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of Science Frontier Research: A

# Physics and Space Science

Highlights

- Enhancing Farm Productivity
- The Heat Transfer by Radiation
- Fine-Structure of the Electron
- Non-Equilibrium Thermodynamics

Discovering Thoughts, Inventing Future

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# The Toroidal Fine-Structure of the Electron

By Gene Gryziecki

*Abstract-* Developments in physics in the past two decades have expanded the well-known mass-energy equation into a rigorous set of relations that provide the electric and magnetic fine-structure and the volumetric structure of the electron as a closed-flux torus, all in agreement with 2018 Codata values. In light of these developments, the present communication questions the physical meaning of the Bohr radius and its implications – the Bohr-Heisenberg theory of the hydrogen atom and its description of an electron as a point-mass particle that only exists when its probability wave collapses.

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*Strictly as per the compliance and regulations of:*

# The Toroidal Fine-Structure of the Electron

Gene Gryziecki

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## I. Introduction

The Bohr theory of the hydrogen atom, theorized by Niels Bohr (1885-1962), includes a negatively charged point-mass electron that travels in a circular orbit about a positively charged nucleus. In the atom's lowest energy (or ground) state, the distance between the two particles is called the Bohr radius and is equal to $0.529 \times 10^{-10}$ m. Since then, further investigation indicated that sometimes the electron behaves like a wave and sometimes like a particle [1]. Thus, the Bohr-Heisenberg model of the atom arose where the electron exists only as a cloud or fuzzy cavity about the nucleus and measurements are based upon the probability of a point particle being found at a certain location in the cloud.

Recently, there has been some rather meticulous scientific research work by Dr. Paulo Correa and his team that has put forth a novel description of the electron as a torus ring, and a heuristic understanding of the Bohr radius and the Bohr-Heisenberg model of the atom. This paper is intended to provide an introduction to, and overview of, an important aspect of this work.

## II. Methods and Results

Building upon the work of Wilhelm Reich (1897-1957) and his research on gravitational pendulums, it became possible to decipher his formula for determining the functional equivalence between mass and length [2]. Reich's work supported the idea that "atomic weights are gravitational functions that can be functionally replaced by pendulum lengths." He selected pendulum lengths, in centimeters (cm), such that they were numerically equal to the gram-molar masses, and thus to the atomic weights, of various elements, while keeping the actual weight of the pendulum constant at 1 gram. For example, the length of gravitational pendulums for Hydrogen, Helium and Oxygen would be 1, 4 and 16 cm, respectively [3]. His process transforms "inertial mass into the rotary or pendular wavelength of the linear free fall motion" understood as weight [4].

In the case of the electron (the entirety of this paper applies to the electron and all reference values have been taken from a single source, CODATA 2018 [5]), this gravitational wavelength is resonant with the "wavelength of the energy circularized as mass-energy (see below) and on which the inertia of a state of rest is anchored as a reaction of that inert mass or of that mass-energy," referred to as the mass-equivalent or amplitude [6] wavelength [7]. In fact, for the electron, these two wavelengths, gravitational and mass-equivalent, are numerically equal, and the wavelength of concern in this paper is the electron mass-equivalent wavelength. The equation for the mass to length transformation for the electron can be shown as:

$$\text{Length} = \lambda_e = m_e N_A 10^{-2} \text{ in meters [2]} \qquad (1)$$

where $\lambda_e$ is the mass-equivalent wavelength of the inert mass of the electron, $m_e$ is the electron mass (in grams), and $N_A$ is Avogadro's number:

$$\lambda_e = (9.109 \times 10^{-31} \text{ kg})\ (10^3 \text{ gm / 1kg})\ (6.022 \times 10^{23} \text{ / mole})\ (10^{-2})\ (\text{m}) = 5.486 \times 10^{-6} \text{ m} \qquad (2)$$

Using this tremendous insight and the famous equation for calculating rest energy or mass-energy, where energy E equals the product of mass m times the speed of light squared $c^2$, $E = mc^2$, one can determine a functional equivalent to the mass-energy of an electron using two physical quantities rather than three, incorporating length and time instead of mass, length, and time. Accordingly,

$$E = m_e c^2 = \int = \lambda_e c^2 \qquad (3)$$

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with c designating the speed of light and the symbol =∫= indicating a functional transformation that involves both dimensional conversion and an equivalence between two different physical systems of measurement [8]:

$$E = (9.109 \times 10^{-31}\ \text{kg})\ (2.998 \times 10^{8}\ \text{m s}^{-1})^2 = 8.187 \times 10^{-14}\ \text{Joules} =\!\int\!= (5.486 \times 10^{-6}\ \text{m})(2.998 \times 10^{8}\ \text{m s}^{-1})^2 = 4.930 \times 10^{11}\ \text{m}^3\ \text{s}^{-2} \quad (4)$$

For electromagnetic (photon) energy consisting of oscillating electric and magnetic fields, where the maximum wave velocity is restricted to the speed of light, the well-known Compton electron wavelength ($\lambda_{ce} = 2.426 \times 10^{-12}$ m) can be used to determine the Compton electron frequency:

$$\upsilon_{ce} = c / \lambda_{ce} = (2.998 \times 10^{8}\ \text{m s}^{-1}) / (2.426 \times 10^{-12}\ \text{m}) = 1.236 \times 10^{20}\ \text{s}^{-1} \quad (5)$$

When energy is quantized, it can be calculated by the product of Planck's constant ($h = 6.626 \times 10^{-34}$ J s) and frequency. If the frequency happens to be the Compton electron frequency, then the result is equivalent to the mass-energy of the electron or to the low-energy limit of a gamma ray photon. Modern science shows this calculation as

$$E = h\upsilon_{ce} = (6.626 \times 10^{-34}\ \text{J s})\ (1.236 \times 10^{20}\ \text{s}^{-1}) = 8.187 \times 10^{-14}\ \text{Joules} \quad (6)$$

matching the results of the $E = m_e c^2$ calculation shown above in equation (4).

Now, it also becomes apparent that a functionally equivalent Planck's constant h, in meter and second units of measure, can be determined by rearranging the above equation as

$$h = E / \upsilon_{ce} = (4.930 \times 10^{11}\ \text{m}^3\ \text{s}^{-2}) / (1.236 \times 10^{20}\ \text{s}^{-1}) = 3.990 \times 10^{-9}\ \text{m}^3\ \text{s}^{-1} \quad (7)$$

Our limited understanding of charge has confused the issue of the fine-structure of the mass-energy of a mass-bearing charge more than necessary. If we go back to James Maxwell's (1831-79) theory, charge, or as he stated, "a [fundamental] quantity of electricity", could be represented using three physical quantities and dimensions, as [9]

$$q = M^{0.5}\ L^{1.5}\ T^{-1} (M = \text{mass},\ L = \text{length},\ T = \text{time}) \quad (8)$$

This is in agreement with the physical quantities for charge in the Electrostatic System of Units (ESU) [10], and also as proposed in the work of Harold Aspden (1927-2011) [11]. If the mass to length transformation is applied to this definition of charge it can be seen that the property of charge is equivalent to a function of linear momentum that is treated as being massfree -

$$q = M^{0.5}\ L^{1.5}\ T^{-1} =\!\int\!= L^2\ T^{-1} = p_e \quad (9)$$

- where $p_e$ symbolizes charge, with massfree dimensionality, as an electric linear momentum vector function [11]. Charge is a special type of linear momentum function that can be expressed inertially or electromagnetically in mass dependent systems of units (as q or e, see below) or electrically in the meters and seconds massfree system of units as $p_e$ [11]. As shown below in equations (15) and (17), this linear momentum charge function is inherent to the mass-energy of the electron and every massbound charge. The functional equivalences of charge in three different systems of units (ESUs, Coulombs, and meters squared per seconds) are

$$\text{"}q = 4.830 \times 10^{-10}\ \text{ESU} =\!\int\!= e = 1.611 \times 10^{-19}\ \text{C} =\!\int\!= p_e = 13.970\ \text{m}^2\ \text{s}^{-1}\text{" [12]} \quad (10)$$

In addition to being expressed in joules, per equation (4) above, the electron mass-energy can also be expressed as charge, represented by "e," multiplied by voltage, found to be equal to 510,998.950 electron volts (eV), per Codata 2018:

$$E = m_e c^2 = (e)(511\text{kV}) = h\upsilon_{ce} =\!\int\!= (p_e)\ (h / p_e)(\upsilon_{ce}) \quad (11)$$

The Duane-Hunt Law states that the maximum frequency of X-rays emitted from a tube, resulting from electrons that being accelerated by an applied voltage strike a metal anode, is proportional to the applied voltage and is quantized by Planck's quantum of action h, per the equation:

$$\upsilon_{max} = Ve / h = K / h \quad (12)$$

where $\upsilon_{max}$ is the maximum frequency, V is the voltage applied to the tube, e is charge, and K is equal to the kinetic energy of the accelerated electron. Notice that if the terms are rearranged to solve for energy and if the maximum frequency happens to be the Compton electron frequency ($\upsilon_{ce}$), then the kinetic energy would have the same magnitude as the mass-energy of the electron:

$$K = h\upsilon_{ce} = Ve = E = (e)(511kV) =\int= p_e (h / p_e)\, \upsilon_{ce} \quad (13)$$

In the meter and second system of units, the term ($h/p_e$) has the physical dimensionality of length which is expressed in meters and is a wavelength. Under the above condition, this wavelength may be determined for the electric equivalent of the electron mass-energy as the quantum of action h divided by the quantum of charge $p_e$; it is, therefore, a constant:

$$\lambda_x = h / p_e = (3.990 \times 10^{-9}\ m^3\ s^{-1}) / (13.970\ m^2\ s^{-1}) = 2.856 \times 10^{-10}\ m \quad (14)$$

Expanding the electron mass-energy equation to include both inertial and electric linear momentum functions results in

$$E = m_e c^2 = p_{Ae} c = h\upsilon_{ce} =\int= \lambda_e c^2 = p_e W_x = h\upsilon_{ce} \quad (15)$$

where $p_{Ae}$ is the (photo)inertial linear momentum $m_e c$, $p_e$ is the electric linear momentum, and $W_x$ is the electric wavefunction corresponding to the intrinsic voltage (511kV) of the electron mass-energy. The function $W_x$ is called "the voltage equivalent electric wave speed of the electron mass-energy" [13] and it can be directly expressed by its equivalent electromagnetic form as a function of the Compton frequency and the Duane-Hunt wavelength – thus, as a function of two constants:

$$511kV =\int= W_x = \lambda_x \upsilon_{ce} = (2.856 \times 10^{-10}\ m)\ (1.236 \times 10^{20}\ s^{-1}) = 3.529 \times 10^{10}\ m\ s^{-1} \quad (16)$$

This confirms that

$$E = 511keV =\int= \lambda_e c^2 = p_e W_x = 4.930 \times 10^{11} m^3\ s^{-2} = (13.970\ m^2\ s^{-1})\ (3.529 \times 10^{10}\ m\ s^{-1}) = 4.930 \times 10^{11}\ m^3\ s^{-2} \quad (17)$$

and it expands the electron mass-energy expression to include $W_x$ and its constituents. It results in

$$E = m_e c^2 = p_{Ae} c = h\upsilon_{ce} =\int= \lambda_e c^2 = p_e W_x = \lambda_e W_k W_x = \lambda_e W_k\ (\lambda_x \upsilon_{ce}) \quad (18)$$

Note that the Compton electron frequency $\upsilon_{ce}$ of the electromagnetic equivalent of the electron mass-energy, $p_{Ae}c = h\upsilon_{ce}$, is shared with the actual electric structure of that mass-energy ($W_x = \lambda_x \upsilon_{ce}$) [14].

Equation (18) requires another wave speed function, namely $W_k$, which is the magnetic wave speed characteristic of the electron charge. As shown by that equation, there is a fundamental equivalence of $c^2 = W_k W_x$. The product of these two wavefunctions, $W_k$ and $W_x$, represents a superimposition, where the two separate wavefunctions are superimposed nearly perpendicularly to one another. Since c and $W_x$ are known, it is a simple matter to solve for $W_k$:

$$W_k = c^2 / W_x = (2.998 \times 10^8\ m\ s^{-1})^2 / (3.529 \times 10^{10}\ m\ s^{-1}) = 2.547 \times 10^6\ m\ s^{-1} \quad (19)$$

Besides being intrinsic to the electric equivalent of the electron mass-energy, the wave speed $W_k$ is actually the magnetic wave speed "intrinsic to the elementary charge of the electron" [15]:

$$p_e = \lambda_e W_k \quad (20)$$

Rearranging the above terms permits the confirmation of the value of $W_k$. An interesting sidebar to the main purpose of this paper is an insight into the meaning of the charge to mass ratio. It can be seen below that this ratio results in a wave speed that is exactly equal to $W_k$, the magnetic wave speed intrinsic to charge [6, 15]:

$$W_k = p_e / \lambda_e = (13.970\ m^2\ s^{-1}) / (5.486 \times 10^{-6}\ m) = 2.547 \times 10^6\ m\ s^{-1} \quad (21)$$

This can be verified by performing the transformation process on the 2018 Codata value of the electron charge to mass ratio of 1.758 x $10^{11}$ C / kg, as follows. Rearranging a portion of equation 10 and substituting the Codata 2018 value for the electron charge "e" gives

$$p_e / e = (13.97\ m^2 s^{-1}) / (1.602 \times 10^{-19}\ C) = 8.72 \times 10^{19}\ m^2 s^{-1} C^{-1} \tag{21A}$$

and from equation (1)

$$1kg =\int= 1kg\ (10^3 gm / 1kg)(6.022 \times 10^{23} / mole)(10^{-2}\ m\ gm^{-1}) = 6.02 \times 10^{24}\ m \tag{21B}$$

then,

$$1.758 \times 10^{11}\ C\ m^{-1} =\int= [(1.758 \times 10^{11} C)\ (8.72 \times 10^{19}\ m^2 s^{-1} C^{-1})] / (6.02 \times 10^{24}\ m) = 2.546 \times 10^{6}\ m\ s^{-1} \tag{21C}$$

showing the enduring value of the process and confirmation of the value of the charge to mass ratio and thus of the magnetic wave speed intrinsic to charge, $W_k$, per equation 21.

Returning to the Electrostatic System of Units of charge as mentioned above in equation (9) and repeated here for reference,

$$q = M^{0.5} L^{1.5} T^{-1} =\int= L^2 T^{-1} = p_e \tag{9}$$

squaring both sides

$$q^2 = ML^3T^{-2} =\int= L^4T^{-2} = p_e^{\ 2} \tag{22}$$

and solving for M results in

$$M = q^2 / L^3T^{-2} =\int= p_e^{\ 2} / L^3T^{-2} = L \tag{23}$$

Whereas, as we have seen from equation 21, the electron mass is part not only of the mass-energy of the electron, but of its very charge structure ($p_e = \lambda_e W_k$), it can also be obtained from dimensional equation 22 (and the squared superimposition of charges) by invoking the proportionality of the fine structure constant, if the term ($L^3T^{-2}$) is made to equal the electron mass-energy

$$\lambda_e = (100\ \alpha^{-1})\ p_e^{\ 2} / E = (W_x / W_k)\ p_e^{\ 2} / E \tag{24}$$

But in the absence of such a proportionality invocation, what results is the very wavelength characteristic of the electron's magnetic wavefunction $W_k$:

$$\lambda_h = p_e^{\ 2} / E = (13.970\ m^2 s^{-1})^2 / (4.930 \times 10^{11}\ m^3 s^{-2}) = 3.958 \times 10^{-10}\ m \tag{25}$$

This immediately allows the determination of the magnetic wavefunction frequency [6] specifically characteristic of the electron:

$$\upsilon_k = W_k / \lambda_h = (2.547 \times 10^6\ m\ s^{-1}) / (3.958 \times 10^{-10}\ m) = 6.433 \times 10^{15}\ s^{-1} \tag{26}$$

This analytical methodology leads to a totally new and strictly electric expression of the electron mass-energy, where basic components and their functions define its fine structure:

$$E = m_e c^2 =\int= \lambda_e c^2 = p_e W_x = \lambda_e W_k W_x = \lambda_e\ (\lambda_h \upsilon_k)\ (\lambda_x \upsilon_{ce}) = (5.486 \times 10^{-6}\ m)\ [(3.958 \times 10^{-10}\ m)(6.433 \times 10^{15}\ s^{-1})] \\ \times [(2.856 \times 10^{-10}\ m)\ (1.236 \times 10^{20}\ s^{-1})] = 4.930 \times 10^{11}\ m^3 s^{-2} \tag{27}$$

Evidently, the wavefunctions $W_k$ and $W_x$ are not electromagnetic, since the $W_x$ wave speed exceeds the speed of light [6]. In effect, it describes the wave speed of the flux in each of the rings of a torus, just as the magnetic wave speed describes the equatorial velocity of the rings with respect to the center of the torus. As such, the radii of the two circular wavelengths are calculated in the normal manner:

$$r = \lambda / 2\pi \tag{28}$$

$$r_h = \lambda_h / 2\pi = (3.958 \text{ x } 10^{-10} \text{ m}) / 6.283 = 6.30 \text{ x } 10^{-11} \text{ m} \tag{29}$$

$$r_x = \lambda_x / 2\pi = (2.856 \text{ x } 10^{-10} \text{ m}) / 6.283 = 4.456 \text{ x } 10^{-11} \text{ m} \tag{30}$$

resulting in the fine geometry of the electron mass-energy torus:

$$E = m_e c^2 = \int = \lambda_e c^2 = p_e W_x = \lambda_e W_k W_x = \lambda_e\ (2\pi r_h \upsilon_k)\ (2\pi r_x \upsilon_{ce}) \tag{31}$$

The structure of the electron mass-energy, broken down this way into its basic constituents, presents itself as a flux of electric energy shaped as a torus due to the superimposed wavefunctions $W_k$ and $W_x$. When the geometric mean of the two wavefunction radii is calculated, the result is the Bohr radius which compares favorably with the CODATA 2018 value of $0.529 \text{ x } 10^{-10}$ m:

$$(r_h r_x)^{0.5} = [(6.30 \text{ x } 10^{-11} \text{ m})\ (4.456 \text{ x } 10^{-11} \text{ m})]^{0.5} = 0.535 \text{ x } 10^{-10} \text{ m} \tag{32}$$

The implication is that the Bohr radius is not really the radius of a spherical cavity, or of a quasi-spherical cloud where a point-mass may locate once the probability wave collapses, but merely the geometric mean of the two radii of the electron mass-energy torus. The latter has the "normal" volume given by [6]:

$$V = 2\pi^2 r_h r_x^{\,2} \tag{33}$$

## III. Conclusions

The proposed model is a much more satisfactory and rigorous description of the electron and explanation of the phenomenological nature of the Bohr radius. Rather than leading a nebulous existence as a supposed particle, wave, cloud, cavity, or "point particle in a cloud of probable locations", it is best understood as a "precise toroidal volumetric flux structure" of electric energy resulting from two longitudinal waves being superimposed upon and trapped with each other, "that occupies the location of the entire 'cloud' [16]."

The torus model also rejoins the problematics of "the ring electron" originally proposed in 1915 by Alfred Parson [17], and taken up during 1917-1921 by others, in particular by Arthur Compton [18, 19] and H. Stanley Allen [20]. However, unlike the ring electron model, the model proposed by the Correas does not invoke for the electron a vortical ring structure, but rather that of a closed torus composed by a large number of continuous rings. The two models share many of the features that overcome the present-day conceptualization and treatment of the electron. Loss of energy by radiation of the closed-loop mass-energy is done away simply by assuming rotation of a ring-shaped charge, and the virtually impossible complications raised by independent orbitals required to explain diamagnetic atoms melt away, given that it is the electron mass-energy itself that has a diamagnetic moment [6]. Likewise, paramagnetism and X-ray diffraction patterns are explained by the tilting of the toroidal ring, confirming the contention of the above three physicists that the elementary magnet is not the atom, but the electron itself. The magnetic susceptibility of paramagnetic substances flows directly from the electron retaining its magnetic properties at low temperatures. Asymmetric scatter of X-radiation is explained by the striking of distinct loops of the torus. Runge's rule that abstrusely related variable magnetic effects to the ratio e/m [20] is replaced by the elegant and eloquent result of equations 21, 25 and 26:

$$W_k = \lambda_h \upsilon_k = p_e / \lambda_e = \int = e / m_e \tag{34}$$

Well beyond what the ring electron model could provide, the Correa model of the electron torus addresses other features still. In effect, the number of toroidal loops is directly obtained by the relation that accounts for both the composite nature of the mass of the electron and the proportionality role played by the reciprocal of the fine structure constant – whose actual value is thereby revised [21] – in the topogeometry of the electron:

$$\text{No. loops} = \lambda_e / \lambda_x = \alpha^{-2} = 19{,}205.9 = (138.5853745)^2 \tag{35}$$

The very fact that the number of loops is very nearly an integer may suggest that it is simply 19,206 or, instead, that the fractional value actually indicates a kink in the toroidal structure (the shorter loop), one that may have phenomenologically induced existing physics into believing that the electron is a point-mass engaged in orbital motion, since the kink will rotate with the magnetic wave speed of the torus. Communication from the Correas suggested they incline to the latter case, as if the torus contained a beat – in perfect agreement with Allen's notion of a pulse travelling around the ring-shaped electron as a "small hump" [20].

While the energy stored in the rotating torus is in a non-radiating form, absorption of kinetic energy by the torus will, under specific conditions (collision, field deceleration), originate radiating energy in the form of photons emitted 1:1 by the loops, such that Planck's radiation law stands explained by

$$K = \alpha^{-2} (h\upsilon_p) \quad (36)$$

where $\upsilon_p$ is the frequency of the emitted photons.

This suggests that the real measure of angular momentum is simply

$$h / 2\pi = p_e r_x \quad (37)$$

Further development of the toroidal model of the electron has led the Correas to analyze dynamic changes in the radial dimensions of the toroidal loops and the magnetic wave speed [6]. It permitted identification of the photoinertial (a.k.a. "spin state") configuration as a limiting one, where the angular momentum conforms to Compton's notion of a wavelength maximum, the Compton wavelength $\lambda_{ce}$:

$$h / 2\pi = p_{Ae} (\lambda_{ce} / 2\pi) = p_{Ae} r_o \quad (38)$$

where $r_o$ is the radius of the wavelength of the wave speed of the flux in each of the rings of the electron torus while in the (photo)inertial configuration.

Such limit is reached when pair annihilation occurs. The same approach also permitted a full understanding of the anomalous gyromagnetic ratio and the Landé factor [6].

Unlike the present explanation for orbital jumps, the torus model of the electron indicates that elastic variation in its volumetric and winding features is not to be assimilated to the fine structure of added kinetic energy. Addition of extra energy does not accelerate the ring rotation – as the ring model held – since the magnetic wave speed of the torus is a conserved characteristic. It is only the loop flux that accelerates to a maximum fixed by the electron mass-energy itself. So-called orbital jumps, then, merely abide by equation 36, as successive kinetic energy states result in emission of resonant photon frequencies. Likewise, the Zeeman effect first observed in 1896 stems from the same resonant process being split by an applied magnetic field.

All the consequences of the Correa model of the electron torus cannot possibly be discussed in the scope of the present paper. They range widely, from a better understanding of thermoelectric effects and the quantum nature of the temperature scale, to a thorough revision of Louis de Broglie's (1892-1987) theory of matter/particle waves, a totally new treatment of the fine structure of nucleons and, most importantly, the discovery of *massfree* (ambipolar) electricity in induction devices, ambipolar plasmas and nuclear fusion. This complex dramatic breakthrough has been ignored for nearly two decades just as the work that started it all 75 years ago - Reich's mass to length transformation technique.

For those further interested in this earth-shaking science, in-depth learning can only be accomplished by reading the monographs, books and other publications generated by the Correas and their research associates (Dr. Gene Mallove, Dr. Malgosia Askanas, Dr. Harold Aspden, to name a few) at the Aurora Biophysics Research Institute. The Correas have provided various proof of concept machines based on their research – demonstrating the utility and correctness of the theories - some of which may be commercialized. Descriptions of these technologies can be found at www.aetherenergy.com. The monographs, meticulously describing the experiments, thought processes and conclusions can be found at www.aetherometry.com.

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# New Applications of Non-Equilibrium Thermodynamics

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*Abstract-* We propose to extend the existing theory of irreversible processes (TIP) to include reversible real processes associated with the performance of useful work. This is achieved by the fact that the main quantities used by this theory, thermodynamic forces and fluxes, are derived not from the principle of increasing entropy, but rather from the law of the conservation of energy. This way of constructing TIP prevents the occurrence of thermodynamic inequalities and allows one to substantiate all its provisions without invoking the postulates and considerations of a molecular-kinetic and statistical-mechanical nature. This opens up the possibility of further reducing the number of empirical coefficients and expanding the scope of TIP applicability to nonlinear systems and states that are far from equilibrium, as well as to energy conversion processes which are primarily of interest to power engineers, technologists, biophysicists and astro-physicists. At the same time, the unity of the laws of transformation of all forms of energy and the difference between their equations, reciprocity relations and efficiency criteria from the generally accepted ones are proved.

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*Keywords: thermodynamics, irreversibility, transfer and transformation, interrelation and similarity of processes, effects of superposition.*

## I. Introduction

In the history of science there are frequent cases when a new theory brought in significant change in the natural science paradigm. The last part of the twentieth century was no exception; as this paradigm shift occurred in the fundamental theories of the thermodynamics of irreversible processes (TIP). Researchers from many countries contributed to its creation [1-11]. It enriched the theoretical thought of the twentieth century with the "principle of reciprocity" of heterogeneous phenomena, sometimes called the "fourth law of thermodynamics", and explained the many effects that arise at the junctions of fundamental disciplines due to the simultaneous occurrence of several non-static processes. However, later on, interest in this theory began to fade. To a large extent this is due, in our opinion, to the fact that the basic quantities underlying this theory, thermodynamic forces $X_i$ and fluxes $J_i$, are included on the basis of the principle of entropy increase, which exclude from consideration the reversible component of real processes. Yet it is precisely this component, connected to the execution of useful external work $W^e$, which is of interest primarily in fields related to energy, technology, biophysics and astrophysics. This drawback can be eliminated by switching to finding these forces and fluxes on a basis of a more general law of conservation of energy. We shall consider the advantages that non equilibrium thermodynamics gains as a result.

