



# A Model for the Formation of Dark Matter in the Universe

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## Abstract

In order to create a model for the formation of dark matter in the universe, the displacement equation is used for changing the state of an elastic medium in a linear approximation. A localized microparticle located in the pre-galactic space is characterized by a point inclusion defect, *i.e.* center of dilation. Dilation is modeled by using divergence. Attention is drawn to the relation, according to which the value of the Burgers vector is defined as the circulation of the displacement differential. The concept is used, according to which two centers of dilation interact only when these centers are in direct contact. Attention is taken into account, by which the divergence is equivalent to the derivative of the abundance function with respect to the molar volume. The Gibbs thermodynamic potential is taken as the abundance function. As a result of finding the derivative of the abundance function with respect to the molar volume, a quadratic algebraic equation has been obtained, the solution of which makes it possible to determine the volume in which dark matter is formed. The dark matter formed in this way is in a circular state, *i.e.* in rotation. The centripetal force condenses the electron gas to the density of a single electron. Dark matter is formed in the form of an uncountable number of rotating electron balls in the pre-galactic spaces of the universe.

## Subject Areas

Classical Physics, Modern Physics

## Keywords

Electron Gas, Elastic Medium, Dilatation, Divergence, Displacement, Centripetal Force, Dark Matter

## 1. Introduction

In recent years, a very important scientific discovery has been made: it becomes

known that the mass of luminous objects in the Universe constitutes about four percent of the total mass in space; the rest of the mass (about 96%) falls on dark matter. It means that the total average density of matter in the universe is many times bigger than its critical density  $\rho_c = 10^{-29} \text{ g/cm}^3$ .

From this it follows that the total amount of matter in the universe is such that it is able to stop its expansion, *i.e.* the universe is closed. The environment in which the mechanism of formation of the dark matter proposed by us can operate is an elastic model of the physical vacuum, and the elementary particle acts as a singularity of this environment.

Consequently, in this model, the physical vacuum is an elastic solid body, and the particle is considered as a localized exciter of this body. It should be noted that such model of the physical vacuum is not something new. Book (Max Born) [1] provides similar model in an elementary but meaningful presentation is given. The work (V.A. Dubrovsky) [2] is devoted to the elastic model of vacuum.

## 2. Definitions, Relations and Facts Used to Create a Model for the Formation of Dark Matter in the Universe

### 2.1. Definitions

An ideal gas is a gas whose molecules occupy negligibly small volume and have no interaction with each other at a distance. Consequently, real gases are the closer in their properties to ideal gases, the greater the average distances between molecules, *i.e.* the lower the concentration of molecules and, accordingly, the density of the gas.

For a given mass of an ideal gas, the ratio of the product of pressure  $P$  and volume  $V^*$  to the thermodynamic temperature  $T$  is a constant value and is called Clapeyronrelation

$$PV^*/T = C = \text{const.} \quad (1)$$

From the definition of the unit of amount of a substance, it follows that 1 mole of any gas contains the same number of molecules  $N_A$  called the Avogadro's constant  $N_A = 6.02 \times 10^{23} \text{ mole}^{-1}$ . Let  $m_0$  is the mass of one molecule, then an arbitrary amount of a substance  $q$  equals to

$$m = m_0 N_A q = Mq,$$

and the molar mass of a gas is determined by the relation

$$M = m_0 N_A = m/q.$$

The molar volume of a gas is called the quantity

$$V_m = V^*/q \quad (2)$$

### 2.2. Relations

The expression (1) can be represented as correlation  $PV_m q = CT$  or

$$PV_m = RT, \quad (3)$$

where  $R = C/q$  is molar gas constant  $R = 8.31 \text{ J/(mole}\cdot\text{K)}$ .

According to Avogadro's law, molar volumes of all gases under the same pressure and temperature conditions are equal.

From Equation (3) we can get Clapeyron-Mendeleev relation

$$PV^* = \frac{m}{M}RT.$$

From this correlation, the density of the gas is determined

$$\rho^* = \frac{m}{V^*} = \frac{PM}{RT}.$$

With account of the Boltzmann constant,

$$k = \frac{R}{N_A} = 1.38 \times 10^{-23} \text{ J/K}$$

from the Equation (3) we obtain

$$P = \frac{kN_A}{V_m}T = kn_0T$$

where  $n_0 = N_A/V_m$  is the concentration of molecules.

