt} = -\frac{qQ\Upsilon_m r_m}{\pi m}\int_0^{2\pi}\frac{R_0\sin(\gamma)}{\left(R_0^2 + h^2 + r_m^2 - 2R_0 r_m\cos(\gamma)\right)^{3/2}}d\gamma. \tag{661}$$

Integrating the (661), we obtain:

$$r_m^2\omega_m = Const. \tag{662}$$

Thus, under conditions of (656) the proton and the electron of plasma in the reviewed dynamic system will be affected by a central force coming from the centre of coordinate system under the action of which moments of momenta of particles relatively to the origin of coordinates will be constant.

Let us represent the (657) as follows:

$$\frac{1}{2}\frac{d^2 r_m^2}{dt^2} - \left(\frac{d\vec{r}_m}{dt}\right)^2 = -\frac{qQ\Upsilon_m r_m}{\pi m R_0^2}\left(\int_{-1}^{1}\Theta_{1(u)}du - \int_{-1}^{1}\Theta_{2(u)}du\right). \tag{663}$$

The following functions and variables are introduced into the (663) by using the (643) - (652):

$$u = \sin(\beta), \quad k_a = k_b = k = \frac{h}{R_0}, \tag{664}$$

$$\Theta_{1(u)} = \frac{f_1\left(1-u^2\right)^{1/2}\left(f_1 + u\frac{\partial f_1}{\partial u}\right)}{\left(k^2+f_1^2\right)^{3/2}\left(1-u^2 f_1^2\right)^{1/2}}, \quad f_1 = \left(1-g^2u^2\right)^{1/2} - g\left(1-u^2\right)^{1/2}, \tag{665}$$

$$\Theta_{2(u)} = \frac{f_2\left(1-u^2\right)^{1/2}\left(f_2 + u\frac{\partial f_2}{\partial u}\right)}{\left(k^2+f_2^2\right)^{3/2}\left(1-u^2 f_2^2\right)^{1/2}}, \quad f_2 = \left(1-g^2u^2\right)^{1/2} + g\left(1-u^2\right)^{1/2}. \tag{666}$$

Let us consider a definite integral:

$$I = \int_{-1}^{1} F_{(u)}du. \tag{667}$$

Let us expand the $F_{(u)}$ function into the Maclaurin series with respect to the u variable:

$$F_{(u)} = \sum_{n=0}^{\infty} \frac{F_{(0)}^{(n)}}{n!} u^n, \qquad F_{(0)}^{(n)} = \frac{\partial^n F_{(u)}}{\partial u^n} \left(u = 0\right). \tag{668}$$

Then the (667) will acquire the following form:

$$I = \int_{-1}^{1} \sum_{n=0}^{\infty} \frac{F_{(0)}^{(n)}}{n!} u^n du. \tag{669}$$

Integration of the (669) provides the following:

$$I = \sum_{n=0}^{\infty} \frac{2F_{(0)}^{(2n)}}{(2n+1)!}, \tag{670}$$

when the sum of terms of the series in the right part of (670) is convergent.

Based on the (663) and taking into account the (664) - (670), we obtain the following:

$$\frac{1}{2}\frac{d^2 r_m^2}{dt^2} - \left(\frac{d\vec{r}_m}{dt}\right)^2 = -\frac{2qQ\Upsilon_m r_m}{\pi m R_0^2} \sum_{n=0}^{N} \frac{\left(\Theta_{1(0)}^{(2n)} - \Theta_{2(0)}^{(2n)}\right)}{(2n+1)!}, \qquad N \to \infty, \tag{671}$$

where:
$\Theta_{1(0)}^{(2n)}$ is the value of derivative No. $2n$ of the $\Theta_{1(u)}$ function with respect to u and with $u = 0$;
$\Theta_{2(0)}^{(2n)}$ is the value of derivative No. $2n$ of the $\Theta_{2(u)}$ function with respect to u and with $u = 0$.