## II. Preventing the Transformation of Equations of Thermodynamics into Inequalities

It is known that the equations of the 1st and 2nd laws of classical thermodynamics of open systems are combined in the form of the Gibbs relation[12]:

$$dU = TdS - pdV + \Sigma_k \mu_k dN_k \qquad (1)$$

This relation connects the internal energy $U$of the object (or system) under study with its entropy $S$, volume $V$ and the number $N_k$ of moles of the $k^{th}$ substances, as well as with the generalized potentials $\psi_i$ conjugated with them (the chemical potentials of these substances is represented by $\mu_k$, absolute temperature by $T$ and pressure $p$ by.), This then becomes the inequalities:

$$\delta Q \neq TdS;\ \delta W_p \neq pdV;\ \delta W_k \neq \mu_k dN_k \qquad (2)$$

This happens because in non-equilibrium systems the parameters $S$, $V$, $N_k$ change not only as a result of external energy exchange, but also as a result of internal relaxation processes (the number of moles $N_k$ *is* due to chemical reactions; the volume $V$ corresponds to the expanded form in a vacuum while not performing work; the entropy $S$ *is* due to friction and other irreversible processes.) As a result, the energy exchange of the system with the environment can no longer be found on the basis of changes in these parameters, and the mathematical apparatus of thermodynamics based on equation (1) turns out to be inapplicable. This disadvantage can be eliminated by going directly to the fluxes of these energy carriers across the boundaries of the system. For this we use the law of conservation of energy in the form proposed by N. Umov (1873) [13]:

$$dU/dt = -\oint j_u \cdot d\mathbf{f}, \qquad (3)$$

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where $j_u$ ($W \cdot m^{-2}$ ) is the internal energy flux density through the vector element $df$ of the closed surface f of thesystem of constant volume $V$ in the direction of the external normal n (Figure 1).

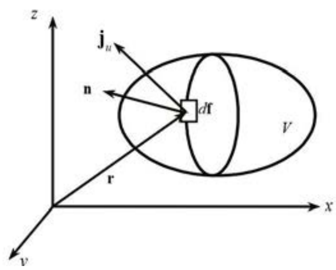


*Figure 1:* Energy flux through the boundary of the system

Unlike the later equation of J. Poynting (1884), this form of the energy conservation law takes into account the kinetics of real processes, without making any assumptions about the mechanism of energy transfer in a solid media or about the internal structure of the system.

According to this equation about short-range effects, energy $U$ does not simply disappear at some points of space and arise in others, but rather carries the $i^{th}$ energy carrier $\Theta_i$ (with the number of moles $k$ of the substance $N_k$ , their corresponding charges $Q_k$, their entropies $S_k$, the impulses $P_k$ , etc.) through the fixed boundaries of the system. Let us now find the expanded form of this law, which is valid for any $i^{th}$ material carrier of energy. For this, we will take into account that the energy flux $j_u$ is the sum of the fluxes $j_{ui}$ carried by each of them. These fluxes, in turn, are expressed by the product of the flux density of the $i^{th}$ energy carrier $j_i = \rho_i \upsilon_i$ by its potential $\psi_i \equiv dU_i/d\Theta_i$, where $\rho_k = d\Theta_i/dV$ and $\upsilon_i = dr_i/dt$ are the density of the $i^{th}$ energy carrier and the rate of its transfer across fixed boundaries systems, resp., i,e. $j_{ui} = \psi_i j_i$, so that

$$j_u = \Sigma_i j_{ui} = \Sigma_i \psi_i j_i, \qquad (4)$$

Using the Gauss-Ostrogradsky theorem, we transform the integral $\oint \mathbf{j}_u \cdot d\mathbf{f}$ into a volume integral $\int \nabla \cdot j_u dV$. Then, after decomposing $\nabla j_u = \nabla(\psi_i j_i)$ into independent components $\Sigma_i \psi_i \nabla \cdot j_i + \Sigma_i j_i \cdot \nabla \psi_{ik}$, the energy conservation law (3) takes the form:

$$dU/dt + \Sigma_i \int \psi_i \nabla \cdot j_i dV + \Sigma_i \int j_i \cdot \nabla \psi_i dV = 0 \qquad (5)$$

If we take the average value $\Psi_i$ of the potential $\psi_i$ and the average value $X_i$ of the potential gradient $\nabla \psi_i$ both from under the integral sign, then equation (5) can be expressed in terms of the parameters of the system as a whole, as is customary in classical thermodynamics:

$$dU/dt + \Sigma_i \Psi_i J_i + \Sigma_i X_i \cdot J_i = 0. \qquad (6)$$

Here $J_i = \int \nabla \cdot j_i dV = \oint j_i \, df$ is thescalar flux of the $i^{th}$ energy carrier through the boundaries of the system; $J_i = \int \rho_i \upsilon_i dV = \Theta_i \overline{\boldsymbol{\upsilon}}_i$ is its vector flux (impulse).

Unlike the Gibbs relation, Equation (6) contains 2$i$terms ($i$=1,2, ... $n$) and describes not only the processes of introducing the $k^{th}$ substance $N_k$ into the system as well as the series $Q_k$, the entropy $S_k$ , the momentum $P_k$ , etc. in the homogenous system being investigated, but also the processes of redistribution of the system volume of overcoming the forces of the $X_i$ and the performance of work "against equilibrium" in it. Therefore, it is applicable to a wide class of open ($N_k$ = *var*), non-closed ($X_i$= *var*) and non-isolated systems ($U$ = *var*), which are the object of study in other fundamental disciplines. At the same time, it allows the irreversibility of the above processes. Indeed, considering (6) together with the integral equation of the energy carrier balance $\Theta_i$

$$d\Theta_i/dt + \int \nabla \cdot j_i dV = \int \sigma_i dV. \qquad (7)$$

In this case, the densities of local and substantial fluxes $j_u$ coincide. We find that, besides the energy carrier $\Theta_i$ appearing in the Gibbs ratio, it takes into account the presence of these internal sources of density $\sigma_i$. It is easy to see that under the conditions of local equilibrium ($X_i$ = 0), Eq. (6) takes the form

$$dU/dt = \Sigma_i \Psi_i d\Theta_k/dt - \Sigma_i \Psi_i \int \sigma_i dV, \qquad (8)$$

i.e., it transforms into a generalized Gibbs ratio for complex multivariable systems $dU = \Sigma_i \psi_i d\Theta_i$ only when the internal sources of entropy $d_u S/dt = \int \sigma_s dV$ and other energy carriers $d_u \Theta_i/dt = \int \sigma_i dV$ (including products of chemical reactions $d_u N_k/dt$) disappear. This testifies to the inconsistency of the hypothesis of local equilibrium, according to which the state of an element of the inhomogeneous continuum of the system is characterized by the same set of variables as in equilibrium. This follows from the fact that this assumption also means the absence of "production of entropy" ($d_u S/dt$ >0). The latter makes it necessary to introduce the parameters of in homogeneity $X_i$ and the fluxes $J_i$ associated with them into the equations of nonequilibrium thermodynamics.

It is remarkable that Equation (6) does not become an inequality despite the obvious inclusion ofthe dynamic (irreversible) processes under consideration. This solves a major "problem of thermodynamic inequalities" which until now has prevented any application of the mathematical apparatus of nonequilibrium thermodynamics to real processes (i.e., those with fluxes at finite speeds).

It is also important that our derivation of an expanded form of the law of conservation of energy (6) contains definite forces $X_i$ and fluxes $J_i$. This bestows it with a definite sense corresponding to an energy field strength $\Theta_{ik}$ and averaged pulse $k^{th}$ energy source $P_i = \Theta_i \upsilon_i$. Furthermore, it does not require a compilation of complex and cumbersome equations for the balance of matter, charge, momentum, energy and entropy. This dramatically simplifies the ability for thermodynamics to solve certain problems.

## III. Thermodynamic Derivation of the Onsager Reciprocal Relations

One of the most important provisions of the theory of irreversible processes is the "reciprocity relation" $L_{ij} = L_{ji}$ between the off-diagonal coefficients $L_{ij}$ and $L_i$ in the "phenomenological" laws postulated by L. Onsager:

$$J_i = \Sigma_j L_{ij} X_j \tag{9}$$

These ratios establish the relationship between dissimilar fluxes $J_i$ and forces $X_j$ and reduce the number of proportionality coefficients between them to be experimentally determined from $n^2$ to $n\ (n+1)/2$. To prove these relations, the future Nobel laureate L. Onsager had to use the theory of fluctuations, the principle of microscopic reversibility and an additional postulate about the linear nature of the laws of decay of fluctuations [1]. All three of these assumptions are somewhat outside of classical thermodynamics; therefore, he rightly called his theory "quasi-thermodynamics".

Meanwhile, it can be shown that these relations gain support from the law of the conservation of energy (6). From that law, based on the independence of the mixed derivative from the order of differentiation with respect to the variables $X_i$ and $X_j$ ($i, j$=1,2,...$n$), it follows:

$$\partial^2 U/\partial X_i \partial X_j = \partial^2 U/\partial X_j \partial X_i \tag{10}$$

This directly implies the relationship between unlike fluxes and forces, which we term *differential reciprocal relations*[13] :

$$(\partial J_i/\partial X_j) = (\partial J_j/\partial X_i). \tag{11}$$

These relations are applicable to both linear and nonlinear transport laws and allow any dependence of the coefficients $L_{ij}$ on the parameters of the equilibrium state $\psi_i$ and $\Theta_i$. Application to the linear laws (9) directly leads to the symmetry of the matrix of phenomenological coefficients $L_{ij} = L_{ji}$:

$$(\partial J_i/\partial X_j) = L_{ij} = (\partial J_j/\partial X_i) = L_{ji} \tag{12}$$

Their derivation shows that these relationships are a consequence of more general reasons than the reversibility in time of micro processes. This explains why these relationships have often turned out to be valid far in domains far beyond the above conditions.

## IV. Finding "Superposition Effects" without using Onsager Relations

In isolated systems, the sum of internal forces $\Sigma_i F_i$ ($i$ = 1, 2… $n$) is always zero. This means that, in accordance with Newton's 3rd law, any one of them can be expressed as the sum of $n$=1 different forces of the $j^{th}$ kind: $F_i = -\Sigma_{n-1} F_j$. The relationship of these forces to thermodynamic forces $X_i$ is easy to construct. From the expression for power $dW/dt = X_i \cdot J_i = F_i \cdot \overline{\boldsymbol{\upsilon}}_i$ it follows that $X_i = F_i/\Theta_i$, i.e., it represents the precise meaning of force in its more general physical interpretation. Taking this into account, laws (17) can be represented in a form closer to (9):

$$J_i = L_i \Sigma_j \Theta_j X_j, \tag{13}$$

Such a form of the laws of transfer and relaxation does not require the empirical coefficients $L_i$ to be constant; this expands the scope of these equations' applicability to nonlinear systems and states far from equilibrium. In addition, it allows to propose a new method for finding the "superposition effects" of irreversible process which are due to "partial" (incomplete) equilibria of the $i^{th}$ kind ($J_i$= 0). The specificity of this method is easier to understand with the example of the diffusion of the $k^{th}$ substance in a continuous heterogeneous composition (with the concentration of components $c_j$, temperature $T$ and pressure $p$). According to laws (13), this process has the form:

$$J_k = -D_k \nabla \mu_k, \tag{14}$$

where $D_k$ is the diffusion coefficient of the $k^{th}$ substance; $\mu_k$ *is* its chemical potential.

If we represent $\nabla\mu_k$ through its derivatives with respect to the concentrations $c_j$ of its independent components, their temperature and pressure, then equation (14) can take the form:

$$J_k = -D_k(\Sigma_j \mu_{kj}^* \nabla c_j + s_k^* \nabla T + \upsilon_k^* \nabla p). \tag{15}$$

where $\mu_{kj}^* \equiv (\partial\mu_k/\partial c_j)$, $s_k^* \equiv (\partial\mu_k/\partial T)$, $\upsilon_k^* \equiv (\partial\mu_k/\partial p)$.

Three components of the resulting force $F_k$ on the right side of this expression handle the usual (concentration) diffusion $F_{kc} = \Sigma_j \mu_{kj}^* \nabla c_j$, thermal diffusion $F_{kT} = s_k^* \nabla T$ and baro diffusion $F_{kp} = \upsilon_k^* \nabla p$. This allows one to separate the thermodynamic factors $\mu_{kj}, s_k^*$, $\upsilon_k^*$ and the kinetic factors $D_k$ of multi component diffusion and establish a number of empirically established relationships between them[15]. Given the existing experimental means, it was mathematically unsound to

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obtain such results via the Onsager diffusion equation $J_k = -\Sigma_i D_{ki} \nabla \mu_i$[1].

As another example, consider an inhomogeneous system divided into two parts by a porous partition. If a temperature difference ($\Delta T \neq 0$) is created in it, then a gas or liquid flux $J_k = D_k(s_k^* \nabla T - \upsilon_k^* \nabla p)$ occurs through the partition, leading, under conditions of incomplete equilibrium ($J_k = 0$), to the occurrence of a pressure difference on both sides of the partition (Feddersen effect, 1873) :

$$(\Delta p/\Delta T)_{st} = -q_k^*/T\upsilon_k^*, \qquad (16)$$

where $q_k^* = Ts_k^*$ represents the heat transfer of the $k^{th}$ substance.

This phenomenon is now called thermo-osmosis. The opposite phenomenon has also been seen: the appearance of a temperature difference on both sides of the partition when air or other gas is forced through it. Both of these effects are of the same nature as the Knudsen effect (1910) - the appearance of a pressure difference in vessels connected by a capillary or a narrow slit and filled with gas of different temperatures. They are also of the same effect as the Allen and Jones “fountain effect” (1938), consisting of liquid helium II flowing out, at the slightest heating, from a vessel closed with a porous stopper. The opposite phenomenon - the occurrence of a temperature difference when a pressure difference is created on both sides of the partition - is called the *mechanocaloric effect* (Daunt-Mendelssohn).

In the case of systems that initially have the same pressure on both sides of the porous partition ($\Delta p = 0$) and initially the same concentration of the $k^{th}$ substance ($\Delta c_k = 0$), when a temperature difference $\Delta T$ is created, a concentration difference occurs on both sides of it (the *Soret effect*, 1881):

$$(\Delta c_k/\Delta T)_{ст} = - q_k^*/T\mu_{kk} . \qquad (17)$$

The opposite phenomenon, the appearance of temperature gradients during diffusion mixing of components, was discovered by Dufour in 1872 and bears his name. In isothermal systems ($\Delta T=0$) for creating pressure differential across the membrane $\Delta p$ occurs via reverse osmosis, i.e., the separation of a binary solution with separation from the $k^{th}$ component (usually a solvent). This phenomenon is widely used in water treatment plants. This occurs when the concentration difference $k^{th}$ part is given by the expression:

$$(\Delta c_k/\Delta p)_{st} = -\upsilon_k/\mu_{kk}. \qquad (18)$$

These results are consistent with those obtained in the framework of TIP [6,8]. However, for this it was not necessary to assume the linearity of phenomenological laws, postulate the constancy of the phenomenological coefficients $L_i$ or $D_k$ and resort to Onsager's reciprocity relations. At the same time, it becomes clear that these effects arise due to the onset of states of partial (incomplete) equilibrium; any multivariable system passes through such states on its way to full equilibrium. In this case, the "effects of superposition" are the result of superposition not of fluxes $J_i$, but rather of forces $F_j$ in full accordance with the principles of mechanics. The advantages of this method consist not only in the further number of phenomenological coefficients from $n(n+1)/2$ in TIP to $n$ [14], but also in the possibility of finding superposition effects in nonlinear systems far from equilibrium. In this case, the TIP itself becomes free from any postulates expressing the coefficients $L_i$ as a function of the parameters of the system.

## V. Establishing the Fundamental Difference between the Laws of Relaxation and Energy Conversion

Consider an isolated system ($dU/dt = 0$; $J_i = 0$)in which energy is converted from one form to another. For such a system, from (6) at once follows:

$$\Sigma_k X_k \cdot J_k = 0. \qquad (19)$$

For the process of converting some $i^{th}$ form of energy into $j^{th}$, this expression can be given the form:

$$J_i/X_j = -J_j/X_i. \qquad (20)$$

According to this expression, the direction of the internal flux $J_i$ of the $i^{th}$ energy carrier, induced by the "exterior" force $X_j$, is opposed to the direction of the "exterior" flux $J_j$, induced by the driving force $X_i$. If we denote the ratio $J_i/X_j$ by $L_{ij}$, and the ratio $J_j/X_i$ by $L_i$, then we come to the antisymmetric Onsager-Casimir reciprocity relations[6, 8]:

$$L_{ij} = -L_{ji}. \qquad (21)$$

This provision keeps the opposing direction of diverse forces; fluxes in the processes of energy conversion and possesses a general physical status. In particular, Faraday's law of induction follows from it, if by $J_i$ we mean the flux of magnetic coupling (expressed by the number of lines of force), and by $X_j$, the resulting voltage.

However, these conditions of anti symmetric matrices with “phenomenological” coefficients indicates also that for the processes of intercom version of ordered forms of energy, in the law (9) of Onsager, the coefficients $L_{ij}$ and $L_{ji}$ must be modified by the opposite signs:

$$J_i = L_{ij}X_i - L_{ji}X_j. \qquad (22)$$

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$$J_j = L_{ji}X_i - L_{jj}X_j. \qquad (23)$$

In particular, as is well known from the practice of working with a welding transformer, an increase in the voltage in the secondary circuit $X_j$ (approaching the "no-load" mode) causes a decrease in the current in the primary circuit $J_j$, and the "short circuit" mode ($X_j = 0$) on the contrary, increases it. Thus, Equations (22, 23) are more consistent with the phenomenological status (based on experience) than is Equation (9).

It is no less important that the condition of interconnection of forces and fluxes (19) is a consequence of the law of conservation of energy (6). Under conditions of system relaxation, these conditions of counter-directional flux are absent, so that the fluxes $J_i$ and $J_j$ become independent. In this case, the reciprocity relations $L_{ij} = L_{ji}$ are fulfilled trivially (they vanish), and the equations of transfer and relaxation take the form of equations of heat conduction, electrical conductivity, diffusion, etc., in which the flux $J_i$ becomes a unique (eponymous) functionof the thermodynamic force $X_i$. This independence was also assumed in the theory of L. Onsager, since he defined the scalar fluxes $J_i$ as time derivatives of the independent parameters of the system.Therefore, strictly speaking, he did not have sufficient grounds for postulating rules (9), in which each of the fluxes depends on all forces acting in the system.

## VI. Development of a Universal Criterion for the Efficiency of Energy Converters

It is generally accepted that the energy conversion efficiency of any reversible non-thermal machine is equal to unity, while for a heat engine it is limited by the thermal efficiency of an ideal Carnot machine [15]:

$$\eta_t = 1 - T_2/T_1 < 1, \qquad (24)$$

where $T_1$ , $T_2$ are constant temperatures of supply and removal of heat in the heat engine cycle, equal to the absolute temperatures of the heat source and sink.

This “discrimination” of heat engines is based on the firm belief that “heat and work are, in principle, unequal” [15].In fact, a closer look reveals that this reflects a misunderstanding of the concepts of absolute and relative efficiency. Thermal efficiency $\eta_t$ , like its analog$\eta_i$ for ordered forms of energy, characterize the ratio of the work $W_i$ performed by the converter to the energy $U_i$ supplied from the source of the $i^{th}$ form of energy. Such efficiencies are usually called *absolute.*

According to the theorem of Carnot efficiency, an ideal cycle of the heat engine does not depend on the properties of its working body, nor on the design features of the machine or the mode of operation. Therefore, such "efficiency" more likely characterizes not its coefficient of performance, but rather the possibilities offered by nature thanks to its inherent spatial in homogeneity (difference of temperatures of the hot and cold heat sources). Strictly speaking, this figure should not have been called "machine efficiency" because this figure is characterized more by the "degree of instability" of the heat source.

The concept of efficiency of electric and other motors has a different meaning. Such efficiencies characterize the ratio of the work $W_i$ actually performed by the engineto the theoretically possible work $W_i^t$. They take into account the losses in the machine itself and are ideally equal to one. Such efficiencies are called *relative internal* $\eta_{oi.}$ In thermodynamics such efficiency$\eta_{oi}$is an evaluation of the performance of the processes of compression or expansion of a body upon which work is done. Naturally, the application of the same term "efficiency" to these two fundamentally different concepts causes non-specialists to misunderstand the inefficiency of heat engines.

In this respect, it is very useful to represent the efficiency through energy fluxes. Non equilibrium thermodynamics allows us to express the efficiency ratio in terms of the output power $N_j$ and the input transforming device $N_i$[16]:

$$\eta_N = N_j/N_i = X_j \cdot J_j / X_i \cdot J_i \leq 1. \qquad (25)$$

This efficiency, which we term “power-based energy conversion efficiency”, or henceforth “power efficiency” for short, is equally applicable to thermal and nonthermal, cyclic and acyclic, straight and reversed machines, including the "direct energy conversion" machines. It takes into account both the kinetics of the energy conversion process and all types of losses associated with both the delivery of energy to the energy converter and the energy conversion process itself. It also depends on the operating mode of the installation, twice turning to zero: in “idle” ($J_j = 0$) and in “short circuit” modes ($X_j = 0$). This also distinguishes it from the "exergy" efficiency, which is expressed by the ratio of free energies at the outlet and inlet of the installation. In a word, this efficiency most fully reflects the thermodynamic performance of the installation and the degree to which it realizes the possibilities that the source of ordered energy provides. Moreover, such an efficiency is the only possible indicator of the performance of an installation in those cases when the concept of absolute efficiency becomes inapplicable due to the impossibility of separating energy sources and receivers in a continuous medium. Examples include force fields, chemically reactive environments, polarized or magnetized bodies, or dissociated or ionized gases. All this makes it an irreplaceable tool for analyzing the efficiency of not only energy, but also technological installations, as well as energy converters

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created by nature itself. This is especially important due to the fact that many non-experts confuse efficiency with the heat transfer coefficient or the coefficient of performance, which may be distinguished by their units. Therefore, the use of power efficiency (24) not only reveals the unity of the laws of transformation of any forms of energy, but also allows us to propose a theory of the similarity of power plants of various types.

## VII. Construction of a Theory of Similarity of Power Plants

A proper generalization of TIP to the processes of useful energy conversion in various machines allows us to propose a theory of the similarity of power plants [16]. This would complement the classical theory of heat engines by analyzing the relationship of thermodynamic efficiency (energy conversion efficiency) with productivity (based on power $N$) and the operating mode of power and technological plants. As in the theory of similarity of heat transfer processes, the mathematical model of such systems includes, along with equations (22,23), the conditions for the uniqueness of the object of study. The latter contain *boundary conditions* determined in the case under consideration by the magnitude of the driving forces at the border with the energy source or object of work $X_i$, $X_j$, or by the magnitude of the fluxes $J_i$, $J_j$ at these boundaries, and by the initial conditions. These latter are set by the magnitude of these forces $X_{jo}$ or fluxes $J_i$ in the initial mode, for example, at the "idle" of the installation (at $J_j = 0$) , or in the "short circuit" mode $J_{jk}$ (at $X_j = 0$) , as well as the coefficients $L_{ij}$ ($i$, $j$ =1,2) characterizing the transport properties of the system. These conditions make it possible to give the transport equations (22, 23) a dimensionless form

$$X_j/X_{jo}+J_j/J_{jk}=1. \qquad (26)$$

and on its basis, propose a number of similarity criteria for power plants. One of them, which we called the load criterion, is composed of the boundary conditions set by the value of the forces $X_j$, $X_{jo}$ or fluxes $J_j$, $J_{jk}$

$$\mathcal{B}=J_j/J_{jk}=1–X_j/X_{jo}. \qquad (27)$$

This criterion depends solely on the load of the installation and varies from zero in no-load mode ($J_j = 0$) to one in the “short circuit” mode ($X_j = 0$)

Another criterion consists of the resistance coefficients $R_{ij}$, the reciprocal of the conductivity coefficients $L_{ij}$:

$$\Phi = R_{ij}R_{ji}/R_{ii}R_{jj} \qquad (28)$$

This formula is similar in meaning to the ratio of reactive and active resistances, known in radio engineering as the “quality factor”, or “Q-factor” for short, of the circuit, and therefore is called the "criterion of the Q-factor" of the installation. Its value fluctuates from zero to infinity ($0<\Phi<\infty$), increasing as the "active" resistances (from the side of scattering forces) $R_{ii}$ and $R_{jj}$ decrease and the "reactive" resistances $R_{ji}$ (from the side of "heterogeneous" forces) increase. Like thermal resistances in the theory of heat transfer, they depend on the transport properties of the system, i.e., ultimately, on the design performance of the installation.

Using these criteria in the expression for the power efficiency (24), it can be given the form of a *criterial equation for the energy conversion process:*

$$\eta_N = (1 - \mathcal{B})/(1 + 1/\mathcal{B}\Phi). \qquad (29)$$

Consequently, the *efficiency of any energy converter under similar conditions* ($\mathcal{B}$, $\Phi$ as above) *is the same.* It is expedient to call this provision the *principle of similarity of power plants)* [16].

This principle allows one to build a universal load characteristic of linear energy - converting systems (Figure 2) [16].Solid lines in the diagram show the dependence of the power efficiency $\eta_N$ of the installation on the load criterion $B$ at different values of the quality factor $\Phi$, and the dash-dotted line shows the dependence on the load of its output power $N_j$..

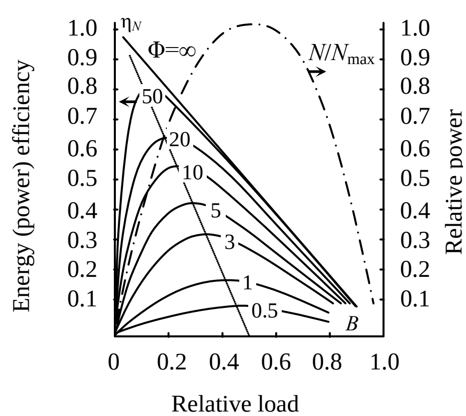


*Fig. 2:* Universal load characteristics of energy converters

As can be seen in Fig. 2, in the absence of energy losses ($\Phi = \infty$) and the steady state of the process of its conversion ($B \to 0$), the efficiency of the installation reaches, as expected, unity. However, in all other cases the value of the power-based efficiency becomes zero twice, once in "idle" setting ($B = 0$, $J_j = 0$) and once in the "short-circuit" setting ($B = 1$, $X_j = 0$).This result is obtained by taking into account the energy consumption for the installation's own needs, as well as losses from irreversible energy exchange (including heat exchange) between the energy source and the working fluid of the installation, friction in pipelines and all kinds of energy "leaks"[3] occurring at idle running of the installation.

The main feature of this characteristic is the presence of a pronounced maximum efficiency for a given load of the installation. Such modes, usually labeled *nominal,* move farther and farther from the maximum power mode, corresponding to the relative load $B = 0.5$, as the efficiency increases. As a result, the power-based efficiency of a real Carnot cycle (from quasi-statistical characteristics of the processes) at $O < \infty$ is not a maximum, but rather zero. Thus, taking into account the power and performance of the power plant brings the results of the thermodynamic analysis of its efficiency closer to reality.

Universal load characteristics are very useful not only for monitoring compliance with the most economical operating modes of basic, peak and transport power plants, but also when choosing the most promising of them with respect to future operating modes. In this way, non equilibrium thermodynamics of energy conversion processes acquire important practical applications.