The latter correlation can be written as

$$P = KT, \quad (4)$$

$$\text{where } K = kn_0. \quad (4a)$$

### 2.3. Facts

It is well known that dark matter is formed in the gravity-curved pre-galactic spaces of the universe. Of interest is the substance of which this matter consists. Therefore, the statement according to which "all ordinary matter in the universe is made of the lightest leptons (the electron and electron neutrino<sup>1</sup>) and the two lightest quarks (u and d)" [3] see p.101) is very important, as it makes possible to determine the composition of matter in pre-galactic spaces. Let us consider the location of these leptons and quarks in natural conditions.

1) The processes similar to the formation of dark matter in the universe do not occur under terrestrial conditions. However, there is a similarity between the processes of electron condensation in terrestrial conditions and pre-galactic space twisted by gravity. Thus, conduction electrons in a metal under the action of an electric field change from a gaseous state to a liquid state, and then to a solid state. Consequently, as a result of the condensation of the metal, a part of the valence electrons is socialized, which are separated from their atoms and form an electron gas in metals [4] (see p. 132).

According to the main provisions of the classical statistical theory, the average energy  $E = \frac{3}{2}kT_a$  of the translational thermal motion of the molecules of any gas with the velocity  $v^*$ , depends only on the absolute equilibrium temperature

<sup>1</sup>Besides the electron-neutrino correlation, there are  $\mu$ -neutrinos and  $\tau$ -neutrinos but we consider them as three states of one particle. This is possible when the laws of conservation of lepton charges are violated.

$T_a$ , but not on the chemical nature and molecular weight of the gas but is equal to the kinetic energy of this gas:

$$E = \frac{1}{2}mv^2. \quad (5)$$

However, according to quantum theory, the electron gas obeys not classical statistics, but Fermi-Dirac statistics. At high temperatures and low densities of the electron gas, the conclusions of both statistics, quantum and classical, coincide, but at low temperatures and high densities, the degeneracy of the gas occurs, that is, a deviation from the classical laws. Degeneration of a gas sets in when the “degeneracy parameter” is

$$^2 A_{\Theta} = \frac{n_0 h^3}{2(2\pi mkT_a)^{3/2}}$$

becomes commensurable with the unit ( $h$  is Planck constant).

Consequently, classical statistics applies to an electron gas only at  $A_1 \ll 1$ . However, for an electron gas in metals in the form of its colossal density (for example, the density of iron is equal to  $7.8 \times 10^3 \text{ kg/m}^3$  and, due to the negligibility of the electron mass ( $m_e = 9.109534 \times 10^{-31} \text{ kg}$ ), this requirement is not satisfied.

According to Fermi-Dirac statistics, under the condition  $A_2 \gg 1$  that is fulfilled for metal electrons at temperatures up to 20.000 degrees [5], the average kinetic energy of the translational motion of free electrons is not proportional to the absolute temperature, and practically does not depend on temperature  $T_a$ , but unambiguously (in the first, fairly accurate, approximation) is determined by the density of the electron gas:

$$E_{n_0} = \frac{3h^2}{40m} \left( \frac{3n_0}{\pi} \right)^{2/3}.$$

Specific expressions for parameters  $A_1$  and  $A_2$  are given in [6].

Since, in addition to the electric charge, electrons have a mass, the electrons, having fallen into a curved pre-galactic gravitational field, move in it under the action of this field. Thus, if an electric field acts on free electrons located in a metal under terrestrial conditions, then the gravitational field of a galaxy acts on electrons located in pre-galactic space. The gravitational field is the cause of the translational motion of the electron gas, which under natural conditions undergoes the following stages of condensation: accumulation of electrons in pre-galactic spaces, *i.e.* formation of electron gas, condensation and compaction of condensed electron gas due to the effect of centripetal force<sup>3</sup> on it, caused by circulation motion.

Using the similarity between the stages of condensation in which the electron gas is found under terrestrial conditions and the state in which the electron gas is found in pregalactic space makes it possible to substantiate the different color

<sup>2</sup>The index  $\Theta$  at the parameter  $A$  means that this parameter is commensurable with unity.