Let us introduce the following function:

$$\Omega_{(g,k,q,v_m)} = -\frac{q\Upsilon_m}{e|\Upsilon_m|} \sum_{n=0}^{N} \frac{\left(\Theta_{1(0)}^{(2n)} - \Theta_{2(0)}^{(2n)}\right)}{(2n+1)!}, \qquad N \to \infty, \tag{672}$$

which will determine conditions of existence of ring-shaped zones of zero action of forces of repulsion of particles of plasma by protons of rings (please refer to Chapter 34). Under conditions for magnitudes of velocities of protons and electrons of the plasma determined in the (637) - (640), the ring-shaped zones of zero action of forces of repulsion of protons and electrons of plasma by protons of rings will coincide and their existence will be determined by the negative range of the function:

$$\Omega_{(g,k)} = -\sum_{n=0}^{N} \frac{\left(\Theta_{1(0)}^{(2n)} - \Theta_{2(0)}^{(2n)}\right)}{(2n+1)!}, \qquad N \to \infty. \tag{673}$$

The calculation of the values of $\Omega_{(g,k)}$ function in the ranges of values of variables $0 \leq g \leq 1$ and $k > 0$ allows for presumption that function is convergent in the specified ranges of values of variables. And at the value of $N > 5$ the values of function are changing to small quantities.

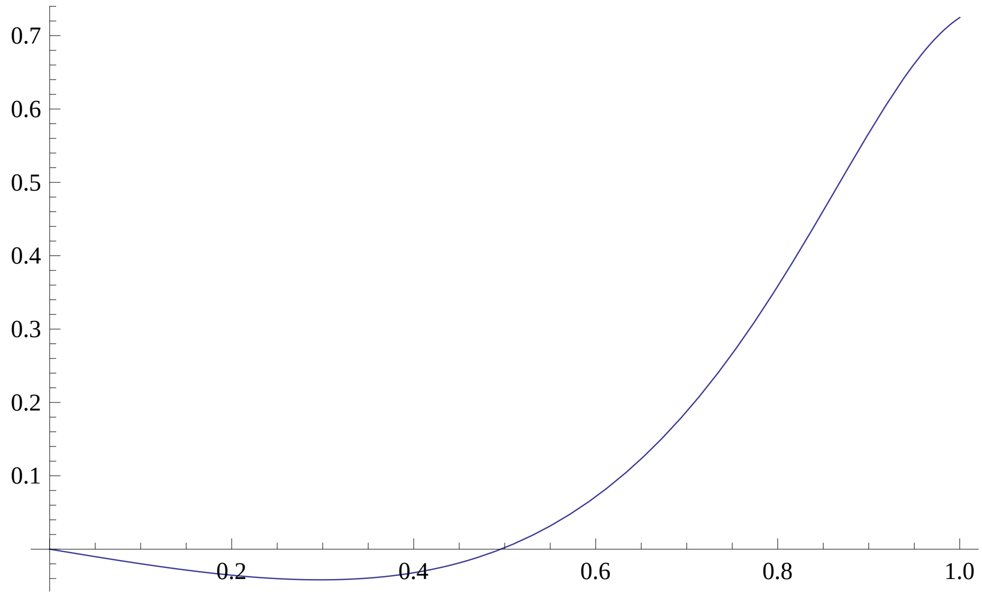

Figure 63: The graph of the $\Omega_{(g,k)}$ function at $N = 5$, $k = 0.6$ and with $0 \leq g \leq 1$ (horizontally)