## VIII. Summary and Conclusion

1. The main disadvantage in using their complete theory of thermodynamics of irreversible processes (TIP) as a general physical theory is its original limitations on processes of energy dissipation; this can be traced to its dependence on the principle of increasing entropy.
2. The approach to non-equilibrium thermodynamics from a more general position of an energy conservation law shows a failure of the hypothesis of local equilibrium. Thus, it highlights the necessity of introducing additional variables of a nonequilibrium state, where upon potential gradients and generalized process speeds would arise.
3. Determination of the basic quantities in which TIP is defined -- thermodynamic forces and energy fluxes-- on a more general basis of a law governing the transfer of energy in path environments allows us to create a locally non-equilibrium thermodynamics. This version of thermodynamics does not exclude from consideration any (reversible or irreversible) component of real processes.
4. We propose an approach, which for brevity we term “energo dynamics”, to prevent the occurrence of inequalities in the transition to non-static processes. This allows to take into account the irreversibility of real processes of energy conversion not only in thermodynamics, but also in other fundamental disciplines.
5. Energodynamics allows us to give a strictly thermodynamic theory, free from the postulates and considerations of molecular-kinetic and statistical-mechanical theories, and one which validates all the provisions of a TIP, thus expanding it domain to nonlinear processes and states far from equilibrium.
6. The isolation of independent processes occurring in the system under study refutes Onsager 's postulate about the dependence of each of the fluxes on all forces acting in the system. It thus makes it possible to find, for each flux, a unique corresponding force whose disappearance results in the cessation of the process.
7. The proposed energo dynamic method for finding the superposition effects of heterogeneous processes allows further reduction in the number of empirical coefficients by $n(n+1)/2$ in TIP to $n$ and explains these superimposed effects not by fluxes, but rather by forces in full accordance with the principles of mechanics.
8. A suitable generalization of TIP to the processes of purposeful transformation of various forms of energy in natural and technical systems reveals their fundamental unity and difference from relaxation processes both in relation to their equations and their reciprocity relations.
9. The transition to the study of the kinetics of energy conversion processes allows us to propose a universal criterion for the efficiency of power and technological installations, taking into account, respectively, their power and performance, and combining the advantages of absolute, relative, exergy, etc. efficiency.
10. The unity of the laws of transformation of thermal and non-thermal forms of energy discovered within the framework of energo dynamics made it possible to propose a theory of the similarity of power and technological installations and to construct their universal load characteristics that facilitate the choice of nominal, peak, etc. modes of their operation.

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# Data-Driven Knowledge Agriculture: A Paradigm Shift for Enhancing Farm Productivity & Global Food Security

By Aprajita Srivastava & Dr. H. O. Srivastava
*World Development Foundation*

*Abstract-* Data-driven Knowledge agriculture using mechanized intelligent computer-based monitoring and control systems and complex Software for machine learning and visualization for predicting a variety of parameters such as future food requirements, resource planning for higher yield, and supply chain is the future of farming. This needs to be urgently adopted by the world farming community to provide food to the growing world population, remove hunger, and at the same time sustain planet resources by judicious uses of input such as water, fertilizer, pesticide etc., as envisioned by Sustainable Development Goals 2030. This paper discusses data-driven technology for identifying trends and other insights for making informed decisions for enhanced productivity and profitability, through market research and evaluating customer needs and sentiments.

*Keywords: precision agriculture, knowledge agriculture, data-driven agriculture, SDG2030, farm data visualization, agriculture analytics, agriculture business intelligence.*

*GJSFR-A Classification: FOR Code: 070199*

DATADRIVENKNOWLEDGEAGRICULTUREAPARADIGMSHIFTFORENHANCINGFARMPRODUCTIVITYGLOBALFOODSECURITY

*Strictly as per the compliance and regulations of:*

# Data-Driven Knowledge Agriculture: A Paradigm Shift for Enhancing Farm Productivity & Global Food Security

Aprajita Srivastava [α] & Dr. H. O. Srivastava [σ]

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## I. Introduction

Knowledge Agriculture™ is a new way of farming that uses technology and tools such as IOT (Internet of Things), Robotics, AI (Artificial Intelligence), UAV (Unmanned Aerial Vehicles), Cloud, Greenhouse, BA (Business Analytics)and specialized software for weather modeling, smart zone seeding, fertilizer modeling, *(Srivastava, 2018; Definitions,2022)*, to address issues relating to food requirements of current 8.0 billion world population, estimated to grow to 9.8 billion in 2050 *(PRB, 2016)*. The current practice of farming in most of the countries is based on traditional methods of sowing, harvesting, storage and marketing which results in poor productivity and profit. We define agricultural productivity as the ratio of outputs to inputs, expressed either in volumes or in physical quantities (kg, tons, etc.) *(FAO, 2018)*. TFP (Total Factor Productivity) is a measure of the efficiency of the contribution of all the significant inputs into production. TFP provides a complete picture of productivity and is more closely connected to unit production costs and market prices than partial productivity indicators *(Fuglie, 2015)*. There is a close relationship between agricultural productivity and farm incomes. Considering this, increasing farm income is at the center of measures related to food security, rural livelihoods, ending hunger in Africa and other parts of the Globe by 2030 and fulfilling SDG2030 targets on food and nutrition security. Despite the importance of agricultural productivity, data on various parameters required to analyze and deduce the current productivity and forecast the model for improved productivity is scarce and of poor quality. There is a need for new and enhanced data collection frameworks to better measure agricultural production and the amounts of inputs used in the production processes.

Data is becoming an ever-important factor in the world, and businesses are developing the skill to use data analysis as a tool for enhanced profit. Agriculture is not immune to this, and data-driven decisions are essential for improved agricultural productivity. Data analysis focuses on cleaning, modeling and visualizing data to provide descriptive, diagnostic, predictive, prescriptive and cognitive analytics. Descriptive analytics based on historical data may be used to generate reports to give a view of a farmer's production, sales and financial data. Diagnostic analytics helps in answering questions about why certain events happened for example anomalies that might be due to unexpected changes in a metric or a particular market. Predictive analytics techniques use historical data to identify trends, for instance changes in demand or consumption and determine if they're likely to recur. Prescriptive analytics is an application of(ML) (Machine Learning)that prescribes optimal actions to achieve a goal or target, for example use of lesser pesticides due to consumer's behavior of changing to organic food. It may also help farmers provide historical crop yield record with a forecast reducing risk management. Machine learning uses statistical algorithms that involve statistical and functional analysis of existing data to learn, a process called training. Patterns and relationships in the data identified during training are used to build a model. The model makes intelligent decisions about data it hasn't encountered before. A process called inference is used to make decisions

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about new data. Training ML models with larger volumes, more relevant, and accurate data increases the forecasting accuracy. Cognitive analytics helps analyse the various changes in a parameter, its effect, and its solution *(Asakiewicz, 2016).* Extensive studies on the predictive ability of ML techniques, such as multiple linear regression, regression trees, artificial neural networks, support vector regression, and k-nearest neighbor for crop yield production, have been undertaken *(Gonzalez-Sanchez, 2014)*. ML and advanced sensing techniques have been used to analyze online multi-layer soil data, and satellite imagery of crop growth characteristics to predict wheat yield *(Pantazi et al, 2016)*. 'Crop Advisor' is a software tool for predicting the influence of climatic parameters on crop yields *(Veenadhari et al, 2014; Majumdar et al,2017)* SMAG, a French company has developed software using 30 years of weather data history, satellite and drone images, and soil types to enable users to track the progress during the life cycle of a plant and predict yields. 80% of French agricultural land under wheat cultivation is managed through this algorithm. InVivo, France's leading agricultural cooperative group with 220 members using the technology, earns €6.4 billion in sales *(Talend, n.d.)*.

## II. Knowledge Agriculture™

Knowledge Agriculture aims to achieve the objectives enshrined in SDG2030 to increase the agriculture yield without harming the environment, sustaining planet resources, and simultaneously countering challenges such as depletion of water resources and increased erosion and loss of productivity due to the occurrence of extreme weather events. The recent global environmental changes are apparent caution to mankind to immediately change the way it produces food and makes it available to the present and future generations. This can be achieved by optimal use of input resources such as seed, water, fertilizer and chemicals by preventing loss in storage, transportation and supply. In knowledge agriculture, data is captured from several sources. Sensors and IOT (Internet of Things) are used to collect farm data such as soil moisture, humidity, temperature, heat, light, etc. A second database stores the survey report that includes, productivity of soils, suitability of soils for raising specific crops, etc. Another database contains details of time for planting, produce to be planted, row spacing, desired yield, waste recycling, water supply, etc. There are several other databases which store historical rates, market details, supply chains, etc. These structured, semi-structured, or unstructured data are ingested into local or cloud-based storage, computing, analyzing, and creating models for ML-based predictions and taking corrective actions. The data allows the farmers to use a DSS (Decision Support System), to make optimized decisions such as tending each plant with water and fertilizers, spraying pesticides, and eliminating the weeds by selective burning or tilling as per its need during the life cycle without damaging the desired plant. Further, supply chain network design, product design and development, demand planning, procurement management, customized production, inventory management, logistics, and agile supply chain are essential components in farm management. A sustainable global supply chain is becoming an ever-increasingly complex system, especially with the need to deal with international partners*(McCue, 2020).*Modern technologies, such as CEP(Complex Event Processing), RFID, block chain, IoT, and WSN(Wireless Sensor Networks), boost supply chain performance. Supply chain analytics allows quick adjustments and more effective tactical decisions.

## III. Storytelling from Farm Data

### *a) System Architecture for the use of machine learning models for Knowledge Agriculture*

A system architecture for predictive analysis of historical and live data and taking corrective actions is shown in Figure 1.

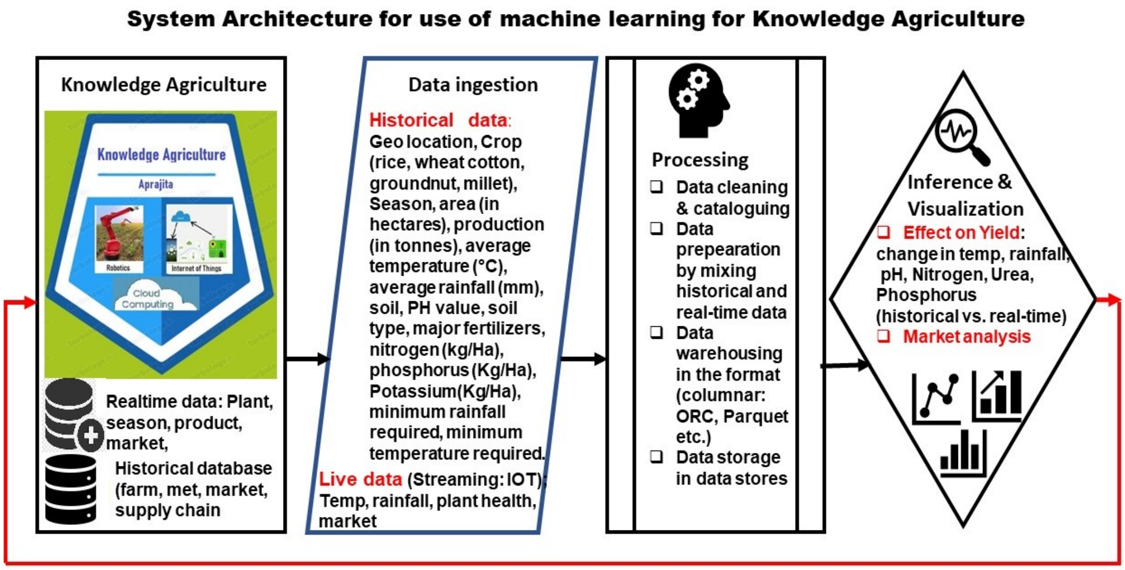


*Figure 1:* System architecture for predictive analysis of historical and live data and taking corrective actions

From the Figure, it will be seen that Knowledge Agriculture involves the use of IOT (Internet of Things) tools such as infra-red cameras, sensors (barometers, hygrometers, light meters, and ambient thermometers), electrodes, GPS (Global Positioning System) guided farm machines (tractor, drones) to detect physical parameters namely moisture, heat, light, pressure, nutrients and pests, etc. These data are streamed directly to the cloud, the technology that relieves the users from maintaining an elaborate computer system with expert staff including programmers and system administrators, for processing, monitoring, and analysis. The historical database is also held on Geo location of the farm, type of the crop (rice, wheat cotton, groundnut, millet), seasons when they are sowed/harvested, area (in hectares), production (in tonnes), average temperature (°C), average rainfall (mm), soil, pH (Hydrogen potentials) value, soil type, major fertilizers, nitrogen (kg/Ha), phosphorus (Kg/Ha), Potassium (Kg/Ha), minimum rainfall required, the minimum temperature required, etc. for optimum yield. Data on logistics, marketing chain, price (historical and current), consumers and input suppliers are also maintained on the cloud. Meteorological data is used for analyzing the weather variation. Bringing all the data to the cloud is part of data ingestion.

The data coming from different agencies may be in structured, unstructured, or in semi-structured formats. These need to be cleaned, normalized, categorized, and cataloged. Since the data is enormous and petabytes of big data need to be analyzed, it needs to be put in a way that analysis becomes possible, a few in real time for taking immediate corrective action in the farm such as tending each plant with water, fertilizers as per its need during the life cycle; eliminating the weeds by the spraying of pesticides, tilling or selective burning without damaging the desired plant. It may need certain data available in CSV (Comma-Separated Values) or JSON (JavaScript Object Notation) formats to be converted in a columnar form known as ORC or Parquet form. These activities come under processing.

The final analysis is done by building visualization for real-time monitoring of the crop for dry fields or identifying plants needing attention for the use of fertilizer, pesticide or heating, etc., and thus allocating resources dynamically and efficiently. Careful and precise application of all inputs for agricultural produce can maximize crop yields and thereby reducing cost, and at the same time minimize waste of pesticide and water usage. Dynamic evaluation of moisture content can stop the excessive use of water for irrigation. This is especially of great value for 18 countries, with almost four billion people who are using their water reserves to the point of exhaustion to produce grains*(Earth Policy Institute, 2013)*.The consolidation of historical weather data with meteorological prediction can be used to build complex models to predict the time of sowing/harvesting the crop. Another real-time model for supply chain can track the movement of food to identify bottlenecks and optimize the movement of product by improving logistics. To summarize, the analysis provides the potential to foresee demand, assess user sentiment, promote coordination and collaboration throughout the supply chain through fleet management tracking solutions, and use GPS-oriented analytics to optimize routing, cut transportation costs and provide an advanced mapping of vehicle locations.

Big data analytics is a complex process of examining the massive amount of data to uncover information such as hidden patterns, correlations, and other insights like market trends and customer sentiments that enables organizations to make informed business decisions. We divide the entire analysis in three steps, namely Data management, Analytics & visualization. This is shown in Figure 2. A few tools used in different stages are mentioned in the Figure.

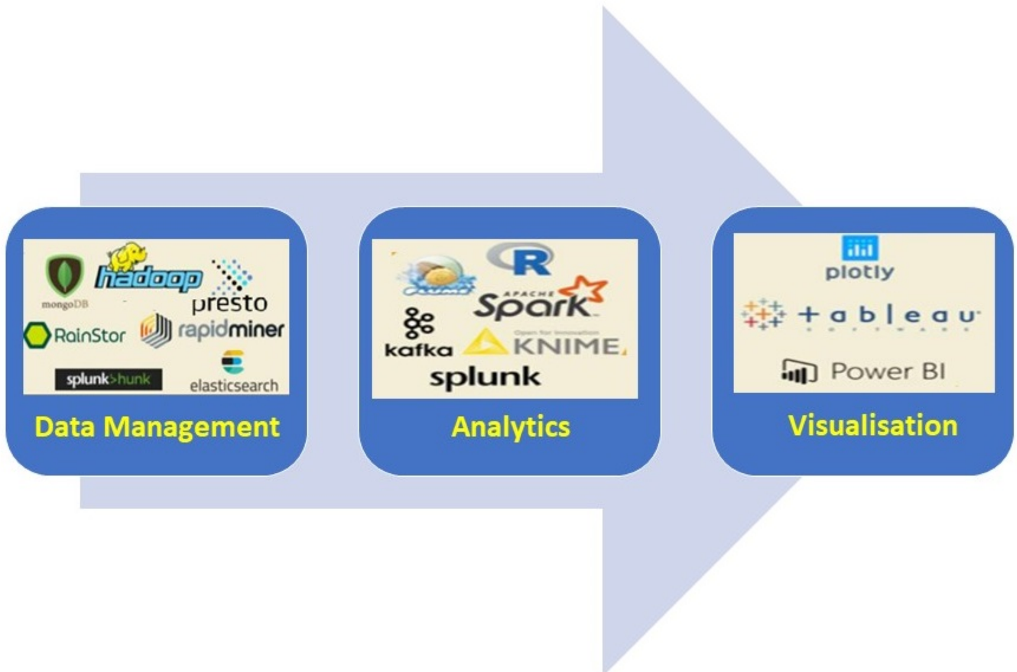


*Figure 2:* Stages of Data analytics and visualization

Hadoop *(Apache Hadoop Documentation, 2014)*is an open-source framework written in Java that provides many analytical tools to store and process large datasets ranging in size from gigabytes to petabytes to generate new insight, which includes Machine Learning and data mining. The Apache Hadoop kernel has a storage part, known as Hadoop Distributed File System (HDFS), and a processing part known as the Map Reduce algorithm for parallel processing. Few of the tools are Apache spark *(Spark Core Programming, n.a.; Kannan, 2015)*, a cluster computing platform to process batch applications, Machine Learning, streaming data processing, and interactive queries; Map Reduce *(Seema & Jha, 2015)*, an Algorithm based on the YARN framework to perform the distributed processing in parallel in a Hadoop cluster; Apache Hive *(Hiba et al. 2019)*, a Data warehousing tool that uses query language known as HQL or HIVEQL; Apache Impala, an open-source SQL engine; Apache Mahout*(Anil et al. 2020)*, used for implementing various Machine Learning algorithms offering implementations of classification, clustering, dimensionality reduction and linear algebraic computations; Apache pig, an open-source Apache library that runs on top of Hadoop, providing a scripting language used for analysing massive datasets by representing them as dataflow *(Swarna & Zahid 2017)*; HBase, a non-relational, NoSQL distributed, and column-oriented database that allows for data to be analysed in real-time, as it is entered (History of Apache HBase, n. a.); Tableau, a software to generate helpful visualizing charts on interactive dashboards and worksheets and many more used in the Business Intelligence Industry *(Tableau, n. a.)*. These tools, with their short descriptions, have been shown in Figure 3.

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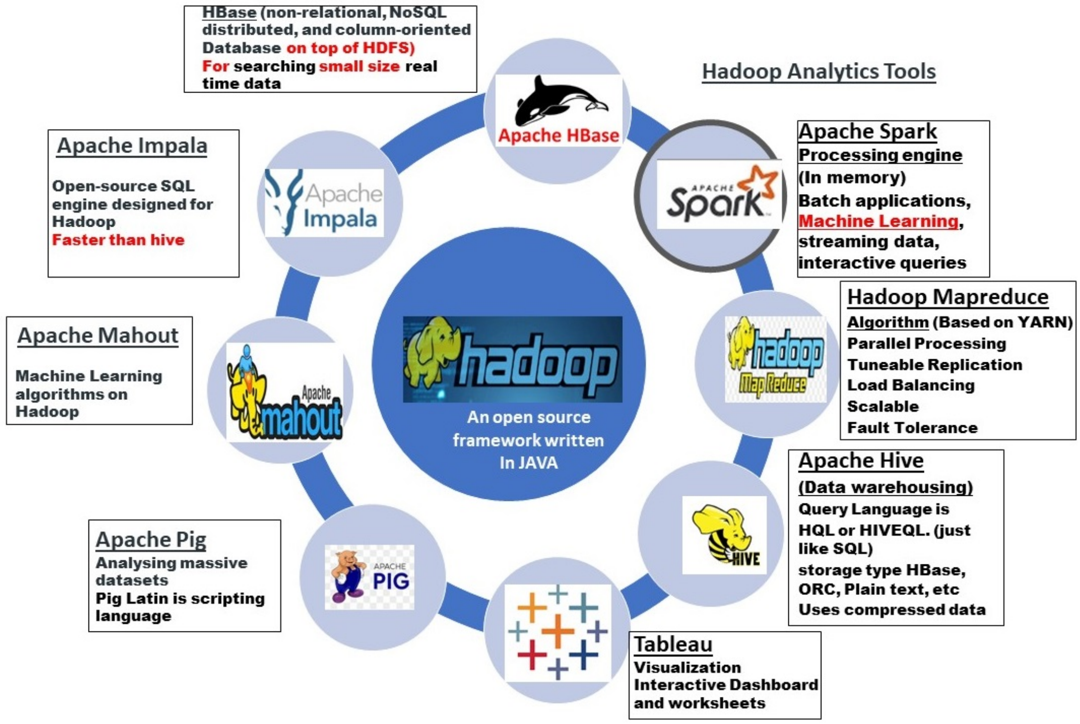


*Figure 3:* Hadoop Analytics tools for Big Data analysis

## IV. Cloud-Based Architecture

Open-source tools can be used for Knowledge Agriculture data analytics, visualization, and undertaking corrective action using BI (Business Intelligence) tools like a tableau. However, this needs hardware and software infrastructure with competent programmers. The alternate solution is to use Cloud-Based platform which offers "SaaS (Software as a Service), PaaS (Platform as a Service), and IaaS (Infrastructure as a Service)"*(IBM Cloud Education, n. a.)*. SaaS utilizes the internet to deliver applications that run directly through web browsers, thus sparing the employees and companies from the efforts of installing, managing, and upgrading software. PaaS provides a framework for developers to build upon and create customized applications. IaaS is a form of virtual cloud computing technology that provides highly scalable infrastructure, including servers, networks, operating systems, and storage. Using IaaS, businesses hire resources on-demand and scale it as per their requirements instead of having to buy the hardware outright. Google Cloud Platform Services (GCP), Amazon Web Services (AWS), Microsoft Azure, Digital Ocean, Linode, Rackspace, and Cisco Metapod are a few companies providing IaaS. In 2020, the cloud-based segment had the largest share of the agriculture analytics market. The large share of cloud-based market is primarily due to easy accessibility, lower maintenance, affordable pricing, and reliable security. Furthermore, benefits provided by cloud-based solutions in terms of SaaS, PaaS, and IaaS for agriculture analytics are helping the segment grow at the highest speed. A few basic architectures based on a few major cloud service providers for big farm data analytics are discussed below.

### a) *Google Cloud Platform (GCP)-based architecture*

A typical system architecture based on the Google cloud platform is shown in Figure 4. Here, data from IOT devices are captured using MQTT protocol through IOT core (fully managed Service for securely connecting and managing millions of IoT devices), and data is prepared through DataPrep (explores, cleans, and prepares structured and unstructured data for analysis). Thereafter this datais analyzed along with the other historical database stored in Firestore (a NoSQL document database), using Cloud Functions (a serverless execution environment for building and connecting cloud services) and BigQuery/ML that creates and executes machine learning models. The information after analysis is made available to Data analysts/farmers through Pub/Sub, which provides messaging between applications.

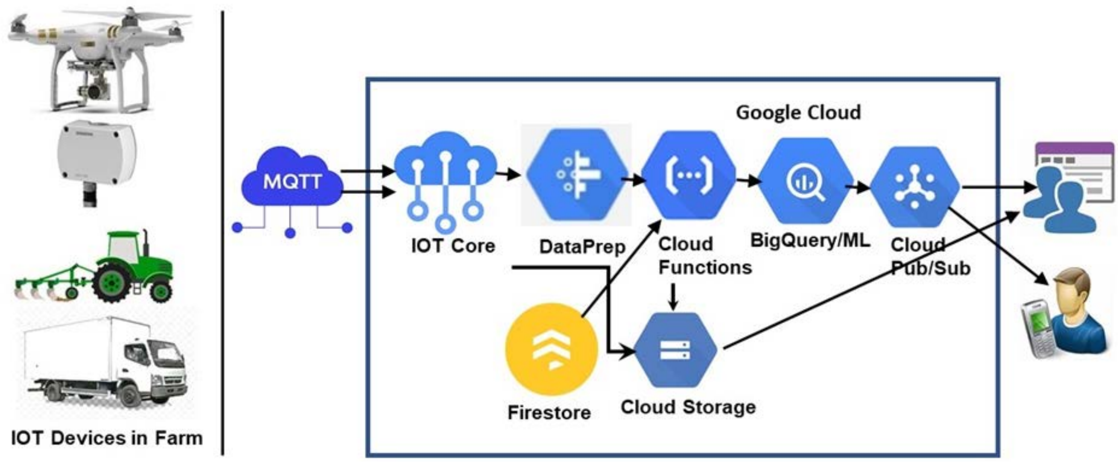


*Figure 4:* System architecture for farm data analysis and prediction based on Google cloud (Note: The GCP icons are available in the open domain)

i. *Use case-Taranis (Google cloud along with Tensor Flow)*

As much as forty percent of crops in agriculture are regularly lost due to pests, crop illnesses, weeds, and lack of nutrients. Using drone technology and artificial intelligence, Taranis *(Taranis, n.d.)*, working in several countries worldwide, with more than 20 million acres of land in Russia, Eastern Europe, and South America, is providing farmers with modern tools on the cloud along with Tensor Flow to reduce crop loss, increase yields, and lower costs *(Google Cloud, n.d.)*.To develop BI (Business Intelligence) models, drones were deployed to capture tens of millions of photographs over the past year and a half, which have been analyzed and tagged. Each photo has up to a thousand items of interest, such as insect damage or leaf discoloration. The company claims to have processed around 100 million distinct features in approximately 700,000 images. The insights provided through visualization provide farmers with the information that enables them to intervene early and prevent crop loss. Farmers can target problems with concrete solutions, like adding fertilizer in a specific area with low in nutrients. The scalable Compute Engine dedicates information from the images when new images arrive. Data is uploaded to a Cloud SQL database for further analysis.

Tensor Flow *(TensorFlow, n. a.)*is an *open-sourced* machine learning platform that delivers a complete functional solution with a focus on deep neural networks to analyze massive amounts of unstructured data. It contains a diverse and complete set of libraries, tools, and community resources. Tensor Flow is used for building the machine learning models by using tens of millions of photographs of agriculture fields for training. Feeding the dataset for the new photographs and comparing them with models is used to discover items of interest, such as insect damage or leaf discoloration.

b) *Amazon Web Services (AWS) based architecture*

A typical broad system architecture using AWS is shown in Figure 5. It would be observed from the Figure that broad modalities are similar. The IOT data is streamed using a tool known as Kinesis which allows real-time streaming of IOT data from the devices deployed on the farm. Another tool, IoT Core connects billions of IoT devices such as sensors, actuators, embedded devices, wireless devices, and smart appliances over MQTT, HTTPS, and LoRa WAN protocols and routes trillions of messages to users without managing any infrastructure.