<sup>3</sup>The centripetal force is always directed towards the center of curvature of the trajectory of a material point.

of electron clouds in pregalactic formations. For the electron gas located in the pre-galactic formations, formula (5) takes place and, therefore, we have a strengthened inequality for the parameter  $A_1 \ll 1$ . In this case, the electron gas belongs to ideal gases. If we take into account E. Fermi's assertion, according to which electrons do not exist in the nucleus in a finished form, but are somehow instantly formed from the energy of the nucleus, it becomes clear that the electrons emitted from atomic nuclei, for example, iron and copper will have a color corresponding to their energy. Therefore, the electron clouds formed from them will have different colors [7].

2) The elementary particle neutrino has a half-integer (like an electron) spin, *i.e.*, it belongs to the class of fermions; this particle has no charge. Due to its very small size (a neutrino with an energy of 1 MeV makes in cross section of  $10^{-48}$  m<sup>2</sup>) it has a small mass; this is the reason for its weak interaction with the gravitational field. Neutrinos pass unhindered through dense matter. Theoretical calculations make it possible to determine the mean free path of a neutrino in dense matter; it is  $10^{16}$  km. As follows from work [8], gravitational waves from neutrino beams passing through the strained layers of the Earth cause earthquakes. A neutrino cannot be in a stationary state; this particle is constantly in motion [9].

On February 23, 1987, a burst of neutrinos was registered in the energy range from 7.5 to 40 MeV. This phenomenon occurred when a supernova exploded in the nearby galaxy, the Large Magelanic Cloud, at a distance of 160.000 light-years from Earth.

3) It has now been proven that all hadrons<sup>4</sup> are composed of quarks, fundamental particles that are very unusual in their properties, which also have anti-particles-antiquarks. Quarks, being colored objects (have nothing to do with the physiology of "vision"), they cannot exist in a free state, but can be inside white colorless particles, hadrons. It turns out that the interaction energy of quarks does not decrease with increasing distance, but increases. The spin of quarks is equal to 1/2 and they have fractional electric charges that are multiples of 1/3 in units of electron charge. Experiments on the scattering of electrons and positrons from colliding beams made it possible to directly "view" the quarks.

Upon collision, these particles turn into a virtual photon, which generates a quark-antiquark pair. From the properties of the lightest leptons and quarks given in paragraphs 3a-3c, it can be seen that the electron is the most realistic candidate for the formation of dark matter in the Universe. Neutrinos and quarks do not undergo those stages of condensation that lead to the formation of dark matter located in pre-galactic spaces. Unlike neutrinos and quarks, under natural conditions, electrons go through the stages of condensation that are necessary for the formation of dark matter.

Based on the stages of electron gas condensation leading to the formation of dark matter, we believe that the electron is an elementary particle that is the cause of the creation of dark matter in the universe.

<sup>4</sup>Hadrons are responsible for the stability of atomic nuclei.

### 3. Model of the Dark Matter Formation

#### 3.1. Displacement Equation for Changes in the State of an Elastic Medium in the Linear Approximation. Modeling Dilation by Divergence

When creating a model for the formation of dark matter, an important place belongs to the description of the displacement of the state of an elastic medium. Therefore, we use some of the results given in monograph [10] concerning this problem.

The displacement equation in the linear approximation with a change in the state of the elastic medium has the form

$$\rho \frac{\partial^2 \mathbf{u}}{\partial t^2} + \mu \operatorname{rot} \operatorname{rot} \mathbf{u} - (\lambda + 2\mu) \operatorname{grad} \operatorname{div} \mathbf{u} = \mathbf{X}, \quad (6)$$

where

$\mathbf{u}$  is elastic medium displacement vector;

$\rho$  is density of medium;

$\mu$  and  $\lambda$  are constants of the elastic medium, called the Lamé coefficients and having the dimension  $\text{erg}/\text{cm}^3$ ;

$\mathbf{X}$  is vector of external action with respect to the elastic medium.

If we introduce the designations  $c_1 = \sqrt{\mu/\rho}$  and  $c = \sqrt{(\lambda + 2\mu)/\rho}$  then the Equation (6) will be written in the form of

$$\frac{\partial^2 \mathbf{u}}{\partial t^2} + c_1^2 \operatorname{rot} \operatorname{rot} \mathbf{u} - c^2 \operatorname{grad} \operatorname{div} \mathbf{u} = \rho^{-1} \mathbf{X}, \quad (7)$$

where  $c_1$  is velocity of propagation of a transverse wave in an elastic medium.

This speed is not used to obtain the volume in which dark matter is formed, *i.e.*  $c_1 = 0$ .