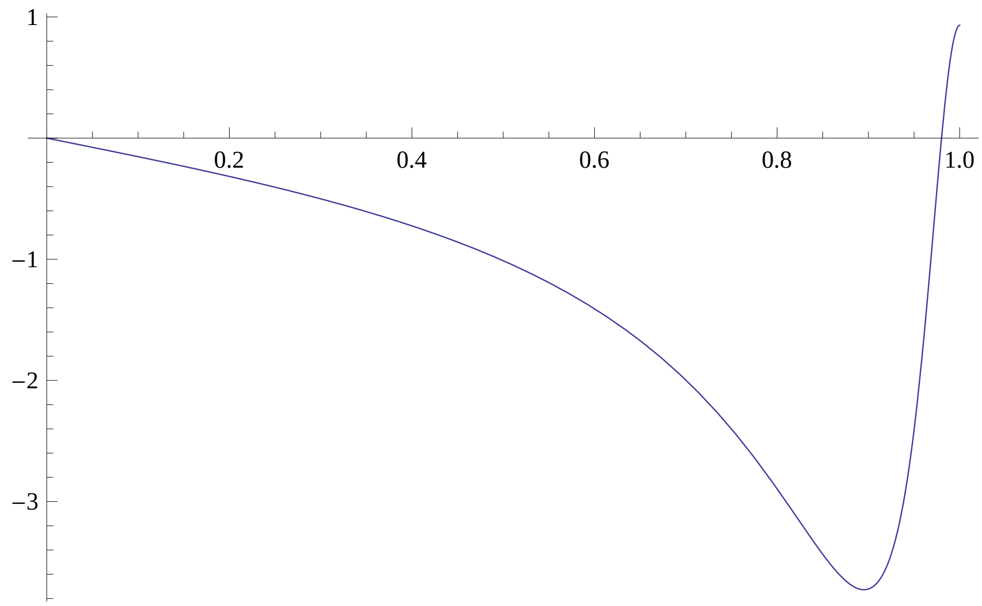

Figure 64: The graph of the $\Omega_{(g,k)}$ function at $N = 5$, $k = 0.1$ and with $0 \leq g \leq 1$ (horizontally)

A graph of the $\Omega_{(g,k)}$ function (673) at $N = 5$, $k = 0.6$ and with $0 \leq g \leq 1$ is plotted at Figure 63.

A graph of the $\Omega_{(g,k)}$ function (673) at $N = 5$, $k = 0.1$ and with $0 \leq g \leq 1$ is plotted at Figure 64.

Negative values of the function at the presented graphs correspond to the attraction of particles of the plasma by the central force whereas positive values relate to the repulsion. Zero values of the function provide the values of g at which there is a point of zero action of forces of repulsion of particles of the plasma by particles of two DSBCs ($g = 0$) and the ring-shaped zone of zero action of forces of repulsion of particles of the plasma by protons of the rings. Calculations also demonstrate that yet with $k > 0.8$ the $\Omega_{(g,k)}$ function at $0 \leq g \leq 1$ is always positive and has only one null at $g = 0$. Thus, at the distances between two DSBCs which are determined by these values of k the system of proton rings of two DSBCs will be unable to form the ring-shaped zone of zero action of forces of repulsion of particles of the plasma, and particles of the plasma will move off from the zone of interaction of the proton rings of two DSBCs.

In the common case, the force acting on the particle of plasma from the side of two proton rings in the system of two DSBCs is not the central. The central force stands within the limits when it is presumed that the Υ_{ms} function (636) is constant and does not depend on variables with respect to which the (641) is integrated. The analogue of the Lorentz force reviewed in the Chapter 30 is an example of the non-central force in PPST.

45 Appendix 2

Let us use the theory and formulas of ballistics of a meteor body in the atmosphere of Earth [64] for calculation of fallout locations of debris of a certain mass and size along the trajectory of flight and destruction of the crystalline body. We presume that the surface of Earth is flat. We will consider the shape of all fragments as spherical. We will review all equations without taking into account the ablation and the gravity of Earth:

$$M\frac{dv}{dt} = -\frac{C_d S_{mid} P_x}{2} v^2, \tag{674}$$

$$P_x = P_0 e^{-\frac{x}{H}}, \qquad M = \frac{4}{3}\pi r_m^3 P_m, \qquad S_{mid} = \pi r_m^2, \tag{675}$$

$$v = \frac{dl}{dt}, \qquad x = x_0 - l\sin(\phi_0), \qquad y = l\cos(\phi_0), \tag{676}$$

where:
l is a distance passed by a fragment along its trajectory (the trajectory is assumed to be straight) after it is separated from the crystalline shell.
x is an altitude of the fragment above the surface of Earth.
y is a projection of the distance passed by the fragment onto the surface of Earth.
M is a mass of the fragment.
S_{mid} is a mid-section of the fragment.
C_d is the drag coefficient.
P_x is a density of the atmosphere at the height of x.
P_0 is a density of the atmosphere at the surface of Earth.