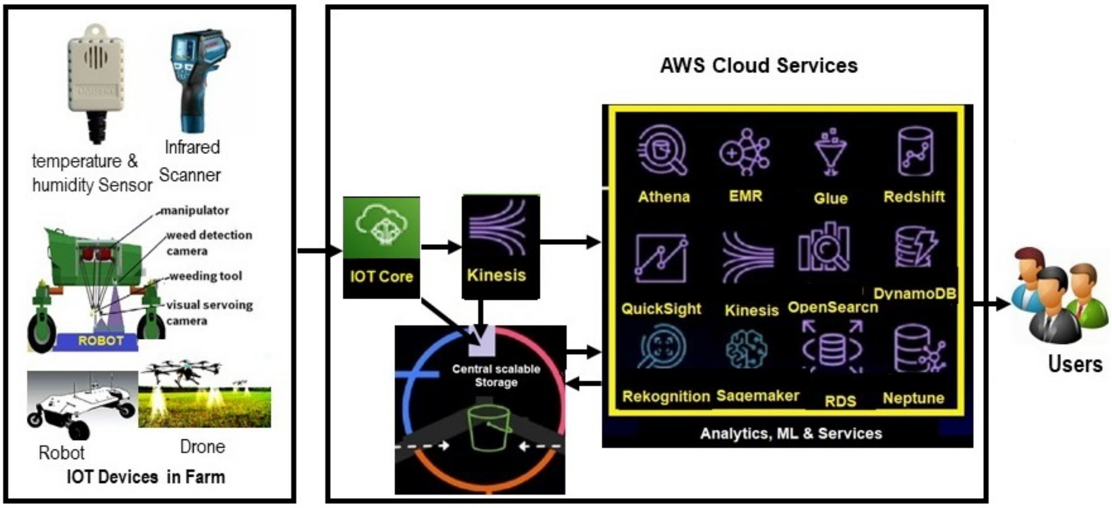


*Figure 5:* System architecture for farm data analysis and prediction based on Amazon Web Services (AWS) (Note: The AWS icons are available in the open domain)

Kinesis Data Analytics (KDA) analyzes streaming data to gain actionable insights and responds to farmers' needs in real-time. It also generates real-time alerts and dashboards. KDA supports standard ANSI SQL and provides an easy-to-use schema editor. It includes open-source libraries based on Apache Flink. IoT Analytics datasets can be taken to the Quick Sight console (Business intelligence tool) for creating dashboards and visualizations. Red shift is a high-performance, petabyte-scale data warehouse service for analytical processing (OLAP) workloads, while RDS Postgre SQL or Aurora typically stores terabytes of relational data for on-line transaction processing (OLTP) workloads. Dynamo Db stores non-relational data, and Neptune is a fully managed graph database. Glue is a server less data integration and ETL (Extract, Transform and Load) tool used for discovering, preparing, and combining data for data analysis and Machine Learning. Open Search provides for free-text search. Athena is a serverless interactive query service, an upgraded SQL query engine from the Trino *open-source* project, that makes it easy to analyze data in storage using standard SQL. Amazon has developed their own EMR, which is taking the place of Apache Hadoop and Apache Spark. This makes it simpler to perform tasks that involve big data analysis such as data transformation, graph analytics, and machine learning on a managed cluster platform. Rekognition is part of the artificial intelligence services provided for image analysis.

i. *Use cases*

Mantle Labs*(Mantle Labs, n. a.)*uses the AWS cloud platform to automate the processing of satellite data from 500 million hectares of agricultural land spanning six continents for tracking vegetation health, soil moisture, and climate impact daily. This service provides an accurate, near real-time risk assessment to the world's 600m farmers, instantly. The company states that it can accumulate and analyze billions of pixels of imagery from several satellites on a daily basis to create a data cube of the entire world. It uses Elastic Container Registry (ECR) for storing container images and Fargate as a serverless compute engine. ECR allows sharing and downloading of images securely over Hypertext Transfer Protocol Secure (HTTPS) with automatic encryption and access controls. Fargate is a serverless compute engine that enables building applications without managing servers. Mantle Labs also leverages Simple Queue Service (SQS) for event-based batch processing of satellite images. The data analysis forecasts crop health, forest changes, climate impact, crop observation, drought impact analysis, and field-level profitability analysis. The deep learning engine has the capability to examine petabyte-scale data to provide high-resolution analysis for any area on the planet. The farmers can use the platform for crop monitoring and near real-time production estimation, including commodity price forecasts, production, and supply chain analysis. To bank and insurance companies, it offers credit risk assessment, underwriting and pricing, portfolio creation and risk diversification, claims fraud management, and processing *(AWS, n. a.).* Mantle Labs, with the Agri-EPI Centre, offered its Geobotanics platform, which runs crop monitoring solutions, for UK (United Kingdom) food security during the coronavirus pandemic ("*Crops and Soil Newson Agri-tech partners support COVID-19 food security", 2020*).

GeoPard, Köln, Germany *(GeoPard, n. a.)* uses AWS for spatial data analytics and artificial intelligence algorithms for crop farming that automates workflows to create VRA maps for seeding, fertilizing, and crop protection based on various data sources and agronomic logic. Variable-rate technology (VRT) allows determination of the exact number of passes over an area to deliver the right amount of farm inputs such as fertilizer, chemicals, pesticide, lime, gypsum, and irrigation water. By creating a Zones Map from specified data layers such as Topography, Satellite Images, Soil Sampling, High-Density Sensors and Cameras, Applied Datasets of Yield, VRA maps can be employed for any agricultural field. Data visualization leads to new ideas, and analytics helps to solve problems by creating solutions and writing prescriptions agronomists.

CropX captures raw data from global soil sensors and integrates it with topography/soil maps, weather forecasts data, satellite imagery, hydraulic models, crop models, user inputs, data from the controllers, and agricultural equipment such as sprayers, tractors & harvesters, and then ingests it to a centralized platform running on Elastic Compute Cloud (Amazon EC2) instances. It then analyses and saves satellite imagery, agronomical data, and insights in the cloud storage. It uses SNS to transfer messages between services. The Service provides crop-specific and growth-stage-specific insights and recommendations, such as advising farmers when, where, and how much to irrigate, fertilize and spray *(CropX, n. a.)*.

*c) Microsoft Azure*

Farm Vibes. AI *(Project Farm Vibes, n.a.)*is Microsoft's *open-source* Multi-Modal Geospatial ML Models for Agriculture and Sustainability. There are three main components of FarmVibes.AI. The first one consists of data ingestion from sources such as satellite imagery (RGB, SAR, multispectral), drone imagery, weather data, custom sensor data (such as weather sensors), and more. The input data is pre-processed for building ML models with ease based on parameters that can be specified. The inbuilt notebooks are used to tune the models to achieve a level of accuracy for the specific parts of the world or seasons. The library includes data for detecting practices (for example, harvest date detection in the country for a particular crop), estimating climate impact (both seasonal carbon footprint and long-term sustainability), microclimate prediction, and crop identification. The artificial intelligence arm of Farm Vibes has three parts, namely, Async Fusion, which pairs sensors and satellite imagery to create nutrient heat and soil moisture maps; Space Eye, which removes clouds from satellite imagery; Deep MC, which uses sensor data and weather forecasts to predict the temperatures and wind speeds of a farm's microclimate; and a "what if" analysis tool that predicts effect on the soil's carbon sequestration abilities based on variances in farming methods.

i. *Use Case-Bayer*

Bayer's Climate Field View™ is a data integration tool that provides yield analysis, field region reports, field health imagery, and manual seed scripts. As per the company's report, the Software is being used on more than 180 million farming acres across more than 20 countries. Microsoft and Bayer have entered into a strategic partnership to build a new cloud-based set of digital tools and data science solutions to enable the rapid development of agriculture food tech applications by the combination of modern cloud technology and adding a layer of data*(Digital Farming, n. a.)*.

## V. Challenges

Soil fertility has severely degraded in many parts of the world due to intensive agriculture, increasing use of fertilizers and pesticides, over-grazing, water pollution, deforestation, salinization, and accumulation of non-biodegradable waste. Climate change due to global warming further aggravates land degradation, soil erosion, and soil fertility. Natural disasters like flooding and landslides are being witnessed more frequently worldwide. Severe soil degradation can reduce crop yield by over 50%*(FAO, 2019)*. At the same time, Food and Agriculture Organization of the United Nations has estimated that the world population will exceed 9 billion by 2050, and the world will lose about 250 million crop-production acres due to urbanization and soil degradation from excessive tillage and other farming practices *(Wilde, 2021)*. Food loss and waste (FLW) in production, postharvest and consumption stages are 24, 24, and 35 percent, respectively, accounting for more than 80 per cent of food wastage in these stages, which is quite alarming *(Li et al, 2017)*.

The agriculture analytics market is expected to grow to $2.27 billion by 2027, at a CAGR of 17.5% from 2020 to 2027. The key factors driving the growth are rising pressure to meet global demand for food, especially in the current world environment of food shortage due to the COVID epidemic, climate changes, and war. This environment has led to an increasing need for improved farm productivity that is possible only by the use of Knowledge Agriculture deploying modern tools and technology of AI and predictive analytics to improve the yield and cut down the losses of 1.2 billion tonnes globally; 40% of all food is never eaten when both farming and post-farming are taken into account, as per WWF-UK *(WWF, 2021)*. Going with cloud-based technologies and applying big data in the agribusiness chain will reverse the trend of farmers selling their land for choosing employment in the service sector and make the agriculture business profitable.

The lack of technical know-how among farmers, the fragmented agriculture industry, and need for heavy capital investment for Knowledge Agriculture, lack of standardization for data management and data aggregation may hamper the growth of this market. Further, political compulsions, farmers', and trade unions' lack of trust in industrialists and solution providers are significant impediments. One of the most significant challenges is discovering stable business and operational frameworks for private-public collaborations. The Indian Government's withdrawal of farm bills is a pointer *(Mukherji in Business Standard, Jan, 17, 2023)*. The explicit motive for data harvesting is the prediction of consumers' wants and needs. The farmers fear that the data collected by service providers can be manipulated by them for their own advantages. For example, the forecast of a higher need for fertilizer in a specific region of the world may lead to an artificial increase in prices in that region in collusion of service provider and fertilizer supplier. Beyond data access and infrastructure, digital democracy calls for a fundamental redistribution of decision-making power from a small number of corporate stakeholders to a broader group of farmers and citizens. GODAN (Global Open Data for Agriculture and Nutrition) of United Nations, currently with more than 374 partners from national governments, non-governmental organizations, international and private sector organizations, pleads for the active sharing of data on agriculture and nutrition among all the stakeholders *(GODAN, n. a.)*. The European Commission's launch of public consultations on the Data Act with the possibility of imposing binding rules to provide governments access to private-sector data has started heated debates. The Data Act is a proposal by the European Commission for a legislative provision that "aims to create a fair data economy by ensuring access to and use of data for legitimate purposes, including in business-to-business and business-to-government [B2G] situations" (European Commission, 2021).

## VI. Way-Ahead

Linking data from farm operations on agricultural sites with information and knowledge collected from laboratories will be required to be effectively analyzed and used to optimize sector performance. The best possible solution for this is to make accessible global data from land globally and provide a platform for analysis and use for long-term sustainable development by improving economic opportunities for farmers. Upgrading the skills of all the stakeholders, resource persons in agriculture Universities, students and farmers, open access to research, meta-analysis, and available data publication is vital for food nutritional security. Providing more specialized Big Data analysis tools on mobile devices, and extending the information about the features, benefits, and limitations of each framework in various local languages will help the world population. Carnegie Mellon University is undertaking a research project for automatic speech recognition for 2000 languages from the present 200 *(Science Daily, 2023)*. WDF University for SDG2030 has developed skill development on-line courses, which provide choice for translation of courses in many Indian and foreign languages *(WDF University, n. a.)*. Hence, technological issues related to ingestion, analysis, processing, and application associated with Farm Data must be included in studies and constitute an essential research topic.

## VII. Conclusion

There is an urgent need to create a sustainable food system to feed the growing population on the earth. The climate crisis grew increasingly severe and irreversible in the year 2022. The world witnessed record ice melt at the poles, catastrophic flooding in Pakistan and China, record-breaking heat waves in the US (United States) and Europe, and severe drought in Africa. The war between Russia and Ukraine has led to rising energy prices and climate-fuelled droughts, and has pushed a perilously stretched global food system to the brink. The situation has led to an increased interest in investigating how our food is grown and ensuring that the most efficient practices are used. Efficiency in growing more food needs urgent use of tools and technology for Knowledge Agriculture. Countries have to adapt it to escape a cycle of catastrophes and debt. The 2030 agenda for 17 Sustainable Development Goals (SDGs) aims to end poverty and malnutrition around the globe, preserve the climate and environment while sustaining the planet's resources. The agenda was adopted in 2015, and now after, seven years (mid-term of 2015-2030), "the world continues to lose ground in its efforts to end hunger, food insecurity, and malnutrition", according to the report of SOFI(State of Food Security and Nutrition in the World) released in 2022 *(Food and Agriculture Organization of United Nations, 2022)*. The information admits that "many of the SDG2 targets are growing wider each year". Eight hundred twenty-eight million people, around 10.5% of the world population, were affected by hunger globally in 2021, an increase of 46 million since the end of 2020. Nearly 3.1 billion people globally could not afford a healthy diet in 2020, an increase of 112 million from 2019 due to the pandemic and war. The government of India has been providing free food, to prevent death from hunger, to its 814 million population since March 2020 under the National Food Security Act, which has been extended up to Dec. 2023 *(The Economic Time, 2022)*. The total adds to 3.924 billion of 7.79 billion, about 50% world population for the year 2020, lacking proper food during pandemic. Serious efforts are required to avoid the bleak future by using modern tools and technology to farm sustainably and climate sustainably and offer farmers an adequate advice, training, and skill.

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# The Heat Transfer by Radiation under Relativistic Conditions

By Emil V. Veitsman

*Abstract-* An expression was obtained for the energy density of the moving black-body radiation, i.e., the Stefan-Boltzmann law valid in the interval of object velocities from zero to the velocity of light in vacuo when the angle of observation θ equals zero. The object temperature is shown to comprise two parts. The first one is a scalar invariant under the Lorentz transformations. The second one is a vector depending on the velocity of system motion. The scalar component of the temperature is a contraction of two tensor components of rank 3. Under normal conditions this mathematical object is a scalar. Taking account of a tensor character of the temperature a new formulation is given for the second thermodynamics law. The results obtained are of the great practical importance, in particular, while designing devices to measure the radiation temperature of moving cosmic objects, e.g., quasars.

*Keywords:* *heat transfer; radiation; relativistic conditions; temperature; thermodynamics; entropy.*

*GJSFR-A Classification:* *DDC Code: 621.4022 LCC Code: TJ260*

THEHEATTRANSFERBYRADIATIONUNDERRELATIVISTICCONDITIONS

# The Heat Transfer by Radiation under Relativistic Conditions

Emil V. Veitsman

*Abstract-* An expression was obtained for the energy density of the moving black-body radiation, i.e., the Stefan-Boltzmann law valid in the interval of object velocities from zero to the velocity of light in vacuo when the angle of observation **θ** equals zero. The object temperature is shown to comprise two parts. The first one is a scalar invariant under the Lorentz transformations. The second one is a vector depending on the velocity of system motion. The scalar component of the temperature is a contraction of two tensor components of rank 3. Under normal conditions this mathematical object is a scalar. Taking account of a tensor character of the temperature a new formulation is given for the second thermodynamics law. The results obtained are of the great practical importance, in particular, while designing devices to measure the radiation temperature of moving cosmic objects, e.g., quasars.

*Keywords: heat transfer; radiation; relativistic conditions; temperature; thermodynamics; entropy.*

## I. Introduction

The problem of the moving black-body radiation arose in 1907 – almost immediately after the creation of Special relativity (SR). It is in this year that Kurd von Mosengeil's big article was published in der Annalen der Physik [1]. This work supervised by Max Planck underlies his relativistic thermodynamics [2]. The great scientist considered the theory of the black-body radiation to be well-studied and the most suitable for formulating foundations of thermodynamics correct over the entire whole interval of object velocities v, i.e., ranging from zero to the velocity of light in vacuo.

In article [1] a system is studied comprising a radiator of electromagnetic waves, receiver and reflector (mirror). The radiators are receivers at the same time. The three elements are moving uniformly and rectilinearly in space with a relativistic velocity forming an acute angle with one another. As a result, the temperature transformation law was obtained under relativistic conditions:

$$T = T_0\sqrt{1-\beta^2}\ , \qquad (1)$$

where $T_0$ is the temperature if $v << c$ (here and below index "0" means that the given quantity concerns normal conditions); $\beta = v/c$.

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For more than 50 years formula (1) had not been called in question until X.Ott's article was published [3], in which the relativistic temperature was shown to transform following another law:

$$T = T_0 / \sqrt{1-\beta^2}\ . \qquad (2)$$

The expression (2) was obtained by X.Ott for a variety of physical processes including electromagnetic radiation. However unlike Mosengeil, X.Ott elected another approach for studying the process of electromagnetic wave radiation under relativistic conditions. He examined wave emission of individual atoms, whereas Mosengeil studied black-body radiation, as we have noticed above. In particular, in [1] Stefan-Boltzmann's law was obtained:

$$\varepsilon_0 = \frac{E_0}{V_0} = aT_0^4\ , \qquad (3)$$

based on the famous Planck formula derived first semiempirically:

$$\rho(\omega,T)d\omega = \frac{8\pi\hbar\omega^3 d\omega}{c^3\left(e^{\frac{\hbar\omega}{kT}}-1\right)}\ , \qquad (4)$$

where $E_0$ is the radiation energy of the black-body; $V_0$ is the volume; $a$ is Stephan-Boltzmann's constant (J/cc ·grad$^4$); $\rho(\omega,T)$ is the radiative energy density (J/cc); $k$ is Boltzmann's constant; $\omega$ is the frequency of oscillator radiation.

As known, Stefan-Boltzmann's constant equals:

$$a = \frac{k^4\pi^2}{15\hbar^3 c^3}\ . \qquad (5)$$

X.Ott's article has induced a long-term polemic on the temperature transformation under relativistic conditions. Some researchers adhered to Planck-Einstein's viewpoint; the others adhered to X.Ott's. Some scientists considered the temperature to be a relativistic invariant [4]. There appear absolutely exotic opinions. For example, the authors of Ref. [5] arrived at a conclusion of the temperature under relativistic conditions being changed both according to Planck, and to Ott, and to Callen and Horwitz as the able

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situation requires. Moreover, P. Landsberg and G. Matsas have decided to put end to the long-time dispute [6, 7]. In particular, they write (I cite): "…the proper temperature T alone is left as the only temperature of universal significance. This seems to complete a story started 90 years ago [8] (more than 100 years today – E.V.) of how usual temperature transforms, and to conclude a controversy [3] of 33 years' standing". ( 50 years' today).

What is authors' opinion [6, 7] based on? Their basis is as follows.

First of all, the authors used an Unruh-De Witt detector, i.e., a two-level monopole, with a unit interval of the radiation energy $\hbar\omega'$. Then the authors [6, 7] suppose that black-body radiation with the proper temperature *T* is at rest in some inertial reference frame *S*. The excitation rate of the detector moving with a constant velocity *v* is found from quantum field theory. It is proportional to the particle number density $n'(\omega',T,v)d\omega'$. As a result, the following formula was obtained:

$$n'(\omega',T,v)d\omega' = \frac{\omega' kT\sqrt{1-v^2/c^2}}{4\pi^2c^2v\hbar}\ln\left(\frac{1-e^{-\left(\hbar\omega'\sqrt{1-v/c}\right)/kT\sqrt{1-v/c}}}{1-e^{-\left(\hbar\omega'\sqrt{1-v/c}\right)/kT\sqrt{1+v/c}}}\right)d\omega' , \quad (6)$$

which, as the authors of [6, 7] noted, could not be reduced at $v=0$ to the well-known formula

$$n'(\omega',T',v)d\omega' = \frac{\omega^2/c^3}{2\pi^2\left(e^{\hbar\omega'/kT'}-1\right)}d\omega' . \quad (7)$$

We obtain from (6) an expression which does not defy interpretation, as $v \to c$.

In opinion of P. Lands berg and G. Matsas, formula (6) is absolutely correct, thus it is unnecessary to speak about an unified law of temperature transformation under relativistic conditions. However it is not completely the case. Both the results obtained by Mosengeil (and soon used by Planck), and the mathematical monster (6) are incorrect. It is necessary to admit that the main reason of such a dramatic situation with a relativistic temperature is a giant scientific authority of Max Planck first and Albert Einstein. Naturally, after publishing X.Ott's article this work was carefully checked. Errors had not been found. But nobody dared check the works [1, 2, 8]. These articles were carried out just after the creation of Special Relativity (SR) when nobody had known on the Bose-Einstein distribution. As we have noticed above, Planck's well-known formula, concerning black-body radiation, was obtained by a semiempirical way without involving this distribution. After the discovery of this distribution, in the twenties of last century, Planck's formula was already obtained with its help. However if the radiator of electromagnetic waves is moving with a relativistic velocity, the form of Bose-Einstein distribution changes drastically – it becomes at least a function of two variables, which immediately follows from SR electrodynamics.

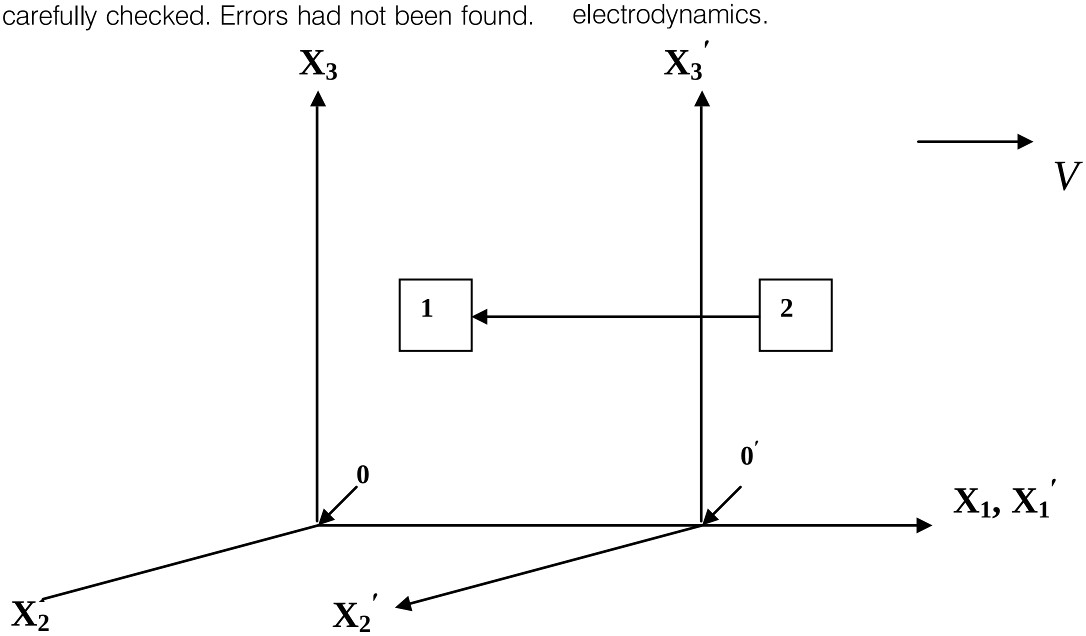


*Fig.1:* $X_1$ ,$X_2$ ,$X_3$ and $X_1'$ ,$X_2'$ ,$X_3'$ are the laboratory reference frame and that moving uniformly and rectilinearly with the velocity v. 1 is the observer at rest; 2 is the radiating black body

Indeed, examine the simplest case represented in the Fig.1. As seen, there are two reference frames. One of them (with primes) is moving uniformly and rectilinearly with the velocity **v**. There is a cylindrical object at rest in the moving reference frame. There is a cylindrical cavity in the object. The walls of the cavity are a black-body. They are emitting and absorbing photons. There is a very small hole on a face-wall of the object (see Fig.1). The flux of photons is flowing out the cavity. Since the hole is very small, the equilibrium of the photon gas in the cavity does not disturb practically. The photon radiator is at rest in the moving reference frame. An observer is at rest in the laboratory reference one. The observer is detecting photons (the energy of the electromagnetic wave). Here Maxwell's 3-D tensor of energy-momentum $\sigma_{\alpha\beta}$ has only one component - $\sigma_{11}$. It is equal to the density of energy in the wave [9]. Knowing the density of energy in the flux of photons, we can estimate the density of energy of the photon gas in the cavity in practice. If the angle $\theta$ between **v** and the observer is $3\pi/2$ (the object is moving away from the observer), then the radiation frequency of the oscillator $\omega$ will be for this case equal to

$$\omega = \omega_0 \frac{\sqrt{1-\beta^2}}{1+\beta}. \qquad (8a)$$

If the object is moving to the observer i.e., the velocity of the system is equal to -**v**, then

$$\omega = \omega_0 \frac{\sqrt{1-\beta^2}}{1-\beta}. \qquad (8b)$$

Denote the frequencies $\omega$ in (8a) and (8b) as $\omega_1$ and $\omega_2$ then

$$\overline{\omega} = \frac{\omega_1+\omega_2}{2} = \frac{\omega_0}{\sqrt{1-\beta^2}}, \qquad (8c)$$

If the angle $\theta$ were $(-\pi/2)$, then the formula for the frequency transformation would have another form, namely:

$$\omega = \omega_0\sqrt{1-\beta^2}. \qquad (9)$$

for the observer in the laboratory reference frame.

Thus without taking into consideration (8) and (9), we cannot evidently use the well-known Bose-Einstein distribution for obtaining the Stefan-Boltzmann law when the object under study is moving with relativistic speed.

The aforesaid allows us to formulate a main goal of our work – obtaining a radiation law for the black-body moving with a relativistic velocity when the angle $\theta$ between the moving velocity **v** and the observer is $3\pi/2$ (see Fig.1). A solution of the problem will be performed by the methods given in [9].

Here we must be added the following. Attempts have been made to obtain the law connecting the radiation intensity with the temperature when relativistic effects are involved [10, 11]. For example, in [11] an ultrarelativistic plasma is examined containing electrons and positrons. Their annihilation generates electro-magnetic radiation. Its intensity is defined, in particular, with the help of a one-dimensional Bose-Einstein distribution. It is proportional to the plasma temperature to the fourth power, with the velocity of the object as a whole being equal to zero. It is plasma particles that are in motion.