$c$  is the propagation velocity of a longitudinal wave in an elastic medium.

In our opinion, the increase in volume in a vacuum curved by gravity, in which dark matter is formed, is described by a stationary equation corresponding to the Equation (7). Based on these considerations, we believe that a localized microparticle is characterized by a point inclusion defect, *i.e.* a dilatation center. The center of dilation represents such right side of the equation corresponding to the stationary Equation (7) at  $c_1 = 0$ , *i.e.* expression

$$-c^2 \operatorname{grad} \operatorname{div} \mathbf{u} = \mathbf{Q}, \quad (7a)$$

which takes the form<sup>5</sup> [10]:

$$\mathbf{Q} = -\frac{b}{\rho} \operatorname{grad} \delta(\mathbf{r} - \mathbf{r}') = \rho^{-1} \mathbf{X}, \quad (8)$$

where  $\mathbf{X} \equiv -b \operatorname{grad} \delta(\mathbf{r} - \mathbf{r}')$ , the vector of external action in relation to the elastic medium presented in expanded form;

$|b| = b$  is the magnitude of the Burgers vector being a constant;

<sup>5</sup>Under  $\delta(\mathbf{r} - \mathbf{r}')$  is meant three-dimensional  $\delta$  Dirac function, *i.e.*  $\delta(\mathbf{r}) = \delta(x)\delta(y)\delta(z)$ , where  $x, y, z$  are space coordinates.

$\delta$  denotes Dirac function;

$\mathbf{r}$ , the vector of the current distance to the center of the inclusion (dilation), *i.e.* the center of the sphere of radius  $r'$ .

The reduced vector of external action (8) creates a potential displacement field in the elastic medium

$$\mathbf{u}(\mathbf{r}) = -\frac{b}{4\pi\rho c^2} \text{grad} \left( \frac{1}{|\mathbf{r}-\mathbf{r}'|} \right).$$

The divergence of this displacement equals zero everywhere except for the singular point, *i.e.*, the point of dilation; according to (7a) and (8) we have

$$\text{div} \mathbf{u} = \frac{b}{\rho c^2} \delta(\mathbf{r}-\mathbf{r}'). \quad (9)$$

According to the definition of divergence, we have

$$\text{div} \mathbf{u} = \lim_{\Delta V_m \rightarrow 0} \frac{\Delta G}{\Delta V_m} = \frac{\partial G}{\partial V_m}, \quad (10)$$

where,

under  $\Delta V_m$  is meant an increase in molar volume  $V_m$  (see (2)), caused by an increase in dark matter;

under  $\Delta G$  is meant an increase in the abundance function  $G$ .

The divergence represents a numerical characteristic of the measure of dilation relative to the change in volume at a given point in the elastic medium. Consequently, the dilation is modulated by divergence, *i.e.*, by the number of vector lines characterizing the value of the divergence of the vector field  $\mathbf{u}$ , and issuing from the dilation center.

### 3.2. Circulation of the Displacement Differential of an Elastic Medium. Determination of the Increase in Molar Volume Caused by the Increase in Dark Matter

The relationship between a certain direction of the magnitude of the Burgers vector and the direction of circulation of the differential displacement of the lines of an elastic medium is given by the expression [11]:

$$\oint \mathbf{d}u = +\mathbf{b}, \quad (11a)$$

and the relationship between the opposite direction of the magnitude of the Burgers vector and the direction of circulation of the displacement differential of the elastic medium has the form [12]:

$$\mathbf{d}u = -\mathbf{b}. \quad (11b)$$

Comparing the formulas (11a) and (11b), we get

$$\oint \mathbf{d}u = - \oint \mathbf{d}u.$$

Therefore, the use of the formulas given in [11] and [12] in relation to the gravity lines of the galaxy makes it possible to determine the direction of the circulation of the differential of the displacement of the lines of the elastic me-

dium.

If we write the integrands of the Equations (11a) and (11b) for  $k$ -component of the displacement  $\mathbf{u}_k$  is written in the form

$$d\mathbf{u}_k = u_{ik} d\mathbf{r}'_i, \quad (12)$$

(where  $u_{ik} = \pm \frac{\partial}{\partial r'_i} u_k$ , elastic distortion tensor), with account of (12) then for  $k$  component of expressions (11a) and (11b) we have

$$\oint u_{ik} d\mathbf{r}'_i = \pm b_k.$$

Thus,  $k$  component of Burgers vector  $b_k$  is equal to the circulation of the corresponding component of the distortion tensor of the displacement vector  $\mathbf{u}_{ik}$ .