x_0 is an initial altitude above the surface of Earth at the moment of separation of the fragment from the crystalline shell.
H is the characteristic scale of altitudes.
P_m is a density of the fragment.
r_m is a radius of the fragment.
ϕ_0 is an angle between the trajectory and the surface of Earth.
e is the Euler's number.

From the (674-676) we obtain the following:

$$\frac{d^2 l}{dt^2} = -\frac{3C_d P_0}{8P_m r_m} e^{\frac{l \sin(\phi_0) - x_0}{H}} \left(\frac{dl}{dt}\right)^2. \tag{677}$$

For short we will introduce the following value:

$$P_{x_0} = P_0 e^{-\frac{x_0}{H}}. \tag{678}$$

Proceeding from the (677) and taking into account the (678), we will obtain the following:

$$\frac{dv}{v} = -\frac{3C_d P_{x_0}}{8P_m r_m} e^{\frac{\sin(\phi_0)}{H} l} dl, \tag{679}$$

Let us integrate the (679) and, introducing the values:

$$w = \frac{3C_d P_{x_0}}{8P_m r_m \alpha}, \qquad \alpha = \frac{\sin(\phi_0)}{H}, \qquad \sin(\phi_0) \neq 0, \tag{680}$$

we will have the dependence of the magnitude of velocity of the fragment on the distance being passed:

$$v = v_0 e^{-w\left(e^{\alpha l} - 1\right)}, \qquad l_0 = 0, \tag{681}$$

where v_0 is the magnitude of velocity of the fragment at the height of x_0.

From the (681) we will find the dependence of the fragment's flight time on the distance being passed:

$$e^{we^{\alpha l}} dl = v_0 e^{w} dt, \qquad e^{we^{\alpha l}} = \sum_{n=0}^{\infty} \frac{w^n}{n!} e^{n\alpha l} \tag{682}$$

$$t = \frac{e^{-w}}{v_0} \left(l + \frac{1}{\alpha} \sum_{n=1}^{\infty} \frac{w^n}{n\,(n!)} \left(e^{n\alpha l} - 1\right) \right), \qquad t_0 = 0. \tag{683}$$

when t is the time it takes the fragment to pass the distance l.

In order to make the picture complete, we need to know the size of the crystalline shell and angular velocities of its rotation relatively to the mass centre. These parameters influence on the value of solid angle within which the debris is scattering.

In order to determine an approximate coordinate y where the fragment dropped, the graphs of dependence of the magnitude of velocity v on the distance being passed l and those of dependence of time t on the distance l to be plotted. The first graph is used for determination of the value of l at which v tends to zero. The second graph is used for determination of the value of l at which t tends to infinity. These values of l will match each other. The coinciding value will be the maximum distance which the fragment can fly over the trajectory. If with the value of l in the point of intersection of the trajectory and the surface of Earth the values of v and t have some certain values (v does not tend to zero and t does not tend to infinity), then these values will be the magnitude of velocity and the time of collision of the fragment with the surface of Earth (as the gravity of Earth is ignored).

References

[1] *Wilhelm Weber.* Electrodynamisce maassbestimmungen// Prince Jablonowski Society, Leipzig 1846, pp. 211-378.

[2] *Wilhelm Weber.* Electrodynamisce maassbestimmungen// Annalen der Physik und Chemie, Leipzig 1848, pp. 193-240.

[3] *Whittaker, E. T. (Edmund Taylor)* A history of the theories of aether and electricity : from the age of Descartes to the close of the nineteenth century// London ; New York : Longmans, Green [etc., etc.], 1910.