## II. Methods and Results

*a) Definition of the number of field oscillators with a given frequency when the angle θ is 3π/2 (Fig.1)*

Assume that we have an opaque object with an inner cylindrical cavity. Its surface is a black body heated up to some temperature *T*. There is a thermodynamical equilibrium in the cavity between its inner surface and electromagnetic radiation. There is a very small hole in the object cover, through which electromagnetic waves radiate out of the cavity (see Fig.1). The object is moving uniformly and rectilinear with the velocity **v** together with the reference frame. The radiation from the cavity is detected with a device being at rest in a laboratory reference frame. First of all, we will show that the Stefan-Boltzmann law (3) is incorrect over the whole range of object motion velocities, i.e., from zero up to *v→c.* Indeed, according to X. Ott [3], the radiation energy in the cavity is equal to:

$$E = \frac{\sum_1^n h\omega_0^{(n)}}{\sqrt{1-\beta^2}}, \quad n=1,2,\ldots l, \qquad (10)$$

then the electromagnetic energy density

$$\varepsilon = \frac{E_0}{V_0\left(1-\beta^2\right)} = \frac{\sum_1^n h\omega_0^{(n)}}{V_0\left(1-\beta^2\right)}, \quad n=1,2,\ldots l, \qquad (11)$$

where *n* is an oscillator serial number, $\omega^{(n)}$ is the frequency of its oscillations.

For the flux of photons moving away from the cavity (see Fig1), the equations (10) and (11) are also correct, Indeed, there is only one component $\sigma_{11}$ of Maxwell's stress tensor (see above). The component is equal

$$\sigma_{11} \sim E_2^2 + E_3^2 + H_2^2 + H_3^2 = \frac{E_{02}^2 + E_{03}^2 + H_{02}^2 + H_{03}^2}{1-\beta^2},$$

$$E_{2(3)} = \frac{E_{02(03)}}{\sqrt{1-\beta^2}}; H_{2(3)} = \frac{H_{02(03)}}{\sqrt{1-\beta^2}}$$

where $E_{2(3)}, E_{02(03)}$ are the intensity components of the electric field in the directions 2 and 3 for the observers in the laboratory reference frame and for the observer moving with the system under study correspondingly; $H_{2(3)}, H_{02(03)}$ are the intensity components of the magnetic field in the directions 2 and 3 for the above observers.

No matter how the temperature of the system transforms, i.e., according to Planck or to Ott or to Callen and Horwitz, we shall always arrive at the point of absurdity. Indeed, let the temperature transform, e.g., according to Planck, i.e., to (1). In this case the right side of (3) will have the following form $aT_0^4(1-\beta^2)^2$. Then, as seen from (11), the right side of (3) appears to tend to zero as $v \to c$, while the left side of this formula to increase infinitely. This indicates a close connection between the radiation law of a moving black body and the temperature transformation under relativistic conditions.

Now find the number of oscillators $g(\omega_1, \omega_2)$ $d\omega_1 d\omega_2$ with frequencies in intervals $\omega_1, \omega_1 + d\omega_1$ and $\omega_2, \omega_2 + d\omega_2$ and a given polarization in the cavity using the well-known procedure [9]. The following fact should be pointed out at once. The number of these oscillators is a function of two variables. The reason for that was explained above but here the following should be noted. If a spherical coordinate system is used for the case $v << c$, then in our case it is convenient to use a cylindrical one taking account of formulae (8) and (9).

The classical approach to finding the quantity $g(\omega)d\omega$ is based on using the number space $n$ followed by transition to a spherical space of the wave vector $k = |k| = n\frac{2\pi}{L}$, where $L$ is the normalized cube edge, and finally to the spherical space of frequencies $\omega$. In the case studied we use a cylindrical space representable as two spaces – flat circular and linear perpendicular to one another. Then to define the necessary quantity we shall use two coordinate systems: polar and one-dimensional Euclidean, i.e., a straight line. The amount of numbers within the spherical layer $dn$ of the spherical space is $4\pi n^2 dn$ [9] (the spherical coordinate system). The amount of numbers $n_1$ in the circular layer is equal to $2\pi n_1 dn_1$ (the polar coordinate system). As to $n_2$ in a linear interval of one-dimension space, it will be equal to $dn_2$. As a result, we have for the whole system:

$$g(\omega_1, \omega_2)\, d\omega_1 d\omega_2 = 2\pi n_1 dn_1 dn_2. \qquad (12)$$

Turning from a number space to a wave vector space and finally to a frequency one, we shall have:

$$g(\omega_1, \omega_2)\, d\omega_1 d\omega_2 = 2\pi n_1 dn_1 dn_2 = \frac{2\pi k_1 dk_1 dk_2}{(2\pi)^3} \Delta L_1^2 \Delta L_2 = \frac{\omega_1 d\omega_1 d\omega_2}{(2\pi)^2 c^3} \Delta L_1^2 \Delta L_2 =$$

$$= \frac{\omega_1 d\omega_1 d\omega_2}{(2\pi)^2 c^3} \Delta V. \qquad (13)$$

In case of electromagnetic waves should be taken into account two polarizations, and then we shall have:

$$g(\omega_1, \omega_2)\, d\omega_1 d\omega_2 = \frac{\omega_1 d\omega_1 d\omega_2}{2\pi^2 c^3} \Delta V. \qquad (14)$$

Here it is important to emphasize that formula (14) is correct for the observer at rest in a real space monitoring, from the referring frame, the object moving then uniformly and rectilinearly with the relativistic velocity **v**. Since the radiation is thermal the average volume of the oscillators with a given polarization will almost be independent of time. In this case, it is unnecessary to define oscillator numbers in Minkowski space.

*b) Relativistic temperature as either a vector or a tensor*

Now we should make a new attempt to solve some problems connected with the relativistic temperature. First of all, we should clarify if this thermodynamic parameter is a scalar or appears to be a vector or a tensor. In this connection we should first recall the formulae for velocity addition in SR. As known, the components of the total velocity in the directions $X_2$ or $X_3$ will tend to zero for the observer in the laboratory reference frame as $v \to c$ (see Fig.1). In turn, the component parallel to axes the $X_1$ will not do that. This suggests immediately that the temperature becomes a mathematical object different from a scalar. What is the object?

Until very recently the temperature in the above case is considered to be either a scalar or a quantity

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forming a vector with other quantities. For example, in [10] V. Hamity represents this thermodynamical parameter as

$$\Theta^{\mu} = \frac{v^{\mu}}{\hat{T}}, \quad \mu = 0,1,2,3, \qquad (15)$$

where $v^{\mu}$ is a unit 4-vector in Minkowski space, moreover

$$v^{\mu} = [v^{0}, v^{\alpha}], \; \alpha = 1,2,3, \qquad (16)$$

i.e., $v^{\alpha} \equiv \mathbf{v}$ is a velocity vector in Euclidean space;

$$v^{\mu} v_{\mu} = 1. \qquad (17)$$

Further, developing the idea of temperature vector representation, the author of [10] finally comes to the following expression:

$$\beta_{\mu} = v_{\mu} / kT , \qquad (18)$$

with $\beta_{\mu} = (\beta,0,0,0)$ , then

$$\beta_{\mu} = \delta_{\mu}^{0} / kT , \quad \delta_{\mu}^{\nu} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}. \qquad (19)$$

Other authors, e.g., [12], also tried to represent the relativistic temperature exclusively as a vector. However, in our opinion, this approach to the problem is incorrect, since the photon gas in the cavity is a continuous medium. Then an expanded tensor approach is necessary to describe energy processes in it. In this case the second thermodynamics law can be represented in Minkowski space as

$$\delta\sigma = \frac{\delta Q^{ijk} g_{jk}}{T^{i\alpha\beta} g_{\alpha\beta}}; i,j,k = 1,2,3,4; \alpha,\beta = 1,2,3,4, \qquad (20)$$

where the heat $Q$ and the temperature $T$ are tensors of rank 3, but $g_{jk}, g_{\alpha\beta}$ are covariant fundamental tensors. Formula (20) needs a special explanation.

As known, M.Planck assumed that $\sigma \neq \sigma$ (v), i.e., the entropy of the system varies exclusively owing to thermodynamical processes in the object under study and is independent of its velocity relative to the observer in the laboratory reference frame [2]. As will be shown below, the law (20) agrees with the Planck statement. Further, the contraction of the heat and temperature tensors with the fundamental tensors transforms them to the vectors multiplied into scalar quantities. The latter are invariant parts of the above tensors that do not vary when passing from one reference frame to another. As to the vectors, their components are equal to unity when the moving system 4-velocity equals to zero, i.e.,

$$\mathrm{n} = \begin{pmatrix} 1 \\ 1 \\ 1 \\ i \end{pmatrix}, \qquad (21)$$

$$n^{'1} = \frac{n^{1} - \beta n^{4}}{\sqrt{1-\beta^{2}}}, n^{'2} = n^{2}, n^{'3} = n^{3}, n^{'4} = \frac{-\beta n^{1} + n^{4}}{\sqrt{1-\beta^{2}}}, \qquad (22)$$

where $i$ is imaginary unit; $\beta = v/c$,

Then the contraction in (20) of two vector quantities in indices $i$ gives a scalar quantity, which is invariant under the Lorentz transformations. As to heat and the temperature, their invariant parts vary exclusively owing to purely thermodynamic reasons. In turn, the vector components vary exclusively, when passing from one reference frame to another. In both cases either the heat or the temperature are inversely proportional to the quantity $\sqrt{1-\beta^{2}}$ . Then the entropy will not change in the absence of heat input into the system. The latter is in a full accord with the results obtained in works [13, 14, and 15] where the temperature was shown to transform under relativistic conditions in inverse proportion to the quantity $\sqrt{1-\beta^{2}}$ . Then we can represent the temperature in Minkowski space as

$$T^{i} = T^{i\alpha\beta} g_{\alpha\beta} = \mathrm{T} n^{i} = \mathrm{T}\,\mathrm{n}, \qquad (23),$$

where $\mathrm{T}$ is the invariant part of the tensor magnitude of rank 3, i.e., $T^{i\alpha\beta}$. In the real space formulae (20) and (23) remain unchanged with the only difference that, first, we now use affine tensors, second, the dependences (21) and (22) take the form:

$$\mathrm{n} = \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix}, \qquad (24)$$

$$n^{'1} = \frac{n^{1}}{\sqrt{1-\beta^{2}}}, n^{'2} = n^{2}, n^{'3} = n^{3} . \qquad (25)$$

At $v$=0 the spatial components of $T^{i}$ coincide in Euclidean space with the same components in Minkowski space.

In space-time the components of squared sum of the vector quantity $\mathrm{T}\,\mathrm{n}$ read

$$\mathrm{T}^2 n_x^2 + \mathrm{T}^2 n_y^2 + \mathrm{T}^2 n_z^2 = \mathrm{T}^2 n_\tau^2 = \mathrm{T}_x^2 + \mathrm{T}_y^2 + \mathrm{T}_z^2 = \mathrm{T}_\tau^2, \tag{26}$$

invariant in all inertial reference frames.
On the other hand the invariant of this sort gives in Euclidean space

$$\mathrm{T}^2 n^{'1} n_1^{'} + \mathrm{T}^2 n^{'2} n_2^{'} + \mathrm{T}^2 n^{'3} n_3^{'} =$$

$$= \mathrm{T}^2 n^1 n_1 + \mathrm{T}^2 n^2 n_2 + \mathrm{T}^2 n^3 n_3 = \mathrm{T}_x^2 + \mathrm{T}_y^2 + \mathrm{T}_z^2 = invar, \tag{27}$$

taking into consideration that $n_1^{'} n^{'1} = 1$ (affine tensors), i.e., the spatial part of the invariant connected with the temperature 4-tensor is completely identical to the invariant connected with the temperature 3-tensor. It is very important since it allows one to solve our problem directly in Euclidean space. As to the ultrarelativistic plasma considered in [11], the aforesaid will be valid in this case as well, which will be discussed below.

*c) Radiation Intensity Dependence vs. Temperature for a Moving Black Body*

Consider a black body moving uniformly and rectilinearly at angle θ=3π/2 with respect to the observer in the laboratory reference frame. Based on the aforesaid and on classical methods (*i.e.,*for $v << c$, see, e.g., [9, 16]) we can now begin its solution taking into consideration the follow. Now we use a cylindrical coordinate system and certain elementary normalizing volume in it. This volume contains two independent oscillators. The first oscillator is oriented parallel to axis 1. The second one is oriented perpendicularly to this axis. Then we can write an expression for the average total energy $\bar{\varepsilon}$ of the linear oscillators with quantum numbers $n_1 = n_2 = 1$ as follows (cylindrical space, zero oscillations are neglected):

$$\bar{\varepsilon} = \overline{(\varepsilon_1 + \varepsilon_2)} \overset{n_1, n_2 = 1}{=} \frac{\hbar(\omega_1 + \omega_2)}{\left(e^{\frac{\hbar\omega_1}{\theta_1}} - 1\right)\left(e^{\frac{\hbar\omega_2}{\theta_2}} - 1\right)}, \tag{28}$$

where $\omega_1$ and $\omega_2$ are the frequencies of oscillators in the direction perpendicular and parallel to the velocity of the moving object; $n_1$ and $n_2$ are positive (quantum) integers for the oscillators in the first and second directions. In this case $n_1 = n_2 = 1$, since photons are bosons, they can be in one quantum state; $T_1, T_2$ are the values of the temperature tensor components.

Obtaining the formula (28), we have used the law of the probability multiplying since the both oscillators are independent one another.

Then the average volume of the total energy $\bar{\varepsilon}$ of the electromagnetic field per unit volume in the moving cavity proves to equal

$$\bar{\varepsilon} = \frac{E_0}{V_0(1-\beta^2)} = \frac{2\hbar}{(2\pi)^2 c^3} \int_0^\infty \frac{\omega_1^2 d\omega_1}{\left(e^{\frac{\hbar\omega_1}{\theta_1}} - 1\right)} \int_0^\infty \frac{d\omega_2}{\left(e^{\frac{\hbar\omega_2}{\theta_2}} - 1\right)} + \frac{2\hbar}{(2\pi)^2 c^3} \int_0^\infty \frac{\omega_1 d\omega_1}{\left(e^{\frac{\hbar\omega_1}{\theta_1}} - 1\right)} \int_0^\infty \frac{\omega_2 d\omega_2}{\left(e^{\frac{\hbar\omega_2}{\theta_2}} - 1\right)}. \tag{29}$$

As a result, we have obtained, in fact, four improper integrals, three of them converge. The last two integrals in (29) differ only by variables. They are easily calculated using variable transformations as follows:

$$y_{1(2)} = \frac{\hbar\omega_{1(2)}}{\theta_{1(2)}} = \frac{\hbar\omega_{1(2)}}{kT_{1(2)}}, \tag{30}$$

$$I_1 = \frac{2\hbar}{(2\pi)^2 c^3} \int_0^\infty \frac{\omega_1 d\omega_1}{\left(e^{\frac{\hbar\omega_1}{\theta_1}} - 1\right)} \int_0^\infty \frac{\omega_2 d\omega_2}{\left(e^{\frac{\hbar\omega_2}{\theta_2}} - 1\right)} = \frac{2\theta_1^2\theta_2^2}{(2\pi)^2 \hbar^3 c^3} \int_0^\infty \frac{y_1 dy_1}{(e^{y_1} - 1)} \int_0^\infty \frac{y_2 dy_2}{(e^{y_2} - 1)} =$$

$$= \frac{2\theta_1^2\theta_2^2}{(2\pi)^2 \hbar^3 c^3} \cdot \frac{\pi^4}{36} = \frac{k^4 \pi^2 T_1^2 T_2^2}{72\hbar^3 c^3} = 0.208 a T_1^2 T_2^2, \tag{31}$$

where *a* is the Stefan-Boltzmann constant, i.e.,

$$a = \frac{k^4 \pi^2}{15\hbar^3 c^3} . \quad (32)$$

$$I_2 = \frac{2\hbar}{(2\pi)^2 c^3} \int_0^\infty \frac{\omega_1^2 d\omega_1}{\left(e^{\frac{\hbar\omega_1}{\theta_1}} - 1\right)} \int_0^\infty \frac{d\omega_2}{\left(e^{\frac{\hbar\omega_2}{\theta_2}} - 1\right)} = \frac{2\hbar}{(2\pi)^2 c^3} I_2^{'} I_2^{''}, \quad (33)$$

$$I_2^{'} = \int_0^\infty \frac{\omega_1^2 d\omega_1}{\left(e^{\frac{\hbar\omega_1}{\theta_1}} - 1\right)} = \frac{\theta_1^3}{\hbar^3} \int_0^\infty \frac{y_1^2 dy_1}{\left(e^{y_1} - 1\right)} = \frac{\theta_1^3}{\hbar^3} \Gamma(z)\zeta(z) = \frac{\theta_1^3}{\hbar^3} \cdot 2 \cdot 1.5498 \approx 3.1 \frac{\theta_1^3}{\hbar^3}, \quad (34)$$

where $\Gamma(z)$ is the gamma function [17] ,

$$\zeta(z) = \sum_{k=1}^\infty \frac{1}{K^z} = 1 + \frac{1}{4} + \frac{1}{9} + \frac{1}{16} + \ldots \approx 1{,}5498; \; \Gamma(z+1) = \Gamma(z); \Gamma(1) = \Gamma(2) = 1.$$

$$I_2^{''} = \int_0^\infty \frac{d\omega_2}{\left(e^{\frac{\hbar\omega_2}{\theta_2}} - 1\right)} = \frac{\theta_2}{\hbar} \int_0^\infty \frac{dy_2}{\left(e^{y_2} - 1\right)} = \frac{\theta_2}{\hbar} \left[-y + \ln\left(-1 + e^y\right)\right]_{y=0}^{y\to\infty} . \quad (35)$$

As seen, the integral (35) is integrated by quadratures but it divergences within the interval $0 - \infty$, namely,

$$I_2^{''} = \frac{k|T|}{\hbar} \left[-y + \ln\left(-1 + e^y\right)\right]_{y=0}^{y\to\infty} \to \infty , \; y = \frac{\hbar\omega_2}{k|T|}, \quad (36)$$

however, we can overcome the difficulties that have arisen. Indeed, we obtain the infinity for zero in the bottom limit of the integral (35). But we can take a number $\vartheta$ in the bottom limit of (35) instead zero. The number has to be very close to zero at a given temperature taking into account of the energy, by which we neglect. It must be much less than the whole energy radiated by the black body in this direction, i.e.,

$$\vartheta << \left[-y + \ln\left(-1 + e^y\right)\right]_{y=\vartheta}^{y\to\infty} . \quad (37)$$

Here we should note that a conscious inaccuracy was made in the classical method of obtaining Stefan-Boltzmann's law. As known, according to this method, the integration takes place in the space of positive (quantum) integers. But they form a continuum for large values. If the integers are small, there is a discrete series, and we cannot formally integrate. If nevertheless we are doing that, we have:

$$I_2^{''} = \int_\vartheta^\infty \frac{d\omega}{\left(e^{\frac{\hbar\omega}{k|T|}} - 1\right)} = \frac{k|T|}{\hbar} \int_\vartheta^\infty \frac{dy}{\left(e^y - 1\right)} = \frac{k|T|}{\hbar} \left[-y + \ln\left(-1 + e^y\right)\right]_{y=\vartheta}^{y\to\infty} = \Lambda \frac{k|T|}{\hbar} . \quad (38)$$

As a result, we have for $I_2$:

$$I_2 \approx \frac{2\hbar}{(2\pi)^2 c^3} I_2^{'} I_2^{''} = 3.1 \frac{2\theta_1^3 \theta_2}{(2\pi)^2 \hbar^3 c^3} = 0.238 \Lambda a T_1^3 T_2 , \quad (39)$$

and

$$\varepsilon = \frac{E_0}{V\left(1-\beta^2\right)} = 0.208aT_1^2T_2^2 + 0.238\Lambda aT_1^3T_2 \ . \quad (40)$$

If the velocity $v$=0, we have from (40):

$$\varepsilon_0 = aT_0^4\left(0.208 + 0.238\Lambda\right) \ , \quad (41)$$

but after this condition we must have 0,208 + 0,238 $\Lambda = 1$ according to Stefan-Boltzmann's law. Then $\Lambda = 3.33$ and

$$\varepsilon = \frac{E_0}{V_0\left(1-\beta^2\right)} = 0.208aT_1^2T_2^2 + 0.792T_1^3T_2 = 0.208T_{(0)1}^2\frac{T_{(0)2}^2}{1-\beta^2} + 0.792T_{(0)1}^3\frac{T_{(0)2}}{\sqrt{1-\beta^2}} \quad (42)$$

for the energy density of radiation under relativistic conditions.

Now we show that the condition (37) is met, i.e., that quantity $\vartheta$ is near to zero and much less than $\left[-y+\ln\left(-1+e^y\right)\right]_{y=\vartheta}^{y\to\infty}$.

First, we should solve a transcendent equation

$$\Lambda = 7.22 = \vartheta - \ln\left(-1+e^{\vartheta}\right), \quad (43)$$

its solution (see Appendix below) is:

$$\vartheta = -\ln(1-e^{-\Lambda}) \ . \quad (44)$$

and $\vartheta \approx 0.0416 << 3.33.$ As we see, condition (37) is full met.

## III. Discussion

It should be noted at once that the dependence (42) does not lead to the point of absurdity and contradictions. The dependence (42) provides rather a probable answer to the question concerning the temperature transformation under relativistic conditions. It is evident that the dependence (1) is incorrect and would be rejected many years ago and without all mathematical involvements if it were not a giant authority of Planck and Einstein. Really, how is the dependence (1) be followed if such cosmic objects as quasars do exist, whose velocity *v* of motion can be equal 0,93c with the luminosity reaching enormous values? The first principle of thermodynamics leads to the point of absurdity under relativistic conditions if one considers that the temperature of the object under study varies with proportion to $\sqrt{1-\frac{v^2}{c^2}}$ as $v \to c$. Indeed, in order to obtain the Lorentz transformation from the first principle of thermodynamics we have to express the heat throw the temperature, i.e., $dQ = TdS$ or $dQ = SdT$. The entropy is a Lorentz invariant, i.e., $S = S_0$. If we did not input the heat in the studied system accelerating it up to speed *v*, then $TdS = 0$ and the quantity *T* disappears from the equation. Only the term $SdT$. gives us the result; it is $T = T_0/\sqrt{1-\beta^2}$. However, e.g., Einstein [8], uses the expression $Q = Q_0\sqrt{1-\beta^2}$ and it means that $T = T_0\sqrt{1-\beta^2}. \neq 0$ as $S = S_0$. It is a nonsense.

In the most general case the temperature is a complex mathematical object. It comprises an invariant part independent of the motion velocity and a part dependent on the velocity and oriented in space. Under normal conditions the temperature becomes a scalar, the same does for the heat. The entropy problem has not been studied completely. It is not improbable that the entropy can be a tensor object in which indices are contracted which results in a scalar independent of the system motion velocity. Evidently, it is for experiment to solve this problem. However no experiment has been performed since the birth of relativistic thermodynamics in 1907. Of course, the law (20) requires justification at the molecular level, however it is other problem.

Having obtained the above results, we can now make important conclusions concerning relativistic thermodynamics as a whole. First of all, they concern a relativistic temperature *T*. Taking into consideration the above results and results obtained in [3, 13-15, 18 - 23], we can now contend with a high degree of probability:

only the dependence of the kind $T \sim 1/\sqrt{1-\beta^2}$ provides a possibility of obtaining a consistent relativistic thermodynamics, which is correct over the entire interval 0 – *c* of the motion velocities of the object under study. As a proof of this argument we represent all fundamental thermodynamical parameters and dependences (as already known and obtained recently) containing them. There is the temperature in these parameters and dependences. It varies in inverse proportion to $\sqrt{1-\beta^2}$ .

1. The average value of kinetic energy of the molecule (atom) translational motion:

$$\bar{\varepsilon} = \frac{3}{2}kT . \quad (45)$$

Evidently, the dependence (45) is correct over the entire interval of object motion velocities if the temperature varies in inverse proportion to $\sqrt{1-\beta^2}$ .

2. The equation of state of perfect gases [13, 20]:

$$\frac{pV}{1-\beta^2} = NkT , \quad (46)$$

naturally, for the observer in the laboratory reference frame; the pressure *p* is Lorentz invariant; the volume of gas $V = V_0\sqrt{1-\beta^2}$ .

3. The equations of state for the interface separating a pure liquid and its vapours [13, 20].

The equations are valid over the entire interval 0 – v of the object velocities if $T = T_0/\sqrt{1-\beta^2}$ ; besides, the surface tension is Lorentz invariant like the pressure.

4. The thermodynamic potentials (internal energy, enthalpy, free energy, free enthalpy) including their specific (J/cm$^2$) values [15]

Dependences obtained are correct on the entire velocity interval 0–v if $T = T_0/\sqrt{1-\beta^2}$ ; the dependences are not contradictory and absurdity. A similar result is obtained for the chemical potential (including its specific values), i.e., $\mu \sim 1/\sqrt{1-\beta^2}$ [23, 24].

As known, the chemical potential of photon gas equals to zero. This fact does not contradict the latter relation. Indeed, write down it as

$$\mu_i(x, y, z) = const/\sqrt{1-\beta^2} ,$$

*const*=zero for the photon gas. As $v \to c$ the root in the relation tends to zero, however 0/0 in the right-hand-side of the relation will be equal to zero because the root only tends to zero but const equals zero by definition.

5. Small fluctuations of volume, microparticles, temperature [22].

The dependences obtained are valid for intervals of object velocities where fluctuations are small. If the temperature in the formulae obtained varies in inverse proportion to $\sqrt{1-\beta^2}$ , we do not come to any contradictions or absurdity.

6. The theory of the charge transfer according to H.Ott and E.V.Veitsman[3, 25].

The theory is correct under relativistic conditions if only the object temperature varies in inverse proportion to $\sqrt{1-\beta^2}$ .

7. A closed thermodynamical cycle and the well-known thermodynamical principles as follows

$$\oint \delta E = 0 ,$$

$$\oint \delta S = \oint \frac{\delta Q}{T} = 0 ,$$

are correct if $T = T_0/\sqrt{1-\beta^2}$ [3, 22].

8. The radiation energy and momentum vary in the range 0 – *c* inverse proportional to $\sqrt{1-\beta^2}$ , i.e., as $T = T_0/\sqrt{1-\beta^2}$ [3].

9. Chemical reaction rates *w*, e.g.,

$$w = \frac{1}{\nu_A}\frac{d[\mathrm{A}]}{dt} = aA_r = (aRT)\frac{A}{RT} = a_1A_1 ,$$

vary over the interval 0 – *c* inverse proportional to $\sqrt{1-\beta^2}$ , i.e., as $T = T_0/\sqrt{1-\beta^2}$ [23]. Here $\nu_A$ is the stoichiometric coefficients of the substance A; $A_r$ is the affinity according to De Donde; *a* is a phenomenological coefficient.