For the positive displacement component  $\mathbf{u}_{ik}$ , defined according to the formula (9), we will have

$$\mathbf{u}_{ik} = \frac{b_k}{\rho c^2} \delta(\mathbf{r} - \mathbf{r}'), \quad i = 1, 2, \dots; \quad k = 1, 2, \dots \quad (13)$$

If we introduce the designation  $\mathbf{u}_{ik} = \Delta V_{mk}$ , then taking into account (13), we can state that as a result of taking into account  $k$  particle that has fallen into the molar volume  $V_m$ , which is in a curved vacuum, there is an increase in the molar volume  $\Delta V_{mk}$  in which dark matter is formed; this increase in molar volume is given by

$$\Delta V_{mk} = \frac{b_k}{\rho c^2} \int \delta(\mathbf{r} - \mathbf{r}') d\mathbf{r} = \frac{b_k}{\rho c^2}. \quad (13a)$$

Therefore, the increase in molar volume (13a) is proportional to  $k$  component of Burgers vector  $b_k$ .

If we are interested in the total increase in the molar volume, caused not by the inclusion of  $k$  particle but by the increase in dark matter, then we should omit the index  $k$  in the formulas (13) and (13a).

### 3.3. Definition of the Abundance Function

Let us introduce the concept of the probability density of finding  $k$  particle in the molar volume  $V_m$ , denoting this probability density by the letter  $p_k(\mathbf{r}', t)$ . In this case, the probability of finding the  $k$  component of the Burgers vector in the molar volume  $V_m$ , will be equal to  $b_k p_k(\mathbf{r}', t)$ .

Let us introduce the definition according to which two dilatation centers do not interact with each other in a non-contact way, *i.e.* we have

$$\Xi(k, l) = -\frac{b_k b_l}{\rho c^2} \int p_k(\mathbf{r}', t) p_l(\mathbf{r}', t) d\mathbf{r}' = 0, \quad \text{if } k \neq l.$$

The interaction occurs only with direct contact of two lumped inclusions:

$$\Xi(k, k) = -\frac{b^2}{2\rho c^2} \int p^2(\mathbf{r}', t) d\mathbf{r}' \neq 0, \quad \text{if } k = l. \quad (14)$$

The probability density distribution function  $p(\mathbf{r}', t)$  included in (14) has



the following properties

$$\int p(\mathbf{r}', t) d\mathbf{r}' = 1, \quad (15)$$

$$p(\mathbf{r}', t) = 1/V_m. \quad (16)$$

Property (15) characterizes an arbitrary probability density function. Property (16) means that the probability density function has a uniform distribution over the electron gas located in the molar volume  $V_m$ .

The abundance function represents the Gibbs thermodynamic potential

$$G(V_m) = \Xi(k, k) - TH(V_m) + TH_0 + PV_m, \quad (17)$$

where  $T$  is temperature of ideal gas located in molar volume;

$H(V_m) = (b/b^*)K \ln V_m$  entropy of ideal gas located in molar volume;  $H_0 = \text{const}$  initial entropy of ideal gas;  $K$  constant coefficient defined according to designation (4a);  $b^*$ , meaning of Burgers vector corresponding to 1 mole<sup>6</sup> of ideal gas;  $P$  molar volume pressure on its surroundings caused by its expansion, *i.e.* dilatation.

### 3.4. Determination of the Molar Volume in Which Dark Material Is Formed

Since we are modeling dilatation by divergence, then the molar volume that dark matter tends to occupy must be determined from the condition that the divergence (10) is equal to zero, *i.e.* from the condition of minimum divergence of the displacement lines of the vector  $\mathbf{u}$  of the elastic medium

$$\frac{\partial G}{\partial V_m} = 0. \quad (18)$$

In order to use the abundance function  $G$  (17) in expression (18) of unconditional optimization, it is necessary to take into account the properties (15) and (16) of the probability density distribution function  $p(\mathbf{r}', t)$  in it. As a result of taking into account these properties, the abundance function will take the form

$$G = -\frac{b^2}{2\rho c^2 V_m} - \frac{b}{b^*} KT \ln V_m + TH_0 + PV_m. \quad (19)$$