[4] *Rosenberger, Ferdinand.* Die Geschichte der Physik in Grundzugen; mit synchronistischen Tabellen der Mathematik, der Chemie und beschreibenden Naturwissenschaften sowie der allgemeinen Geschichte// Braunschweig, F. Vieweg und Sohn, 1882-90.

[5] *Дорфман Я. Г.* Всемирная история физики (с начала XIX до середины XX в.в.)// М., «Наука», 1979г., 317 с.

[6] *Fechner G. T.* Uber die Verknupfung der Faradayschen Inductions-Erscheinungen mit den Ampereschen electro-dynamischen Erscheinungen// Annalen der Physik und Chemie, Leipzig 1845, Vol. 64, pp. 337-345.

[7] *Nicholas Karpowicz, Jianming Dai, Xiaofei Lu, Yunqing Chen, Masashi Yamaguchi, Hongwei Zhao, and X.-C. Zhang.* Coherent heterodyne time-domain spectrometry covering the entire "terahertz gap" // Appl. Phys. Lett. 92, 011131 (2008); doi: http://dx.doi.org/10.1063/1.2828709

[8] *Ginzburg V. L.* Superconductivity and superfluidity (what was done and what was not)// Phys. Usp. **40** 407–432 (1997); DOI: 10.1070/PU1997v040n04ABEH000230

[9] *Livshits, A.M., Lozovik, Y.E.* Crystallization and melting of a system of charges in a liquid helium cluster// Exp. Theor. Phys. (2007) **105**: 571. doi:10.1134/S1063776107090142

[10] *Ambarish Ghosh and Humphrey J. Maris.* Phys. Rev. Lett. **95** 265301 (2005)

[11] *Levchenko A. A., Mezhov-Deglin L. P.* Crossing of a liquid-vapor boundary in hydrogen by negative charges// JETP Lett., Vol. 60, 25 Sep. 1994. pp. 470–474.

[12] *Raciti G., Cardella G., De Napoli M., Rapisarda E., Amorini F., Sfienti C.* Phys. Rev. Lett. **100** 192503 (2008)

[13] *V. A. Karnaukhov, et al.* Thermal multifragmentation, nuclear fog and critical temperature for the liquid-gas phase transition// Particles and Nuclei, Letters. 2002. No. 4[113]. http://www1.jinr.ru/Pepan_letters/panl_4_2002/01_karn.pdf

[14] *Whittaker, E. T. 1873-1956.* A Treatise On the Analytical Dynamics of Particles And Rigid Bodies: With an Introduction to the Problem of Three Bodies.// 2d ed. Cambridge: University Press, 1917.

[15] *Бочкарев О. В., Коршенинников А. А., Кузьмин Е. А. Муха, И. Г., Оглоблин А. А., Чулков Л. В., Яньков Г. Б.* Двупротонный распад ^6Be// Письма в ЖЭТФ. 1984. **40**, вып. 5. С. 204–206.

[16] *Wehlitz R., Juranic P. N., Collins K., Reilly B., Makoutz E., Hartman T., Appathurai N., Whitfield S. B.* Photoemission of Cooper Pairs from Aromatic Hydrocarbons//Phys. Rev. Lett. **109**, 193001 – Published 5 November 2012.

[17] *Holmlid L., Manykin E.A.* Rydberg matter — a longlived excited state of matter // JETP, Vol. **84**, No 5, p. 875, May 1997.

[18] *Agafonov A. V., Bagulya A. V., Dalkarov O. D., Negodaev M. A., Oginov A. V., Rusetskiy A. S., Ryabov V. A., Shpakov K. V.* Observation of Neutron Bursts Produced by Laboratory High-Voltage Atmospheric Discharge // Phys. Rev. Lett. **111** 115003 (2013)

[19] *Богуля А. В., Далькаров О. Д., Негодаев М. А., Огинов А. В.,Русецкий А. С.* Изучение стимулирования ядерных реакций и излучений на границе твердого тела и плазмы высоковольтным разрядом и пучками ионов и электронов на уникальных установках ФИАН // Инноватика и экспертиза. 2015. Выпуск 2 (15) С. 201-221.