We cannot obtain a consistent aggregate of the thermodynamic parameters and dependences containing the parameters under Lorentz transformation if $T = T_0$ and $T = T_0\sqrt{1-\beta^2}$. What is more, we sometimes come to contradictions with special relativity and the first principle of thermodynamics using these relations, e.g., $T = T_0$ (see below). As to the theories where the latter temperature transformations are used for a specific process, and contradictions are absent at first sight, so we again come to absurdity but in a implicit form. For example, Clapeyron's equation $pV = NkT$ is quite formally correct under relativistic conditions even if the gas temperature varies according to Planck, however at the same time formula (45) describing the energy of the molecule (atom) translational moving is correct under the relativistic conditions if the temperature of the object transforms only following Ott's theory. The other variants are absent here. However this dependence and Clapeyron's equation treat the same division of physics – thermodynamics of gases and vapours. But if in the framework of this division of physics the temperature of the system may transform under relativistic conditions otherwise, then it is nonsense.

Take, e.g., the equality $T=T_0$ $(T=T')$. As known, the temperature of gases or liquids depends on the velocities $w$ their molecules (atoms) relatively the mass centre of the system under study. Let us be an observer in the laboratory references frame (see above, Fig,1). He is observing the microparticle velocities relatively the mass centre of a moving system containing a gas. The velocity components are equal according to SR:

$$w_1 = \frac{w_1' + v}{1 + \frac{v w_1'}{c^2}},$$

$$w_2 = \frac{w_2'\sqrt{1-\beta^2}}{1 + \frac{v w_1'}{c^2}},$$

$$w_3 = \frac{w_3'\sqrt{1-\beta^2}}{1 + \frac{v w_1'}{c^2}}.$$

As we see, the velocity $w$ has to vary at transition from one reference frame to another one. The equality $T=T_0$ contradicts to SR. It contradicts also the first principle of thermodynamics. Indeed, according to Callen and Horwitz [4] enthalpy $H$, chemical potential $\mu$ and temperature $T$ are the Lorentz-invariants. However, then we will be at a deadlock because according to the Gibbs' equation (it follows from the first principle of thermodynamics)

$$T = \left(\frac{\partial H}{\partial S}\right)_{p,N}; \mu = \left(\frac{\partial H}{\partial N}\right)_{S,p}, \qquad (47)$$

where $S$ is the entropy, $p$ is the pressure and $N$ is the number of microparticles in the system. Going from one referee frame to other one, we obtain in (47) 0/0, i.e., indeterminate forms which we cannot evaluate.

Of utmost interest is to consider if the dependence (20) remains valid for the case of an ultrarelativistic high-temperature spherical plasma (fireball) [11]. According to the author of [11], the spectrum of its equilibrium radiation $d\varepsilon_\gamma(\omega_*)$ (J/cc) due to the annihilation of electrons and positrons is described by the dependence

$$d\varepsilon_\gamma(\omega_*) = \frac{T^4}{\pi^2\hbar^3 c^3}\frac{\omega_*^2\sqrt{\omega_*^2 - \Delta^2 f}}{e^{\omega_*}-1}d\omega_*, \qquad (48)$$

in the fireball, where $\omega_* = \hbar\omega/T$ is the dimensionless frequency; $T>>mc^2$ is the energy, i.e., apparently, $\theta = kT$ ($k$ is the Boltzmann constant, $T$ is now the absolute temperature; $\theta$ not to be confused with the angle similarly designated (see above); $\Delta = \hbar\omega_{p,rel}/T$; $\omega_{p,rel}$ is the relativistic frequency of the plasma oscillations; $f$ is a dimensionless constant.

Formula (20) is valid for the case (48) with the vector part of the temperature dependent on the total velocity of electrons and positrons in the fireball but not on the velocity of its centre of mass. If their velocities are very high, then we have the well-known case described, e.g., in [10]. This is the case of a system of particles being widely apart and moving with very high velocities. It should be noted that these two cases are not fully identical, since the microparticles in [10] are not identical before and after the collision. In article [11], an electron-positron collision results in their annihilation. However these cases are very similar, thus the system energy $\varepsilon$ may be given as

$$\varepsilon \sim \sum \frac{m_i c^2}{\sqrt{1-\frac{v_i^2}{c^2}}}, \qquad (49)$$

where $m_i$ is the microperticle mass, $v_i$ is its velocity.

Then the vector part of the temperature in the ultrarelativistic case will transform in inverse proportion of the roots $\sqrt{1-v_i^2/c^2}$. Here we immediately arrive at the conclusion that the dependence (48) is very doubtful, since the right side does not transform identically to its left side under the relativistic conditions. It should be also noted that the object studied in [11] is, in fact, a stable fireball. Evidently, when the density of electrons and positrons exceeds a certain limit, the stability will be broken, and an explosion will occur.

## IV. Conclusions

Law was obtained for the black-body radiation in the whole interval of its (black-body) movement speed, i.e., from zero up to the speed of light in vacuum. This law is a special case when an angle $\theta$ between the movement velocity of the object under study and the observer is equal to zero. When the black-body speed is zero we obtain Stefan-Boltzmann law; when the black body speed tends to the speed og light in vacuum we do not come to absurdity and contradictions.

*Appendix. Obtaining the solution of (44).*
We have from (43)

$$\ln e^{\vartheta} - \ln\left(-1 + e^{\vartheta}\right) = \ln e^{\Lambda}, \qquad (50)$$

$$\ln\left[\frac{e^{\vartheta}}{-1 + e^{\vartheta}}\right] = \ln e^{\Lambda}, \qquad (51)$$

$$\left[\frac{e^{\vartheta}}{-1 + e^{\vartheta}}\right] = e^{\Lambda}, \qquad (52)$$

$$e^{-\Lambda} e^{\vartheta} = -1 + e^{\vartheta}, \qquad (53)$$

$$(e^{-\Lambda} e^{\vartheta} - e^{\vartheta}) = -1, \qquad (54)$$

$$e^{\vartheta}\left(e^{-\Lambda} - 1\right) = -1, \qquad (55)$$

and finally

$$\vartheta = \ln\left(-\frac{1}{e^{-\Lambda} - 1}\right) = \ln\left(\frac{1}{1 - e^{-\Lambda}}\right) = -\ln(1 - e^{-\Lambda}), \quad \text{i. e., (44).}$$

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# The New View at the Physics of the Planet Earth

By Danilov Vladimir Igorevich

*Technical University (MADI)*

*Annotation-* In this article, a solution is proposed for several questions that have been facing modern Earth Science for a long time.

The questions of Earth's magnetic field physics, mountain formation, oceanic currents, tides, earthquakes, geodynamics and other natural phenomena caused by the influence of external gravitational forces are considered. A different view of the underlying physics allows for an easy and well-argued explanation of many natural phenomena, making it understandable even to unprepared readers. This view, when applied to other planets, can help in explaining other phenomena in the Solar System.

It is hoped that the scientific community will adopt this new explanation as a tool for further investigation of nature. Any constructive criticism on the topic is welcome.

*Keywords: geotectonics, mountain building, planetary magnetic field, ocean currents, tides, satellite movement.*

*GJSFR-A Classification: DDC Code: 785.8 LCC Code: M1003*

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*Strictly as per the compliance and regulations of:*

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*Note:* As this article was being written, the sad news came of the passing of Seiya Uyeda on January 19, 2023 at the age of 93. Seiya Uyeda was a member of the Japanese Academy of Sciences, a professor at Tokyo and Tokai Universities, a foreign member of the academies of sciences of various countries, including the Russian Academy of Sciences. His scientific interests included the magnetism of rocks, heat flows on oceans and land, plate tectonics, dynamics of subduction zones, etc.

## I. Introduction

This article is written under the impression of reading Seiya Uyeda's (上田誠也) book "The New View of the Earth. Moving Continents and Moving Oceans".

A wonderful book where, in simple Japanese, ordinary words, without cluttering the text with elaborate expressions and a multitude of mathematical formulas, without introducing unclear, rather unrealistic, assumptions, the author spoke about the process of understanding the structure of our planet. He approached the material being considered very critically, indicating not only accepted facts, but also contradictions. He argued the unsoundness of some hypotheses, but in others, he did not notice any obvious distortions of reality.

Although the result of the research conducted by him was an increase in the number of questions rather than found answers, this work determined the main circle of issues that should be given attention to understand the physics of processes occurring on the planet. As they say, "Correctly posed questions are already half the way to a solution».

The goal of this article will not only be to answer the questions raised in the book, but also to add others, explain them, and also bring them together into a single mechanism that controls the majority of processes happening on the planet and that can be applied to any Earth-like planet.

Like in the book of Uyeda, the article will not contain formulas or unverified numbers. All evidence is presented in the form of measurement results that visually show the behavior of the parameters being considered, and in the form of graphs. Also, natural phenomena that can be observed should and can serve as evidence. They can be considered as the results of experiments set by nature. The combination of these phenomena provides a basis for the assertion of the validity of the proposed approach to the physics of the planet.

Since the book is quite large in volume and there is no possibility, or need, to transfer all of the interesting information in it, we will only quote the specific tasks or puzzles in it that require an answer.

The main natural phenomena, according to Uyeda and his predecessors, that are subject to consideration and resolution are: "Some Unsolved Problems in Geophysics" written by JI. G. Adams, President of the American Geophysical Union, in 1947, and in it, the following six problems were listed:

1. Origin of mountain systems;
2. Origin of geosynclines (deep basins filled with deposits);
3. Causes of volcanic eruptions and other magmatic processes;
4. Causes of deep-focus earthquakes;
5. Origin of Earth's magnetic field;
6. Temperatures prevailing in the Earth's depths.

Although the listed problems were not the only pressing issues, they were indeed of great importance. Furthermore, none of them has been fully resolved to this day; all of them remain as pressing as ever.
Page 9, Uyeda [1].

Following is the question of mobilism, that is, the movement of continents- what and how does it drive them to move? The hypothesis of movement from the process of cooling of the internal mass is shown to be insufficient.

This ends the list of questions in the book.

Allow me to add more to this list:

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How is the mass distributed inside the planet?

How is the high temperature inside the planet maintained? (almost a repetition of the 6th question from the book)

The shape of the Earth geoid- why?

What forces drive the movement of ocean waters, creating the main ocean currents?

How to explain the behavior of water tides in the ocean?

What forces drive the air masses reaching stratosphere heights?

"Killer waves"- the reason for their appearance?

Since the laws of physics apply to other planets as well, it's probably appropriate to add another question to these issues- the behavior of the Moon. Why does it and many other planet's moons rotate around their axis as they orbit their planet? Although these questions appear to be from different fields of knowledge and involve different phenomena and even planets, as will be shown below, they are united by one force, or rather, its manifestation. This is the external force of gravity acting on the internal mass of the planet, leading to the phenomena mentioned above. Of course, not all problems explained by the proposed mechanism of planetary interaction are addressed. Some can be seen in the article [18], where more data from measurements and observed facts are presented.

Let's consider the principle of nature study set by Newton: "I do not invent hypotheses. Everything that cannot be deduced from phenomena should be called a hypothesis; but metaphysical, physical, mechanical, and hidden properties have no place in experimental philosophy».

All the laws he derived are real and still work today. He also said, «…Either don't report anything new or have to spend all your energy defending your discovery».

We will answer all the questions asked, though it may not be in order. The first and main one will be the distribution and movement of matter inside the planet. All the others will be additional confirmations of the first, as they are manifestations of it. Additionally, I would like to mention the excellent book by O.N. Korotsev, "Astronomy," which gave a lot of insight into what is happening on the planets.

*Accepted but not real.*

It is necessary to immediately say about those postulates that are now accepted by some, but in reality have no place to be:

- "Coriolis force" - this force does not actually exist. It is a hypothetical "force" introduced to describe the behavior of a body when transitioning from different observation systems. There is no source of this force in nature. It does not move or act on anything.
- Satellites do not fall or miss their planets. They move in orbits where the centripetal forces are equal to the gravitational (attractive) forces. There is no free fall with acceleration, and therefore tidal effects can be observed.
- Convection inside a planet. Convection cannot exist within a planet's body. Often, the example of a heating teapot is used to describe convection, but a planet is not a teapot, it is more like a thermos. And in a thermos there can be no convection- once the temperature is distributed, it will not change this distribution if there are no external influences. Of course, this is without taking into account minor, insignificant losses. If the planet is not heated by the Sun, then the temperature on the surface will drop to minus, which means that internal heating of the planet is very small.

In Uyeda's book, the question of convection is given a lot of space- from pages 171 to 190. Many options are considered, even up to convection in the mantle!!! The result was such a statement: "There is no need to say that the problem has not been finally solved by us. A whole series of scientists continues to work on it and at present time».

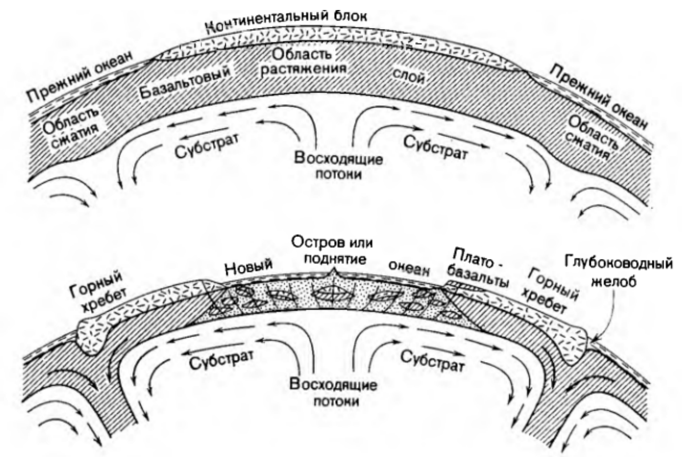



Рис. 1-14. Модель конвекции в мантии как возможного механизма континентального дрейфа [24].

Показано растаскивание континента восходящими мантийными потоками и образование нового океана в результате разрастания рифта. В районе нисходящего потока образуется горный хребет, а рядом с ним — глубоководный желоб.

Drawing from the Uyeda book

Such drawings do not reflect reality - rising streams will not cool down without cooling. The ocean does not boil, does not receive heat, and the temperature difference on the surface of the planet and under the crust exceeds 3000 degrees Celsius. There is no active heat transfer. A thermos, in fact a very good one, has been working for many centuries.

These streams explain the generation of the planet's magnetic field, these streams explain tectonic movements and much more.

Taking the hypothesis of convection as a working one and building theories on this basis, scientists are far from reality, replacing them with fantasies. Reality, at least on the example of a kettle, says that the kettle, in the end, boils and there is no convection in it, there is a fierce mixing with one temperature throughout the volume. For reference, the boiling temperature of iron and silicon is only 2800 degrees Celsius.

Additionally, it is worth noting that convection requires a constant inflow of energy. It follows that there must be a perpetual, inexhaustible source of heat inside! The reality observed on the planet does not provide examples of this. Based on what has been said, it must be considered that everything underlying this hypothesis is definitely false (see Newton's law).

- It is doubtful to consider nuclear reaction (radiogenic hypothesis) as a source of maintaining high temperature inside the planet for the following reasons: the lava flowing from volcanoes is less radioactive compared to, for example, the radiation from an atomic power plant reactor. Also, the concentration of radioactive elements is very low in the overall mass of the planet. Most of them have a short half-life.
- The inflow of water into the ocean does not correspond, or even contradicts, the inflow (bulge) of the Earth's crust.

## II. Distribution of Mass within a Planet's Body

Based on the previously mentioned Newton's principle, let's see what "phenomenon" can be taken as a prototype of the planet. A very suitable for this is the well-known spherical aquarium. It is filled with water and various materials with different specific weight - sand, stones, plastic toys, fish, feed, etc. As they are distributed, everyone knows. If you tilt it, a shift will occur, and if you rotate it, a constant movement directed towards the Earth by the heavy mass will occur. The aquarium is in a constant gravitational field of the Earth, similarly the Earth is in the attraction field of the Sun. And the Earth is such an aquarium relative to it. And the distribution will be similar - closer to the Sun, heavy masses, the lightest on the opposite side. Now if we imagine that the walls of the aquarium are made of soft, rubber-like material, we can simulate the behaviour of the Earth's crust under the action of the attraction forces of the Sun. If we add water to an inflated air balloon, we will get a visual representation of the behaviour of the Earth's crust - "hump" and its movement upon rotating the balloon.

It should be noted that the planet is in a nearly equipotential field of the Sun, meaning that any part of it is attracted to it equally. The distance to the Sun is immeasurably larger than any distance on the planet.

The only significant difference between these two vessels is that the weak gravitational forces of the mass located inside the aquarium do not affect its distribution, or rather do not show themselves, while large masses of the planet can redistribute it.

Inside the planet, if considered separately from external forces, the total gravitational attraction vector at any point is directed towards the center, and the value of the force decreases to zero at the center where the bi-directional attraction from the peripheral masses is compensated.

If external gravitational forces are absent, the heavy components of the planet's matter will strive to sink into the central region, driving the lighter ones closer to the surface.

Therefore, the regions where denser masses can accumulate are located in the center of the planet and closest to the external source of gravity and the inner side of the crust.

Since the main external sources are two - the Sun- distant but powerful, and the Moon- much less massive but close, then there are three places of accumulation of heavy masses. Two of them are very dynamic, and the central one should be subject to oscillation and may even follow the first two. It is currently impossible to determine. Measurements based on single seismic waves cannot reflect the real picture due to the speed of events. Perhaps additional measurements of gravitational forces will be required. In our case, to describe the phenomena on the surface, it does not play a decisive role. For simplicity of description, let's assume that it moves. Let's call it the heavy part of the planet's core.

Let's consider the gravitational forces from which masses affect the readings of the gravimeter sensor. (Fig. 1.)

- Fз is the constant force of attraction of a planet's stationary mass.
- Fл is the variable force of attraction of the Moon.
- Fя1 is the variable force of attraction from the mass of the core attracted by the Moon.
- Fя2 is the variable force of attraction from the mass of the core attracted by the Sun.
- Fc is the variable force of attraction of the Sun.

At the same time, Fя1 and Fя2 depend on the values of Fc and Fл, as well as on the position of the Sun and the Moon relative to each other and to the Earth. In addition, the data measurements are affected by the location of the masses attracted by the Sun and the Moon, as the projections on the vertical are measured, and the same mass located directly under the sensor will show a higher value than one at the same distance but at an angle.

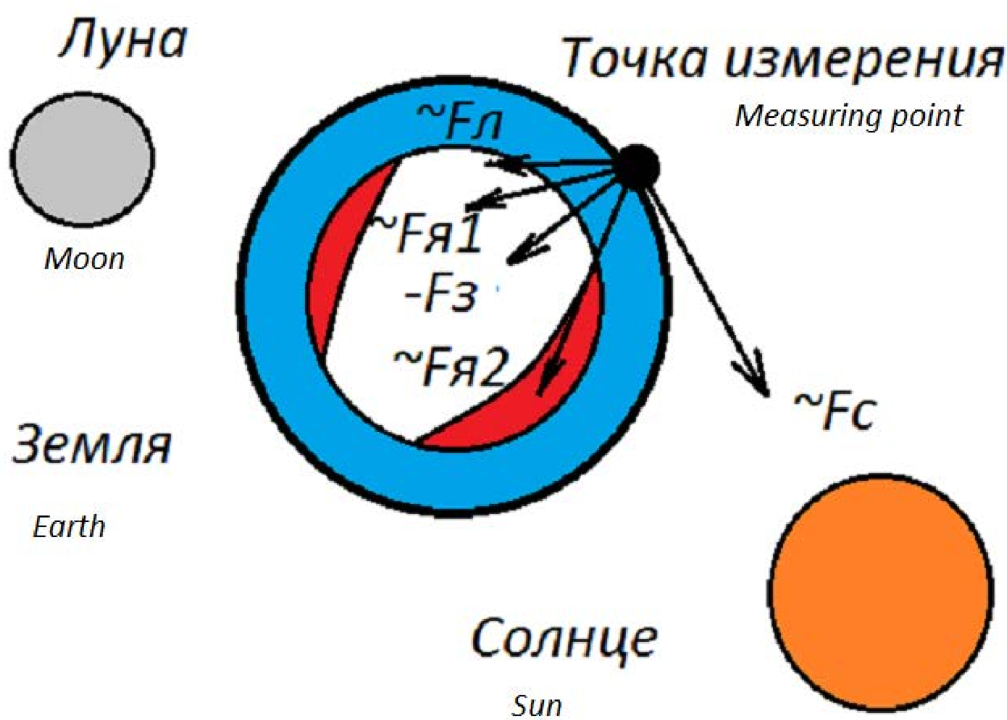
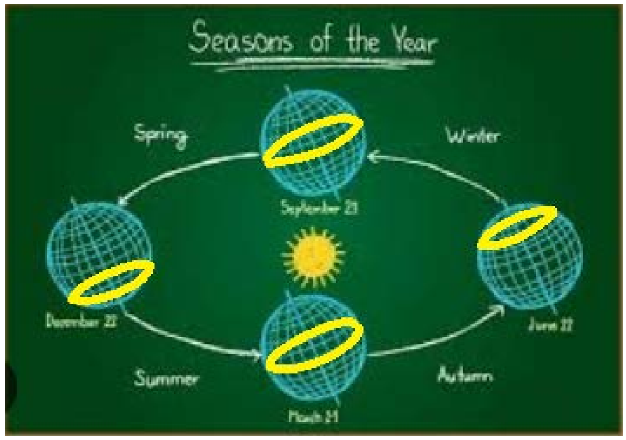



*Fig. 1:* Schematic diagram of forces composing the readings of the gravimeter

*a) Seasonal shifts in the trajectory of the core movement*

In reality, the heavy part of the core moves from East to West and in a spiral North-South and back, with a change in the planet's position relative to the Sun (change of season). (Fig. 2)



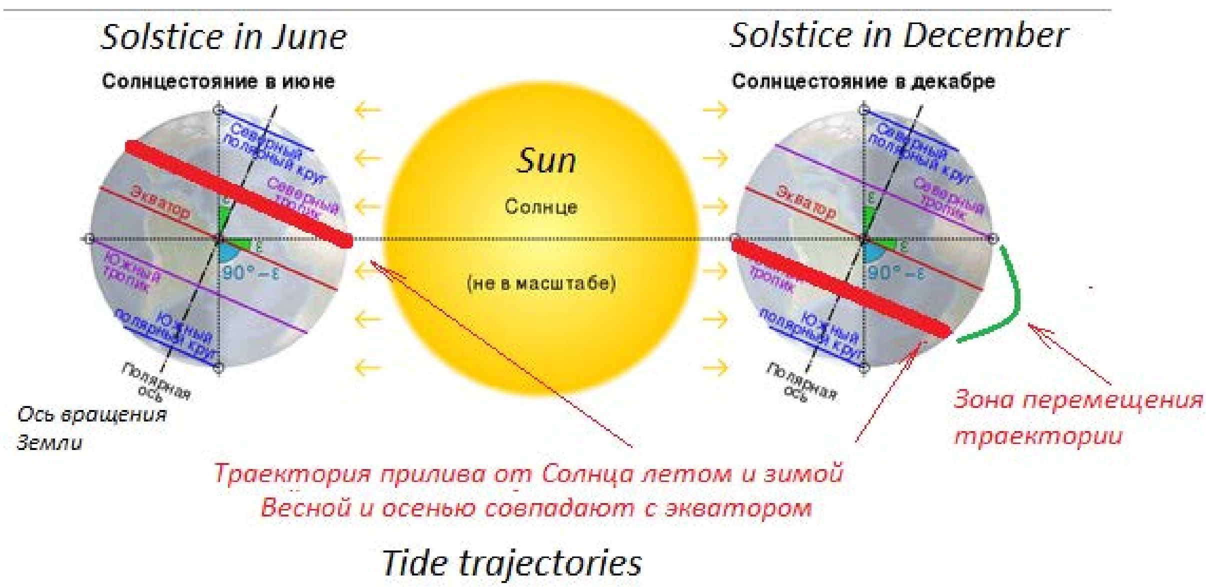
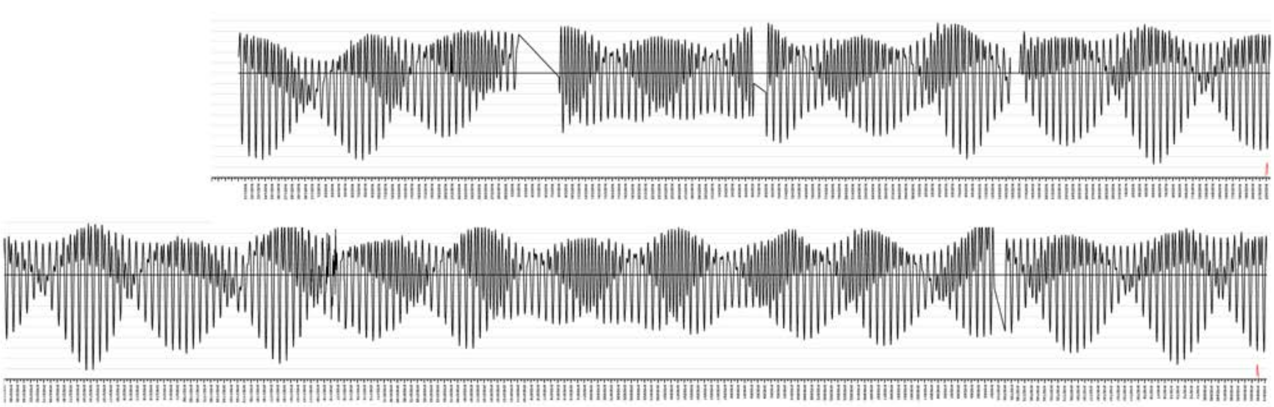




*Fig. 2:* Seasonal changes in the trajectory of the heavy part of the nucleus

*b) Analysis of the results of gravity force measurements*

The study of the behaviour of gravitational forces, presented by employees of the DVO RAN laboratory, some of which are presented in work [7], and combined with their positions of the Sun and Moon, calculated at the same time and tied to the station's location, confirms the mechanism of the behaviour of the planet's internal masses previously discussed using the aquarium as an example.



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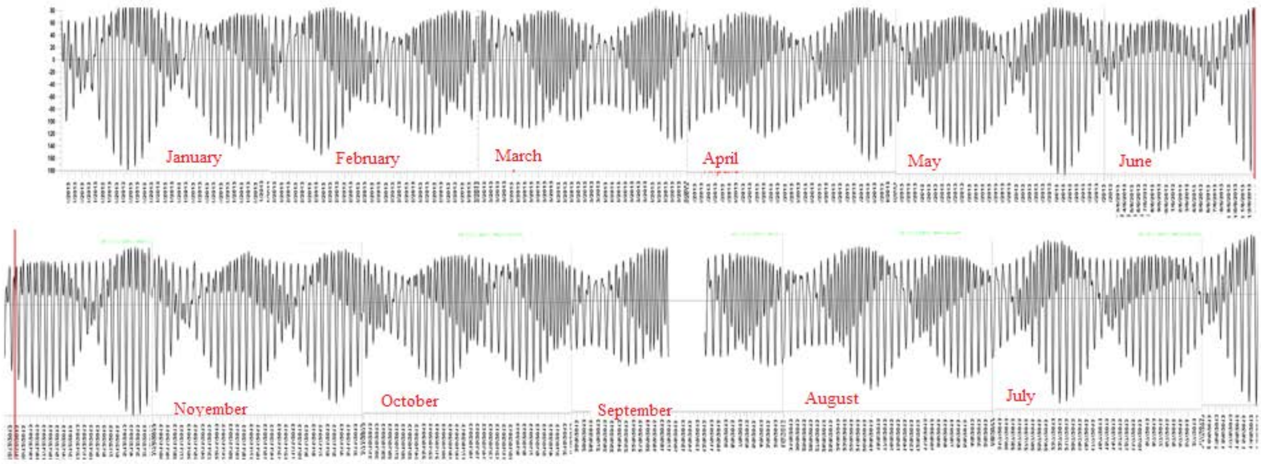


*Fig. 3:* Gravitational force behavior before June 22nd, 2016 (upper), 2013 (lower), and its mirror reflection after. Coast area of the Sea of Japan

The changes in the trajectory of the heavy core's movement are clearly shown in the gravity charts for the year (Fig. 3).