Substituting the potential (19) into condition (18) leads to the algebraic equation written for the molar volume

$$PV_m^2 - JV_m + \Lambda = 0, \quad (20)$$

where

$$J = \frac{KT}{b^*} b, \quad \Lambda = \frac{b^2}{2\rho c^2}.$$

The solution to Equation (20) has the form

$$V_m = Db, \quad (21)$$

<sup>6</sup>A mole is a unit of the amount of a substance equal to the amount of the substance of a system that contains as many structural elements (atoms, molecules, electrons, etc.) as there are atoms in carbon <sup>12</sup>C mass 0.012 kg.

where

$$D = \Phi\Psi . \quad (21a)$$

In the last expression, we have the following designations:

$$\Phi = \frac{KT}{2Pb^*}, \quad \Psi = 1 + \sqrt{1 - \frac{2b^{*2}P}{\rho c^2 K^2 T^2}} \quad (22)$$

Before the root in the designation  $\Psi$  must have two characters “+” and “-”. However, in view of the fact that dilatation means expansion, we take into account only the sign “+” [13]. If we take into account the formula (4), strengthened inequality  $1 \gg \frac{2b^{*2}}{\rho c^2 KT}$  and take into account the designations (22), then the designation (21a) will be written as follows:

$$D = \frac{1}{b^*} . \quad (23)$$

If in formula (21), we take into account the equality (23), then we can determine the molar volume occupied by dark matter

$$V_m = \frac{1}{b^*} \oint d\mathbf{u} . \quad (24)$$

When determining the volume according to (24), the direction of circulation is not significant. The system corresponding to carbon<sup>12</sup>C and having a molar mass

$$M_e = \frac{1}{b^*} = \frac{1000}{12} = 83.33 \text{ kg} ,$$

consists only of electrons. According to the formula (19), the constant parameter  $b^*$  is considered as a normalizing factor in the value  $b$ , so the expression (24) can be represented in the following form

$$V_m = \oint d\mathbf{u}(M_e) . \quad (25)$$

Therefore, the molar volume (25) in which dark matter is formed is defined as the circulation of the displacement differential  $d\mathbf{u}$  of the elastic medium vector.

### 3.5. Numerical Characteristics of Dark Matter

The optimization principle dominates in the universe: with a given volume, a body is formed that has the smallest area of surface; such body is a ball, in our case, colliding around the axis, passing through the diameter of the ball and coinciding with the axis  $oz$  in the Cartesian coordinate system. This means that the circulation occurs due to the rotation of the electron ball. All points of the ball rotate with the same angular velocity  $\boldsymbol{\omega}$ , and the linear velocity  $\mathbf{v}$  of each point of the ball relative to the axis  $oz$  obeys the vortex relation  $rot_z \mathbf{v} = \pm 2\boldsymbol{\omega}$ .

In order to determine the radius  $R_{m_e}$  of the electron ball, you must use the formula

$$V \equiv \frac{4\pi R_{m_e}^3}{3} = \frac{M_e}{\rho_{m_e}} ,$$

where  $\rho_{m_e}$  is the density of electron ball,  $V$  volume of electron ball.

From this relation, the desired radius can be determined

$$R_{m_e} = \sqrt[3]{\frac{3M_e}{4\pi\rho_{m_e}}} . \quad (26)$$

The concept is taken into account, according to which the density of a compacted electron ball  $\rho_{m_e}$  is equivalent to the density of an individual electron  $\rho_e$  i.e.  $\rho_{m_e} \equiv \rho_e$ . This concept is based on the fact that due to the action of the centripetal force  $F$  in the process of circulation, the electron ball is compacted to the density of an individual electron. This density is determined by the equality

$$\rho_e = \frac{m_e}{\frac{4\pi r_e^3}{3}} , \quad (27)$$

where  $r_e$  is electron radius.

The centripetal force  $F_i$  acting on  $i$  material point of mass  $M_{ei}$ , located inside or on the surface of the electron ball and pressing it (point) closer to the axis of rotation of the ball, is determined by the formula

$$F_i = \frac{M_{ei} v_i^2}{R_{m_{ei}}} , \quad (28)$$

where  $M_{ei}$  is a mass of  $i$  material point of the electron ball;  $v_i = \pm R_{m_{ei}} \cdot \omega$  linear speed of rotation of  $i$  material point of the electron ball;  $R_{m_{ei}}$  denotes radius drawn from the center of the ball to  $i$  material point;  $\omega$ , angular velocity of the ball rotation.