[20] *Stuart J. Greaves, Eckart Wrede, Noah T. Goldberg, Jianyang Zhang, Daniel J. Miller, Richard N. Zare.* Nature. **454** 88 (2008)

[21] *John Lawrence, Cornelius Tobias, John Linfoot, James Born, Edward Manougian, John Lyman,* Heavy Particles and Bragg Peaks in Therapy //Annals of Internal Medicine Vol. **62**, Issue 2, 400 (1965).

[22] *Лосев Д. В., Ломанов М. Ф., Черняев А. П.* Аналитический расчет модифицированной кривой Брега // Препринт НИИЯФ МГУ - 2003-16/729.

[23] *Месяц Г. А.* Взрывная электронная эмиссия // Издательство физико-математической литературы, 2011. - 280 с.

[24] *Yu.N. Eroshenko* Physics news on the Internet (based on electronic preprints). Gamma-ray bursts caused by lightning// Phys. Usp. **56** 103–104 (2013) https://www.nasa.gov/mission_pages/GLAST/news/vision-improve.html

[25] *Rudnitskii A. A.* Thermoelectric Properties of the Noble Metals and Their Alloys.//Translation USAEC-tr-3724 (1948). http://www.dtic.mil/dtic/tr/fulltext/u2/a398277.pdf

[26] *Бернштейн А. С.* Термоэлектричество.-М. Гостехиздат, 1957 г. 56 с.

[27] *Sadovskii M. V.* Pseudogap in high-temperature superconductors// Phys. Usp. **44** 515–539 (2001).

[28] *Mannella N., Yang W. L., Zhou X. J., Zheng H., Mitchell J. F., Zaanen J., Devereaux T. P., Nagaosa N., Hussain Z., Shen Z.-X.* Nature. **438** 474-478 (2005)

[29] *Кадомцев Б. Б.* Перезамыкание магнитных силовых линий// Успехи физических наук. 1987. **151**, вып. 1. С. 3-29.

[30] Internet resource: http://www.eso.org/public/news/eso1405/

[31] Internet resource: http://www.gmanetwork.com/news/scitech/science/366494/nasa-ids-potential-target-for-asteroid-mission/story/

[32] *Ginzburg I. F., Kotkin G. L., Serbo V. G., Polityko S. I.* Coherent bremsstrahlung in colliding beams// JETP Lett., Vol. **55**, No. 11, 614-617, (10 June 1992).

[33] *Gershman B N, Trakhtengerts V Yu* Very-low-frequency radio emission of the upper atmosphere and its relationship with other geophysical phenomena// Sov. Phys. Usp. **9** 414–429 (1966); DOI: 10.1070/PU1966v009n03ABEH002891

[34] *Khrenov B.A., Garipov G.K., Klimov P.A., Panasyuk M.I., Tulupov V.I., Shirokov A.V., Yashin I.V.* Transient flashes of electromagnetic radiation in the upper atmosphere// Cosmic Research. 2008. Vol. **46**. No. 1. pp. 25-34.

[35] *Gurevich A V* Nonlinear effects in the ionosphere// Phys. Usp. **50** 1091–1121 (2007); DOI: 10.1070/PU2007v050n11ABEH006212

[36] Internet resource: https://www.youtube.com/watch?v=iCawTYPtehk

[37] Internet resource: http://www.youtube.com/watch?v=wuljJYRoYUs

[38] Internet resource: http://www.youtube.com/watch?v=gQ6Pa5Pv_io

[39] Internet resource: http://www.youtube.com/watch?v=H6PtMBzvRKg

[40] Internet resource: http://www.youtube.com/watch?v=CPvphDKgVvY

[41] Internet resource: http://www.youtube.com/watch?v=Ex1a14XHZQs

[42] Internet resource: http://www.youtube.com/watch?v=OM-5ngYg5Mg

[43] Internet resource: http://www.youtube.com/watch?v=LFsZitw6CKk

[44] *Алпатов В. В., Буров В. А., Вагин Ю. П., Галкин К. А., Глухов Я. В., Давиденко Д. В., Зубачёв Д. С., Иванов В. Н., Кархов А. Н., Коршунов В. А., и др.* Геофизические условия при взрыве Челябинского (Чебаркульского) метеороида 15.02.2013 г.// М. ФГБУ «ИПГ». 2013.