It is very well seen that there is almost a perfect match between the values before June 22nd and its mirror reflection after. This means that after the day of solar opposition, the mass inside the planet with the same daily and monthly dependence returns to the Southern Hemisphere, where, after reaching the maximum distance on December 22nd, it begins to move back. And so on, forever. Movement without end. (Fig. 2).

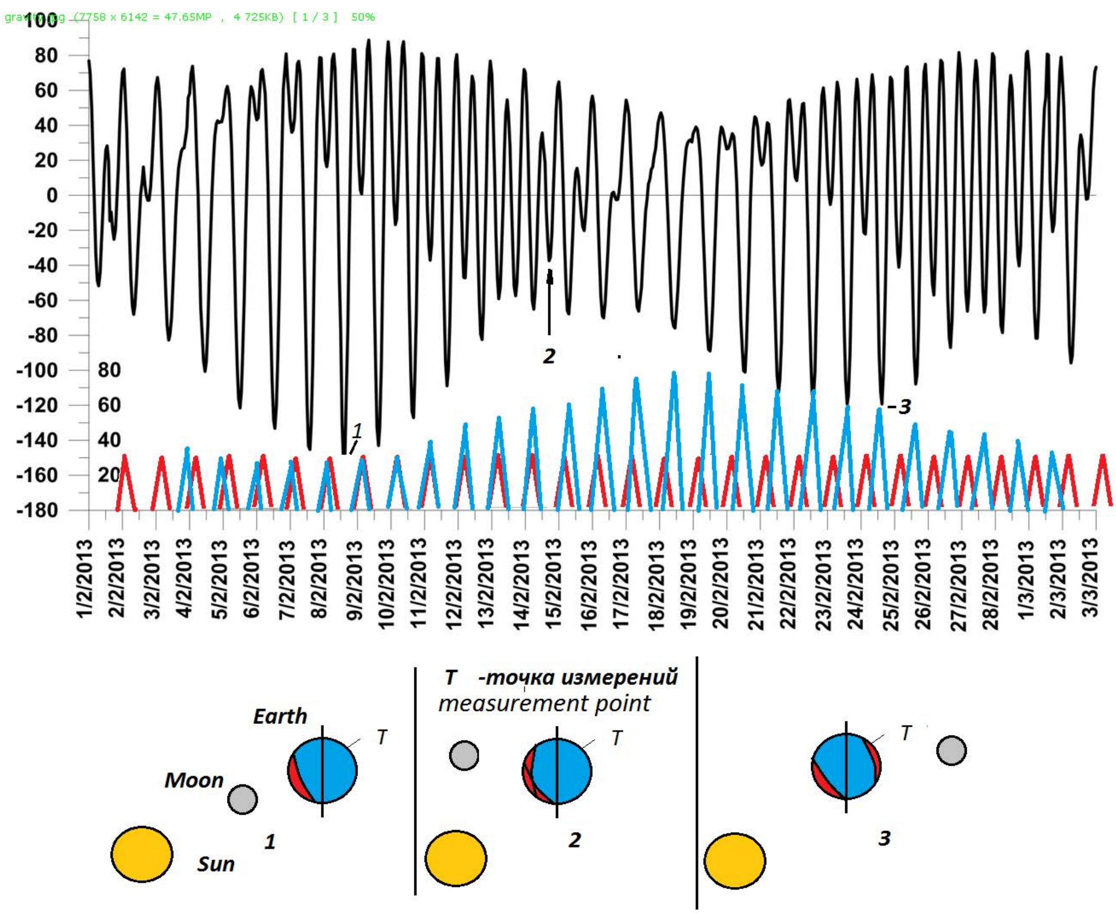


*Fig. 4:* The graph of the forces of attraction and a hypothetical illustration of the positions of the planets for the selected minimum values that occur during nighttime. February 2013. The Sun is indicated in red and the Moon in blue- sunrise, zenith, sunset

The graphs also show a decrease in amplitude in the spring and autumn months.

If we assume there is no movement of the core, then in the winter, when the Sun and Moon rise the lowest above the horizon, the change in gravitational forces should be of the lowest amplitude. But the measured values indicate otherwise. The increase in amplitude of the signal is caused by the approach and removal of the planet's internal mass.

The heavy part of the core can move away from the measurement point by a significant distance. Such a removal will necessarily lead to a change in the gravimeter readings, which is observed and very sharp, with a quadratic dependence.

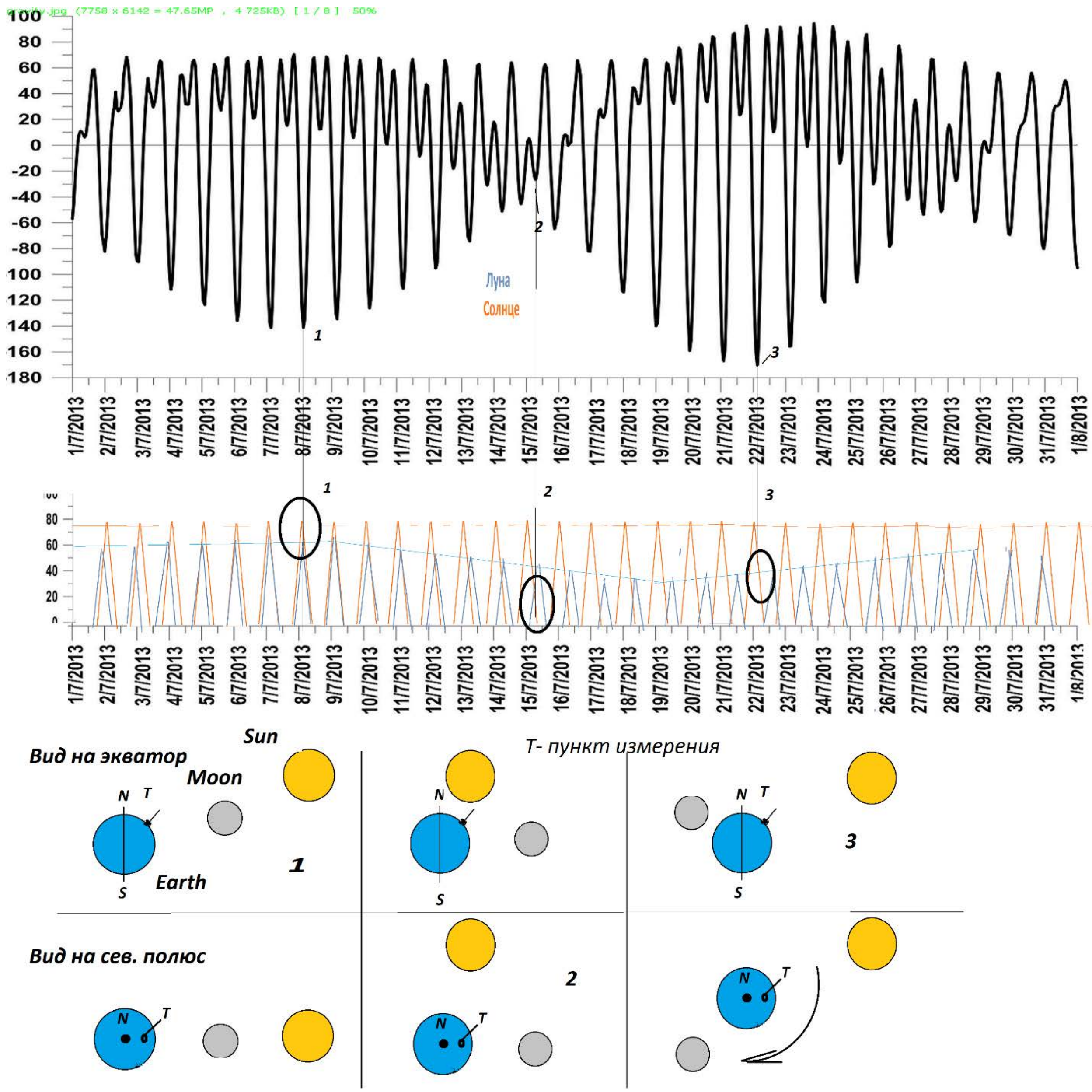


*Fig. 5:* The graph of the forces of attraction and a hypothetical illustration of the positions of the planets for the selected minimum values that occur during daytime. July 2013. View in twoprojections, hypothetical

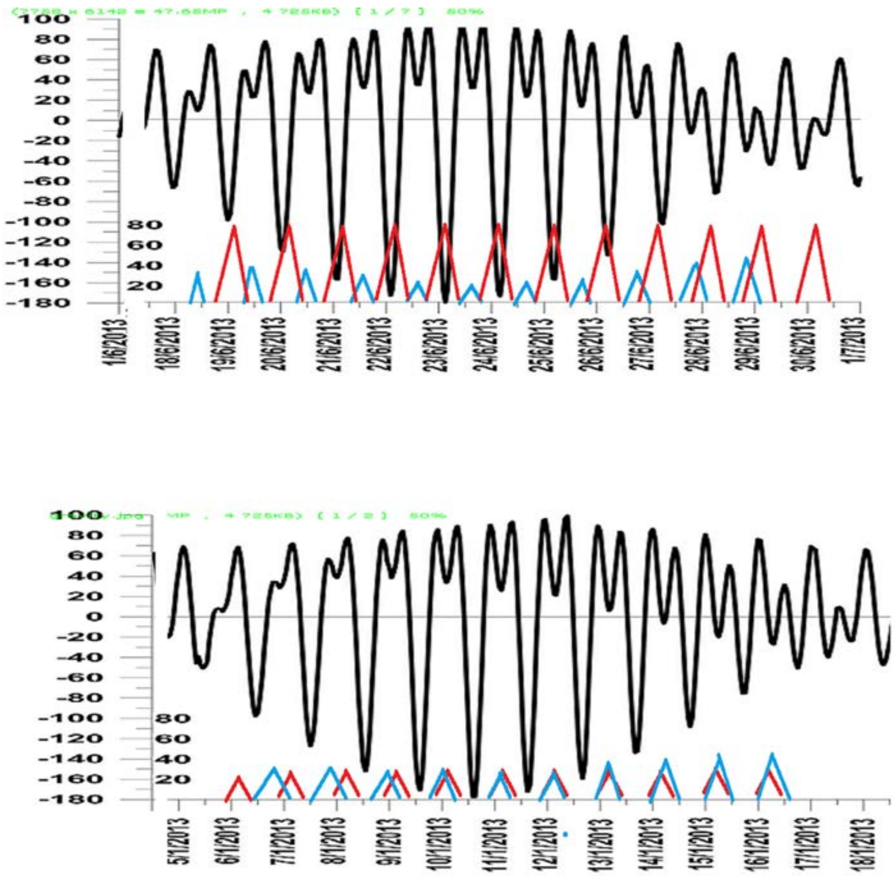


*Fig. 6:* Almost identical shape of the signal with absolutely different positions of external forces. June and January 2013. If the minimum occurs at noon in June, then at midnight in January

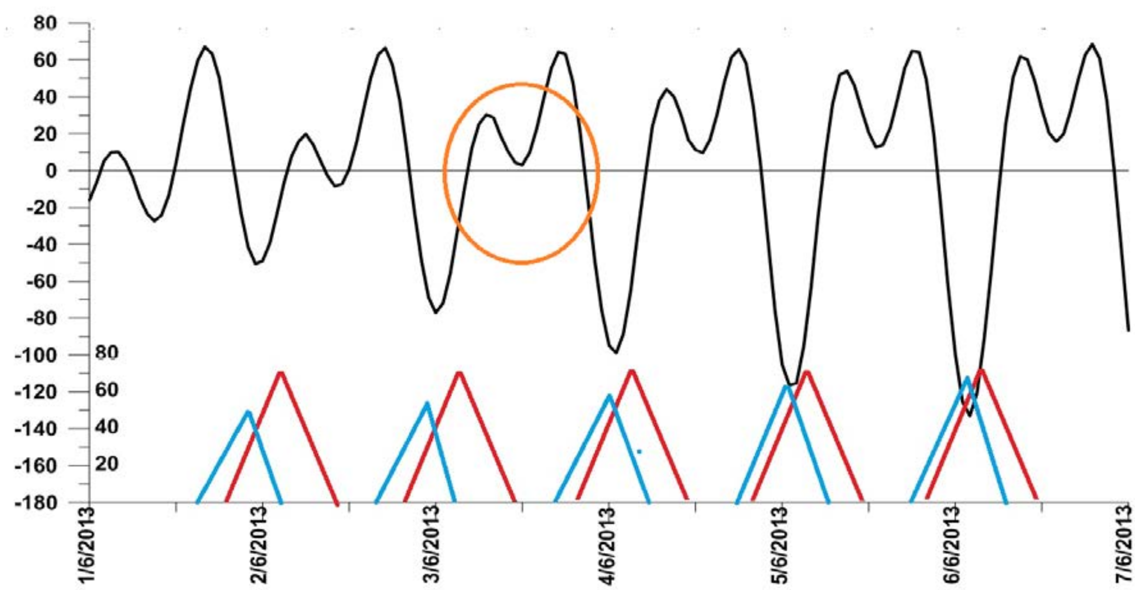


*Fig. 7:* The behaviour of gravitational forces, June 2013. A characteristic drop during night time caused by the heavy mass core moving away from the gravimeter's location.

Formation of the Dip in the Gravitational Attraction Graph at Night Time.

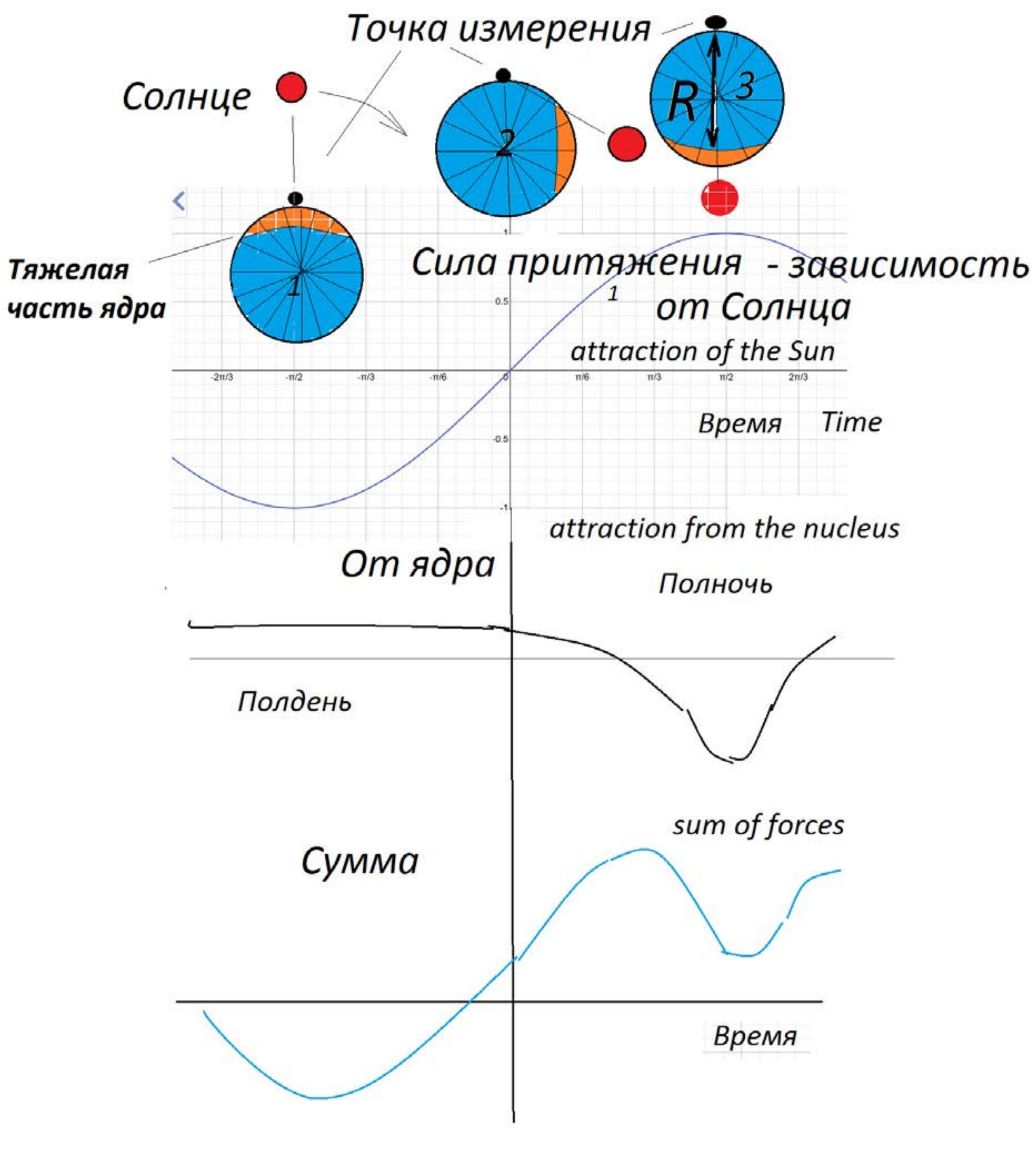


*Fig. 8:* View from the Pole. Only the Sun's influence on the core mass is shown. Conventional illustration. Gravimeter located at measurement point

The movement of the internal mass at the initial stage has little effect on the instrument readings due to the small projection of the gravitational attraction vector onto the vertical at the point of measurement. Subsequently, the dependence becomes close to the inverse square of the distance R and the value of the gravitational force decreases sharply.

In the summer months, the value of R is smaller than in the winter, but in winter, the point of measurement is initially further away from the core mass.

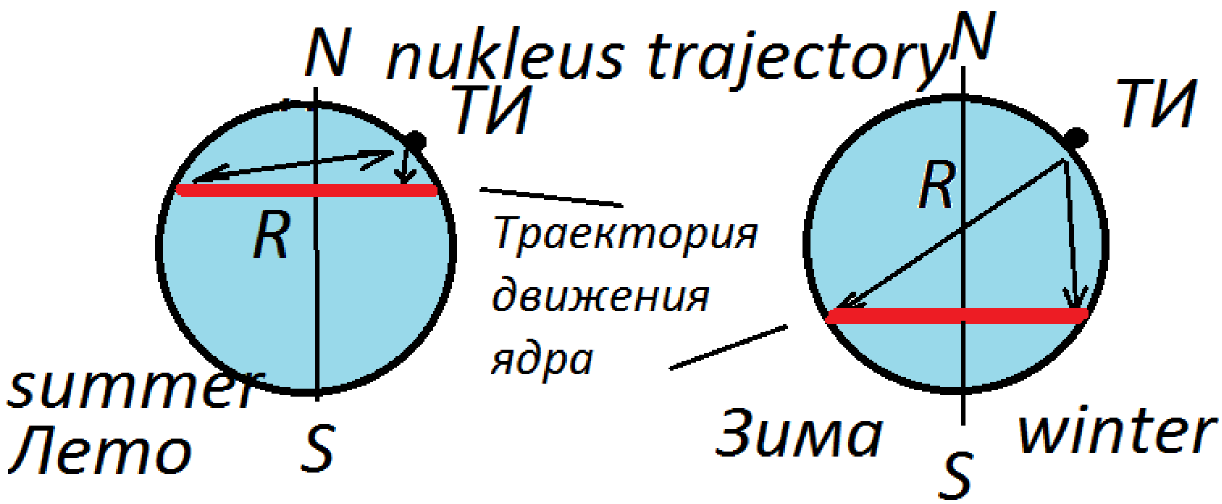


*Figure 9:* Distances from the measurement point to the position of the heavy part of the core in summer and winter

This displacement of the core and the collapse of the gravitational force explains the occurrence of the surface tide at night. That's why it is directly opposite the daytime tide.

All that has been said about the influence of the Sun also applies to the influence of the Moon.

It is worth noting another fact - when summing up two sinusoidal signals, that is what will be from the influence of the masses of the Sun and Moon on the readings of the gravimeter, the trajectories are almost circular, a symmetrical signal shape is obtained. However, the measurement data (Figures 3-6) are clearly not symmetrical, which again confirms the influence of additional forces.

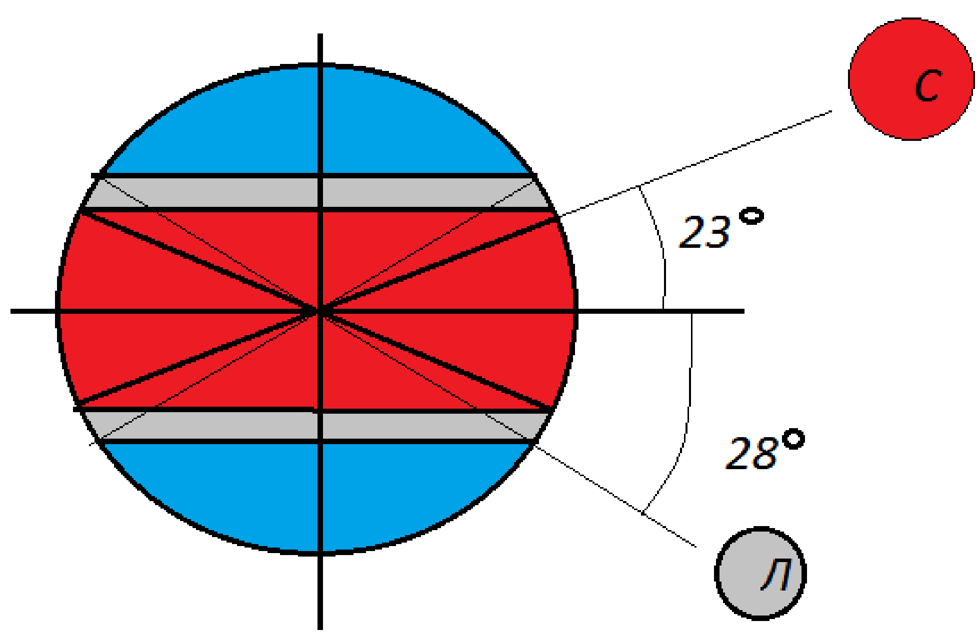


*Figure 10:* A schematic representation of the distribution of zones of influence from the Sun and Moon

The constant movement of mass in the same sector of the planet inevitably leads to the "bulging" of the Earth's crust, giving the planet the shape of a geoid.

Of course, one immediately wants to understand which has more impact on the formation and movement of the core, the Sun or the Moon. Unfortunately, this is not yet obvious. To understand this, a comparative analysis of the readings of gravimeters located on opposite parts of the planet is probably necessary. From existing data, it can be seen that the core can split into two parts and vice versa, causing a more significant impact on the gravimeter sensor. The difficulty of the analysis lies in the multitude of variables and their interdependence.

## III. Conclusion

The analysis of data from gravitational force measurements leads to a clear conclusion about the influence of attraction forces from masses moving inside the planet's body on the gravimeter readings.

The periodicity of these changes has daily, monthly (sidereal month), seasonal, semi-annual, and yearly (astronomical year) dependencies.

The amplitude and shape of the signals also have a cyclicality and depend on both the absolute position of the Sun and Moon, and their mutual position.

*Note:*

In the work "Rotational Factors of Tectogenesis - History of the Question and Modern State" by L.I. Ioganson of the O.Yu. Schmidt Institute of Physics of the Earth of the Russian Academy of Sciences [19], a very detailed approach to the question of the movement of the planetary interior matter is systematised. Many options for explaining this movement and the evolution of understanding this issue are shown, and how many scientists have dealt with this issue is shown. By referring to this work, I try to deflect accusations of a small list of used literature. There is no need for references to what is not based, not confirmed by measurement data or natural phenomena. The words "core movement" do not yet speak of the concept of the causes that cause this movement, nor of all the consequences of this movement. And just because they are mentioned somewhere, it doesn't mean that the issue is resolved there.

This is the only place in the article where I will allow myself to criticise the contemporary approach to explaining the structure of the Earth. The purpose of the article is not to criticise various models, but to reveal and explain what is measured, what manifests itself in the form of natural phenomena, taking into account the laws of physics.

Since many refer to the works of Avsyuk Y.N. [9], let's take them as the generally accepted ones, although others are almost not different. For example, such a statement.

"The stiffness of the bond and the frequency of the free vibrations of the Earth's inner core have been estimated by several authors. The magnitude of the force acting on the inner core can be recalculated into its displacements through the value of the stiffness coefficient k. There is some uncertainty in the value of the bonding coefficient k, depending on the difference in density values between the core σ1 and the surrounding liquid material σ2. Therefore, several variations of (σ2 - σ1) were taken into account [Avsyuk, 1996]."

Estimates show that forced internal core displacements of 0.4-11.6 m with a half-sidereal month cycle (6x10-7 sec) "stir" the surrounding liquid core with a power of 3.5-10.5x1018 erg/s. As a result, the power of the core displacement process by solar disturbances surpasses the upper limit of the power of the "generator" capable of regenerating the Earth's magnetic field. To sustain the current dipole field at 0.6 Ga, a generator with a power of 1014-1015 erg/s is necessary. For a toroidal field at 100 Ga, the "generator" must be more powerful, of the order of 1017-1018 erg/s.

The calculation that the movement of the axis (the geographic pole) is caused by the movement of the planet's core is certainly acceptable as a hypothesis, but what is the connection between the cyclicity in half a sidereal month and the movement of the Sun? Such a movement- several meters, will not be reflected in real gravimeter readings, will not create daily, monthly, seasonal, semi-annual periodicities. And there are dependencies and they are obvious- it means that it's not the core, or rather not such a movement and location. On the other hand, we all know perfectly well how unbalanced bodies affect their behavior during rotation. Just a few grams on the rim lead to the vibration of quite a massive wheel of a car. And in a planet, a relatively small accumulation of mass in some place on the inner side of the crust will lead to a change in the Chandler wobble of the axis. There is abundant data on the change in the rotation time of the planet during major earthquakes, and they occur quite far from the core.