Substituting  $\rho_e$  from the designation (27) into (26) gives

$$R_{m_e} = r_e \sqrt[3]{\frac{M_e}{m_e}} . \quad (29)$$

Formula (29) determines the radius of an electron ball in a rotational state. To find the numerical value of the radius  $R_{m_e}$  of the electron ball, it is necessary to take into account the numerical values of the parameters  $m_e$ ,  $M_e$ ,  $r_e$ .

The numerical value of the electron mass  $m_e$  is given in Section 1 (see point 3a). The numerical value of the mass of the electron ball  $M_e$  is given in the text after formula (24). The numerical value of the radius of the electron  $r_e$  is known:  $r_e = 2.81794 \times 10^{-15}$  m.

Substituting the numerical values of these parameters into formula (29) allows us to determine the numerical knowledge of the radius of the electron ball

$$R_{m_e} = 2.81794 \times 10^{-15} 10(\text{m}) \sqrt{\frac{\frac{1000}{12}}{9.109534 \times 10^{-31}}} \approx 0.000166 \text{ m} = 0.166 \text{ mm} , \quad (29a)$$

where  $m$  means meter.

Since the electron ball has a small radius (29a), it can be called a "globule".

According to formula (28), it is possible to determine the total centripetal force  $F$  acting on the mass  $M_e$  (kg) of an electron globule with a radius  $R_{m_e}$  (m):

$$\sum_i \mathbf{F}_i = \mathbf{F} = M_e R_{m_e} \mathbf{N}, \quad (30)$$

where  $\mathbf{N}$  is designation of the force in Newtons:  $1\mathbf{N} = \frac{\text{kg} \cdot \text{m}}{\text{s}^2}$ ,

$s$  means time in seconds.

The angular acceleration of the globule can be determined from the relation

$$\omega^2 = \frac{1}{s^2} = \left( \frac{\pi}{180^\circ} \right) \left( \frac{180^\circ}{\pi} \right) \frac{1}{s^2} = \left( \frac{\pi}{180^\circ} \right) \text{rad/s}^2, \quad (31)$$

where  $1 \text{ rad} = 57^\circ 17' 44.8''$ .

Taking into account the ratio (31) in the formula (30) allows determining the numerical value of the centripetal pressure  $\mathbf{W}$ , measured in Pascal ( $\mathbf{Pa}$ ) and acting on the electronic globule:

$$\mathbf{W} = 13833333178 \mathbf{N}/S = \frac{83333333}{12.56 \times 166} \mathbf{Pa} = 40.000 \mathbf{Pa}, \quad (32)$$

where  $1\mathbf{Pa} = \mathbf{N}/S$ ,  $S = 4\pi R_{m_e}^2$ , the area of globule surface.

Consequently, the centripetal pressure (32), acting on the mass  $M_e$  of electron gas located in the molar volume  $V_m$  (25), causes the gas to condense, and then, continuing to act on it, compacts the condensed gas to the density of a single electron.

The creation of a molar volume  $V_m$ , in which dark matter is formed and in which centripetal pressure condenses the electron gas, should be considered as a single process for the formation of dark matter in the Universe.

## 4. Results

1) From the condition of minimalism of the divergence of gravitational lines of an elastic medium, an algebraic equation is obtained, which satisfies the molar volume of the dark matter.

2) Numerical characteristics of dark matter are determined.

## 5. Conclusions

In the process of dark matter formation, various kinds of foreign non-electronic impurities in the form of cosmic dust, which have a specific density lower than that of an electron, are added to the electron gas. This is the reason why flaws are formed in the electron globule, because the centripetal pressure acts on impurities with less force and therefore does not compact them as it would be with electron globule without impurities. The mass of the electron globule  $M_e^*$  formed taking into account the flaw is less than the mass  $M_e$  of the globule without a flaw, *i.e.*  $M_e^* < M_e$ . The electron globule formed in this way rotates again around the axis passing through its diameter. However, in this case, no work is done, and the power  $\Pi$  exists:

$$\Pi = M_e^* |\boldsymbol{\omega}|.$$

The countless number of rotating electron globules with defects enveloping

galaxies in the form of so-called “clouds” and “nebulae” represent the dark matter of the universe.

### Conflicts of Interest

The author declares no conflicts of interest.

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