[45] Internet resource: http://www.meteorite-recon.com/home/meteorite-documentaries/chelyabinsk-superbolide/p6

[46] *Steven D. Millera, William C. Straka, A. Scott Bachmeierb, Timothy J. Schmitc, Philip T. Partaina, and Yoo-Jeong Noh* Earth-viewing satellite perspectives on the Chelyabinsk meteor event//PNAS, November 5, 2013, vol. 110, no. 45, 18097.

[47] *Шарыгин В. В., Карманов Н. С., Тимина Т. Ю., Томиленко А. А., Подгорных Н. М.* «Проплавленные» фрагменты метеорита Челябинск: минералогия и генезис (Метеорит Челябинск: сообщения 1-8) // http://www.meteorites.ru/images/yuzhnouralsky2013/chebarkul_21-22.06.2013_asteroidy_i_komety_cheljabinskoe_sobytie.pdf

[48] *Анфилогов В. Н., Белогуб Е. В., Блинов И. А., Еремяшев В. Е., Кабанова Л. Я., Лебедева С. М., Лонщакова Г. Ф., Хворов П. В.* Петрография, минералогия и строение метеорита “Челябинск”// Литосфера. 2013. № 3. С. 118–129.

[49] Internet resource: http://cimss.ssec.wisc.edu/goes/blog/archives/12356

[50] Internet resource: https://tune.pk/video/1003361/падения-метеорита-в-симферополе-hd-21112013-падения-метеорита-в-крыму-hd-21112013

[51] Internet resource: http://www.youtube.com/watch?v=uuwvYdovMEg

[52] *Дубровин В. И., Смирнова А. А.* Анализ записей чебаркульского метеорита на инфразвуковых станциях ядерного мониторинга// Вестник НЯЦ РК, выпуск 1, март 2014, С. 91-95.

[53] *Alexis Le Pichon, Lars Ceranna, Christoph Pilger, Pierrick Mialle, David Brown, Pascal Herry, Nicolas Brachet.* Geophysical Research Letters. V. **40**, Issue 14. pages 3732–3737. 28 July 2013.

[54] *Murty, T.S.* Seismic Sea Waves: Tsunamis// Published by Department of Fisheries and the Environment Fisheries and Marine Service, 1977

[55] *Donn W. L., Shaw D. M.* 1967. Exploring the atmosphere with nuclear explosions. Rev. Geophys. 5: 53—82.

[56] Internet resource: https://www.youtube.com/watch?v=5Rh2-v-gFEs

[57] Internet resource: http://www.youtube.com/watch?v=3kc274wZgMg

[58] *Баклунд О. А.* Комета Энке// Известия Императорской Академии Наук, 6-я серия, 1908, том 2, выпуск 3, С. 239-242.

[59] *A. P. Drozdov, M. I. Eremets, I. A. Troyan, V. Ksenofontov, S. I. Shylin.* Conventional superconductivity at 203 kelvin at high pressures in the sulfur hydride system . Nature, 2015; DOI: 10.1038/nature14964.

[60] https://en.wikipedia.org/wiki/Earthquake#/media/File:Quake_epicenters_1963-98.png

[61] Internet resource: https://www.youtube.com/watch?v=p8xjpLB5XrU

[62] Internet resource: http://www.nasa.gov/topics/solarsystem/features/electric-moon.html

[63] *Belenkaya E S* Magnetospheres of planets with an intrinsic magnetic field // Phys. Usp. **52** 765–788 (2009); DOI: 10.3367/UFNe.0179.200908a.0809

[64] *Андрущенко В. А., Сызранова Н.Г., Шевелев Ю.Д.* Моделирование падения Челябинского метеорита// Компьютерные исследования и моделирование. 2013. **5**, № 6. С. 927-940.