The values of power presented by Avsyuk are not justified and do not reflect anything. It is not shown how and why the core moves, how the "generator" works (in traditional physics, there is no concept of a "magnetic field generator". It is created either by a permanent magnet or by an electric current), how the current appears and flows in it, and how the real magnetic field (MF) is created. In addition, it is said that the MF must be constantly regenerated - but why? A permanent magnet, which eventually becomes the body of the planet, does not need this. How, for example, can the Kursk magnetic anomaly be regenerated without making other regions anomalous?

As we can see, almost nothing is confirmed by neither the results of measurements, nor the known laws of physics, nor natural phenomena. This is precisely why works of this kind and similar ones are not included in the list of literature. The situation is even worse with all sorts of "mathematical models." In them, an electric current can flow in a circle, not along the path of least resistance, and magnetic "embryos" can develop and power lines can twist in eights. Physics is completely ignored. The paper tolerates everything.

Changes in the measured values of Newton's gravitational constant G at different times have led scientists to consider the influence of external gravitational forces, called gravitational waves. Many scientific organizations are actively searching for these waves and significant funds are being invested in creating installations. In the work of A.V. Vikulin [14], the history and problems arising in the study of these phenomena are considered in detail. However, the change in the force of attraction can be explained by the internal movement of masses, especially since these changes are well recorded and appear to be periodic, depending on the position of the Sun and the Moon (Fig.3-Fig.7).

a) *Temperature inside a planet, changes in matter properties*

What temperature and what changes in matter properties occur inside a planet - let professionals better explain this.

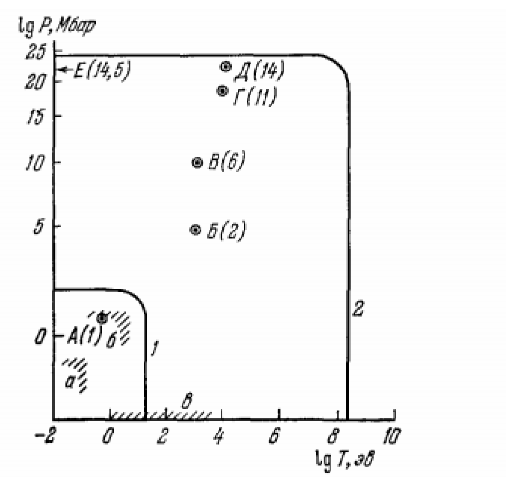


Рис. 1. Экстремальные состояния в природе и в лабораторных условиях.
*А* — центр Земли, *Б* — центр Солнца, *В* — центр белого карлика, *Г* — кора пульсара, *Д* — мантия пульсара, *Е* — ядерное вещество. Цифры в скобках указывают логарифм плотности (в *г/см*³). Область *а* соответствует статическому, *б* — динамическому методам получения высоких давлений, *в* — методам получения высоких температур. Кривые *1* и *2* ограничивают рассматриваемую в обзоре область экстремальных состояний.

«At relatively low pressures and temperatures, the substance continues to exhibit the exceptional diversity of its forms that is inherent in its cold, uncompressed state. Accordingly, the characteristics of the substance remain highly sharp and non-monotonic functions of its composition.... However, with increasing pressure or temperature, the substance acquires a more universal structure and its characteristics become increasingly smooth functions of the substance's composition. This clearly expressed trend is related to the fact that with the increase in the internal energy of the substance, it becomes possible to have a certain order and 'simplification' of its structure.

Molecules or molecular complexes break down with increasing pressure or temperature and the substance transitions to a purely atomic state. The electronic shells of the atoms rearrange, acquiring a more regular filling of energy levels. At the same time, the outer electrons, which determine the chemical individuality of the substance, are detached. Finally, if the substance remains in a solid state during compression and heating, it becomes ordered and its crystal lattice is organized. Going through a series of structural transformations, it becomes more densely packed and ultimately acquires a uniform (face-centered cubic*) structure for all substances.»

You can learn more by watching the primary source [3].

This can be easily explained on a household level - squeezing a handful of cherries, we see how the cores are compressed into a fairly solid clump, and the flesh (electrons) separates. Of course, Coulomb's forces, both attraction and repulsion, have not been canceled.

As already mentioned, the movement of mass occurs in a limited sector of the planet's body, determined by the angle of tilt of the axis of rotation and the direction of external forces. Fig. 10.

The movement of masses occurs at a huge linear velocity. If it is assumed that the movement takes place at the boundary of Mohorovicic, it is difficult to imagine that it is close to the speed of sound in air, approximately 1300 km/h (360 m/s) (This is only an assumption!!).

The movement of masses causes heating of the parts undergoing deformation and is a source of heat that maintains the planet's temperature in its current state.

There are no real observations of other heat sources.

As previously stated, all other known energy sources on the planet have long since depleted. The maintenance of such an internal temperature is facilitated by the property of the Earth's mantle, such as low thermal conductivity. This is because with a huge temperature difference inside and outside the planet, there is a noticeable decrease in surface heating when intense solar radiation is lost.

The appearance of an electrical current and the planet's magnetic field.

Free electrons, separated as a result of heating and increased pressure, carrying a negative charge, are hundreds of times lighter than the remaining positive ions. The ions, like pebbles in an aquarium, settle on the bottom, that is, on the side facing external gravity (the Sun, the Moon), pushing out electrons.

The mass inside the planet creates an electric dipole as it is separated by external gravity. The heavy, positively charged part will be closer to the surface of the Earth and to external sources of gravity (Fig. 11).

Of course, the Coulomb forces which work on attraction at the point of contact and repulsion within the resulting volumes were not canceled.

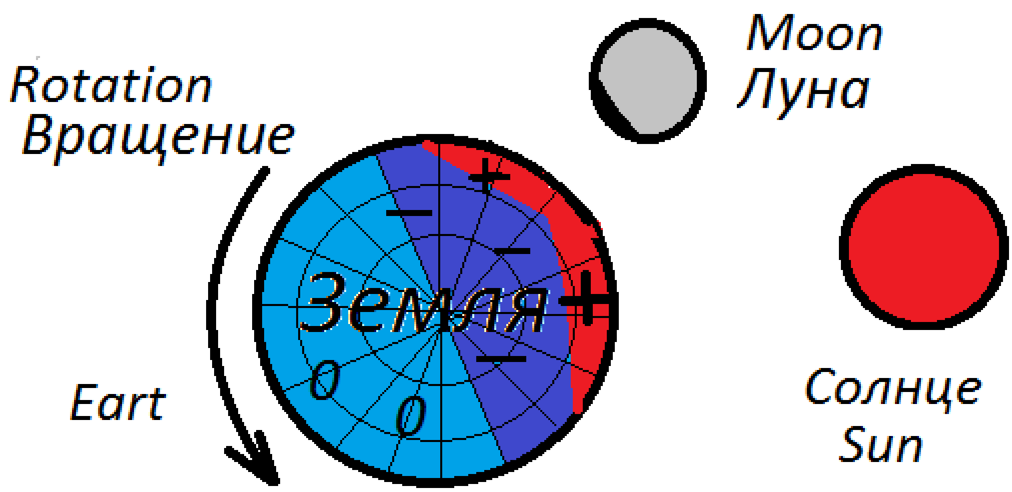


*Figure 11:* Dipole division. Conventional drawing

The movement of these heavy, positively charged masses occurs from East to West when the planet rotates. The movement of electrically charged parts is equivalent in effect to an electric current in a conductor. Since positively charged masses are moving, the direction of the current will also be from East to West. According to the "compass" or "crowbar" rule - whichever one you prefer - the force lines of the magnetic field generated by such a current will be directed from the South geographical pole to the North. In other words, it's all as in reality. Figure 12.

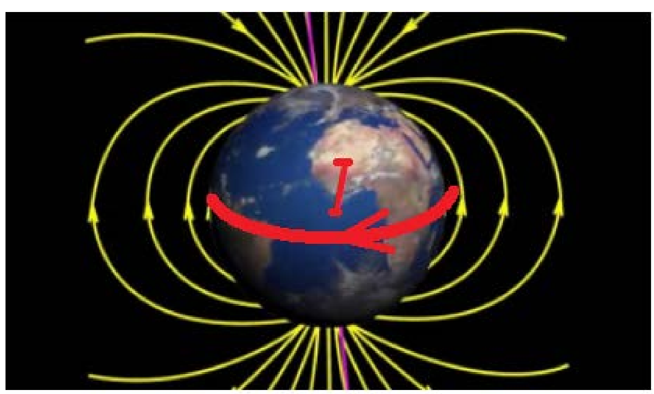


*Fig. 12:* Positive ion flow and magnetic field generated by it

This moving flow creates a variable (pulsating) Earth's Magnetic Field.

The pulsating (at a surface point), with a period of 1 day, magnetic field is supported by the planet's paramagnetic properties, which smooth and stabilize its behavior. At the same time, the planet's body itself is magnetized.

The magnetized planet mass creates the Earth's main Magnetic Field.

It is clear that existing magnetic anomalies formed with a different direction of charged flow movement, with different speeds and potentials. The current field is not able to remagnetize them.

Thus, the creator and driving force of charges that create the magnetic field of any planet with a liquid core are the combined forces from the Sun, moons, and neighboring planets moving relative to the planet.

Very interesting measured data were presented by the employees of the Institute for Climate and Environmental Systems Monitoring in their work (Yu. P. Malyshkov, 2009) [6].

Based on the multi-year research of natural impulse electromagnetic fields on Earth (NIEFE) in seismically active regions of the Pribaikalye, they have come to the conclusion about the movement of the planet's core and related natural phenomena - seismic

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activity, influence on human organisms, etc. These are truly remarkable works, continuing, already at a more technological level, the research of A. Chizhevsky. [5].

Intensity maps of NIEFE changes at different times [6] exactly mimic the movement of the dipole's heavy part.

From this, it becomes clear the appearance of a magnetic field on other planets where there are satellites or dynamic influence from the Sun, and its absence where there is none. This is described in more detail in [18]. The same applies to the 11-year cycle of solar activity that affects the Sun's core and the mass of the largest planet in the Solar System, Jupiter, and its impact on the Earth's biosphere.

*b) The origin of mountain systems*

In our case, it does not matter how the planet evolved - whether it was formed from a dust accumulation or a melted debris. We take it as it is - inside the melts, on top the cooled "foam" in the form of a crust. This is what we observe.

The Earth's crust is measured and classified. It is known about the unevenness of its inner surface, and it is known about the "overlapping" of its individual parts on each other. The question of where these titanic forces come from and how they act on tectonic movements remained unresolved.

*Fig. 13:* Photos of mountains and rapids

"Mountain formation is a geological process of formation of mountain structures under the influence of intense upward tectonic movements, whose speed exceeds the speed of processes leading to the leveling of the Earth's surface." This process is commonly explained in this way, but, as already noted earlier, there are no upward movements inside the planet.

The most similar phenomenon to mountain formation in the environment is river rapids. There is a flow of water in a river and there is movement of mass under the crust inside the planet. There are big masses moving in both places, there are rapids in a river and mountains on land. The location of mountains is mostly south-north, across the movement of mass inside the planet, the location of rapids is mostly across the flow, but there are exceptions in both places. The analogy is complete. (Fig. 13). The movement of the planet's core mass is constant and multi-millennial. Mountain formation alternates with the destruction and weathering of mountains.

*Second question:*

The origin of geosynclines (deep valleys filled with deposits); According to Uyeda, "Many mountain rocks that make up modern mountain ranges originally accumulated on the seabed, and their thickness often exceeded 10,000 meters."

If the formation of mountains is possible with the rise of the bottom of a former ocean by several kilometers, why is it not possible to form valleys at the same time? If we look at how gorges are formed, everything becomes clear.

*Third question:*

The causes of volcanic eruptions and other magmatic processes; Let's go back to the rotating aquarium. The contents of the aquarium, or rather, its heaviest and densest part, move along the wall, along the boundary of the body. The same occurs inside the planet. Where is this boundary? Maybe this is the Mohorovičić boundary? Yes, it is possible, but if we imagine the inner surface of the aquarium not from a smooth glass, but like, for example, the bottom of a mountain stream, then all kinds of deposits will appear in the form of small fragments, over which bare cliffs rise - in our case, these are the "underground" parts of mountain ranges.

Just like in ice when troughs are formed, voids and cracks occur in the Earth's core, through which magma, under the pressure of constantly moving core mass, emerges to the surface. Once a channel has formed, melting and forming a throat, it becomes a place of eruption for many centuries.

It is important to note that the pressure of the moving mass will be directed not towards the center of the planet, but towards the external gravitational force, i.e. the Sun and Moon. And moving under the throat, this mass will squeeze out magma like a piston.

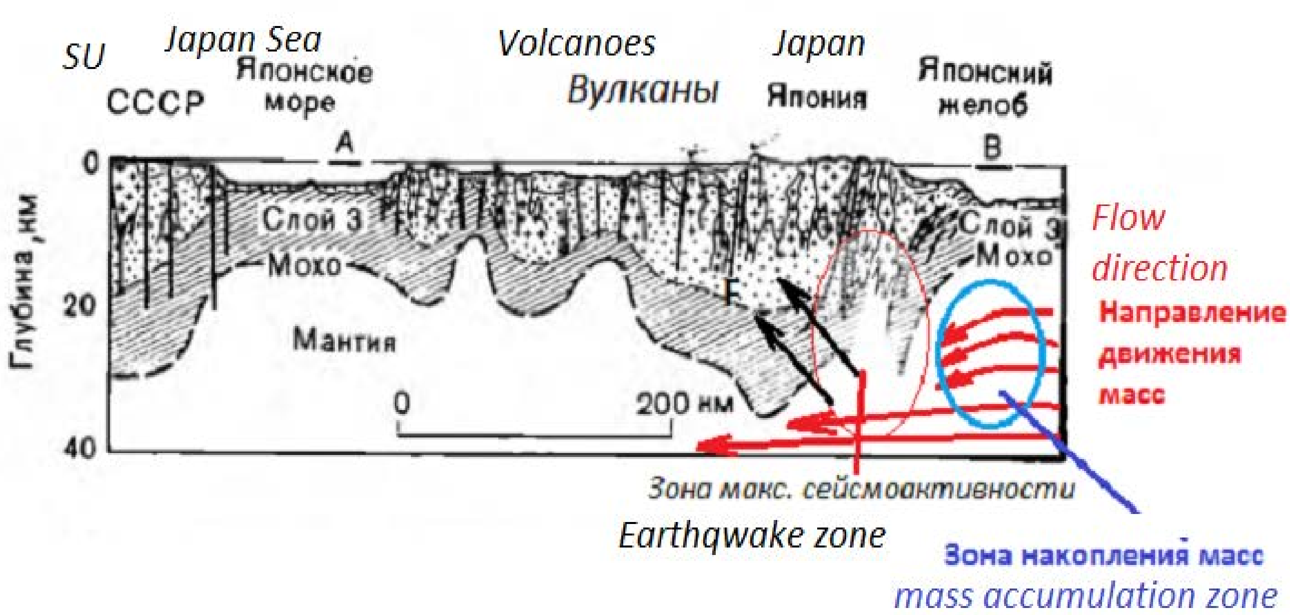


*Fig. 14:* The direction of the movement of the mass of substance causing pressure in the area of existing volcanic vents has been added to the illustration from Uyeda's book. The areas of mass accumulation before the earthquake and the area of maximum seismoactivity are indicated

Since Uyeda is Japanese, it is natural that he provided data mostly concerning his homeland.
The fourth question from the book:
causes of deep-focus earthquakes.
Let's consider what effects are observed during strong earthquakes:

- Vibrations and movements of the Earth's crust
- Witnesses report a rumbling sound, like the movement of a large mass, like a mountain landslide.
- Electromagnetic disturbances, magnetic storms.
- A sudden change in the period of rotation of the Earth
- The effect of "calm" of seismic activity and electromagnetic background radiation before major earthquakes is known.

Uyeda pointed out another effect: "Here it is important to mention another astonishing fact. It has long been known that every strong earthquake that occurs in Japan causes its Pacific coast to rise several meters. But between earthquakes, the coast gradually sinks."

Only the first two points are performed during weak earthquakes.

It is logical to assume that these are two different types, with different physics.

Since we are interested in the type of deep-focus events, we will consider its causes and consequences.

When the flow moves and after accumulating a critical mass in a convenient area, a collapse may occur which triggers an earthquake. For example, as shown in Fig. 14. During the collapse, the natural pressure will be exerted downward on the continental part. In the case of the Uyeda being considered, this is the Pacific part of the island. Afterwards, this part returns to its place.

The confirmation of such a mechanism of earthquake occurrence is that most earthquake epicenters are located on the borders of tectonic plates, that is, at geological faults

This phenomenon can be the cause of movements in the mantle's surface layers, leading to the appearance of additional earthquake epicenters and aftershocks.

It is also important to note that magnetic storms on Earth are accompanied by low-frequency oscillations of the Earth's body, and conversely, earthquakes are accompanied by electromagnetic emissions, that is, these two phenomena are interrelated, and this can also serve as confirmation, as there are spikes in electrical charge (flow of charged matter), and the transition process, as is known, has a wider spectrum than a constant current.

The "calm" effect of seismic activity and electromagnetic background radiation, described in work [6], before major earthquakes is caused by the accumulation of a critical mass.

Due to the non-uniformity of the inner mantle surface, the effects on it will naturally be uneven. Powerful "collapses" of accumulated mass will cause changes in the rotation time of the planet, that is, changes in astronomical time.

The collapse that occurred in the Earth's crust under the ocean and transmitted to the surface will cause a large wave, called a "killer wave."

The mass of the planet's core, subjected to the influence of various gravitational forces from the Sun and the Moon, moves along the "inner" surface of the Earth, constantly mixing, hitting irregularities, and carving a new channel for itself every day. The inner part of the Earth's crust is constantly being affected, which is transmitted to the tectonic plates, causing them to gradually move, thus moving the continents. And they indeed move in the latitudinal direction (East-West) and do not move in the longitudinal direction (South-North).

This is in response to the question posed in Uyeda's book on mobilism, as we can see it is easily explained by the proposed physics.

Sometimes, in literature, movement is associated with tidal forces. But tidal forces are considered differently, these words carry a completely different physical meaning. And even if you accept their interpretation, only tidal forces cannot create movements, as they are first directed towards the East, and then exactly the same time towards the West.

Only the moving mass of the planet's core is constantly directed from East to West.

The causes of the main (defining) ocean currents on the planet are the trade winds and ocean tides.

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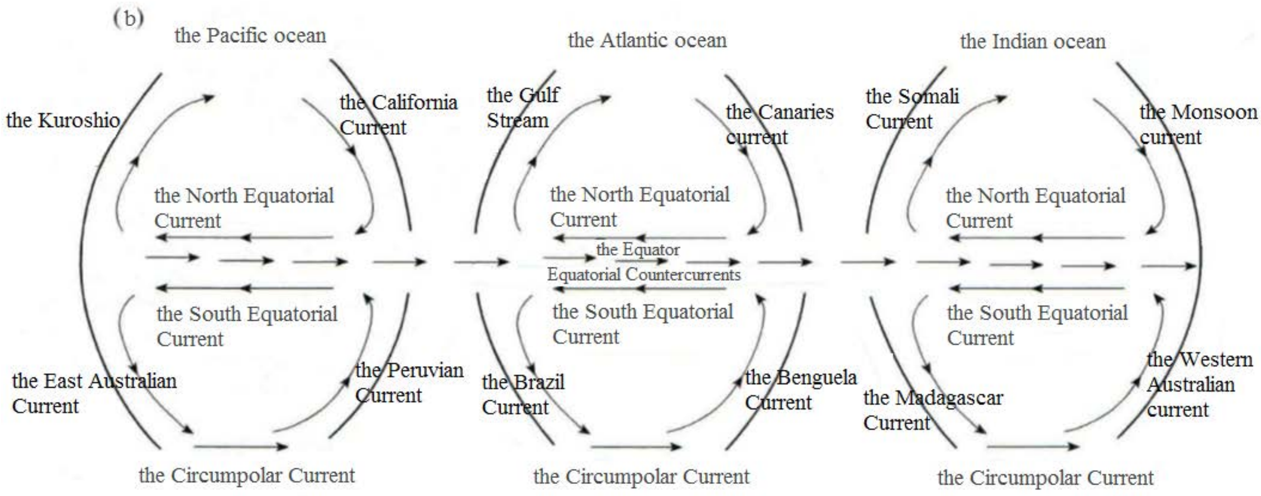


*Fig. 15:* Map of ocean currents and a conditional diagram (Garetsky 2006 [17]) showing the similarity of structures of large-scale currents in the Pacific, Atlantic, and Indian Oceans

As seen from Figure 15, the main currents that create all others are the North and South Equatorial currents. If there were no continents, they would close into a circular global current. Meeting the continent, they diverge on different sides of the equator and circulate in closed ocean spaces.

As previously discussed, there is a movement of the core mass in the equatorial zone, and this gravitational influence on the ocean waters creates the equatorial currents. This is the only force directed constantly from East to West. These currents lead to increased ocean levels on their western parts, which in turn creates conditions for the appearance of equatorial countercurrents- surface compensating currents.

Similar gravitational effects on air masses result in the formation and maintenance of closed ring-like trade winds, whose heights reach stratospheric levels and are not impeded by land, and these winds can no longer be subject to surface heating temperature effects on Earth.

The moving "bulge" caused by the deformation of the Earth's crust due to the attraction of the heavy core part and barely noticeable to the average observer, leads to the tidal water flow in the ocean away from the location of the "bulge" to the coastal parts of the oceans, causing oceanic tides. This is why ocean tides never coincide with the passage of the Sun or Moon at the zenith in this place, but they do coincide with low tides. For the same reason, there are no significant tides in the open ocean, while according to contemporary interpretation, they should be maximum and follow the Sun and Moon.

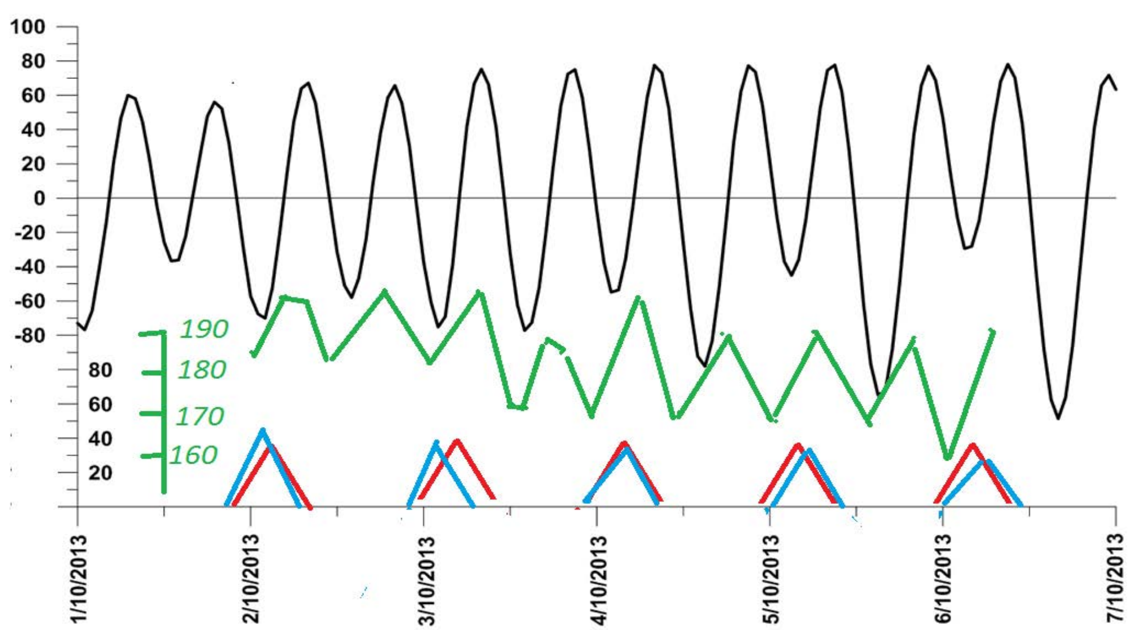


*Fig. 16:* Measurement data. Station "Posiet" on the Pacific coast. On the horizontal axis is World Time

*Black* - measured gravity strength. µGal.

*Red* - position of the Sun in degrees above the horizon (time of sunrise, maximum position, sunset)

*Blue* - position of the Moon in degrees above the horizon (time of sunrise, maximum position, sunset)

*Green* - ocean water level. cm.

A time interval has been specially selected when the Sun and Moon are on the horizon and simultaneously affecting the Earth's core.

The data on gravitational forces was provided by employees of the gravimetry laboratory of the Institute of Oceanology of the Russian Academy of Sciences.

Ocean level data is measured at the "Posiet" station meteorological station.

The times of sunrise, maximum position, sunset, and angle of ascent of the Sun and Moon were taken from the StarCalc program with a reference to the station location.

It can be seen that a couple of hours before the Sun and Moon pass through the zenith points, a tidal surge occurs and at the same time the gravitational force decreases, i.e., a tidal surge of the solid part of the planet. A tidal surge is also visible at night when there is a tidal surge of the mantle as the planet's core moves to the opposite part of the Earth.

The “hump” on the mantle will change its position and size daily depending on:

- Season (tilt of the rotation axis);
- Distance of the Moon and Sun from Earth;
- "Phase", i.e. different positions of the Moon and Sun; and the tidal surge near the shore will not be constant, but will depend on these factors and the bottom topography.

Now about the tidal rise (surge) on the opposite side of the Earth's sphere.

Unfortunately, this is difficult to demonstrate visually, as in the first case, but here too everything is quite simple. The shifted towards the Sun and Moon mass of the planet's core will weaken the gravitational force on the opposite side of the ball proportional to the square of the shift distance. On the graph provided, these will be gravity forces dips (black color) during periods when there is neither the Sun nor the Moon above the measurement point. These surges of the Earth's surface also lead to an ebb at this place, and at this time, the ocean waters.

*c) Why do we see only one side of the Moon?*

It is usually explained that it makes one rotation on its axis as it orbits around Earth. But what and how makes it do this?

There is another explanation, due to tidal forces, but what are the tidal forces on the Moon and how do they affect it? If there are tides, there should be ebb and flow, but they have not been detected.

In principle, these two explanations are correct, but it is necessary to explain the mechanics of such movement. By the way, many moons behave similarly, rotating around their planets.

The presence of meteorite craters all over its surface, not just on the side facing space from where meteorites arrive, speaks to its former rotation.

Its former rotation is also confirmed by the fact that it previously had a strong magnetic field, now only residual, i.e., what remains as magnetized particles of the lunar ground. A magnetic field could only arise from the movement of electric charges, and movement is only possible with rotation.

During the evolution of the Solar System and the cooling of the Moon, heavier masses of interior material stopped moving and grouped on the side facing Earth of the satellite, turning the Moon into a kind of "see-saw" and causing it to rotate towards us with the same heavy side. And just like the see-saw, it swings, relative to the heavy part, creating what is known as libration, allowing the Earth observer to glimpse behind the geometric edges of the visible flat circle. Fig. 17. It seems that the same fate awaits Earth in the future.

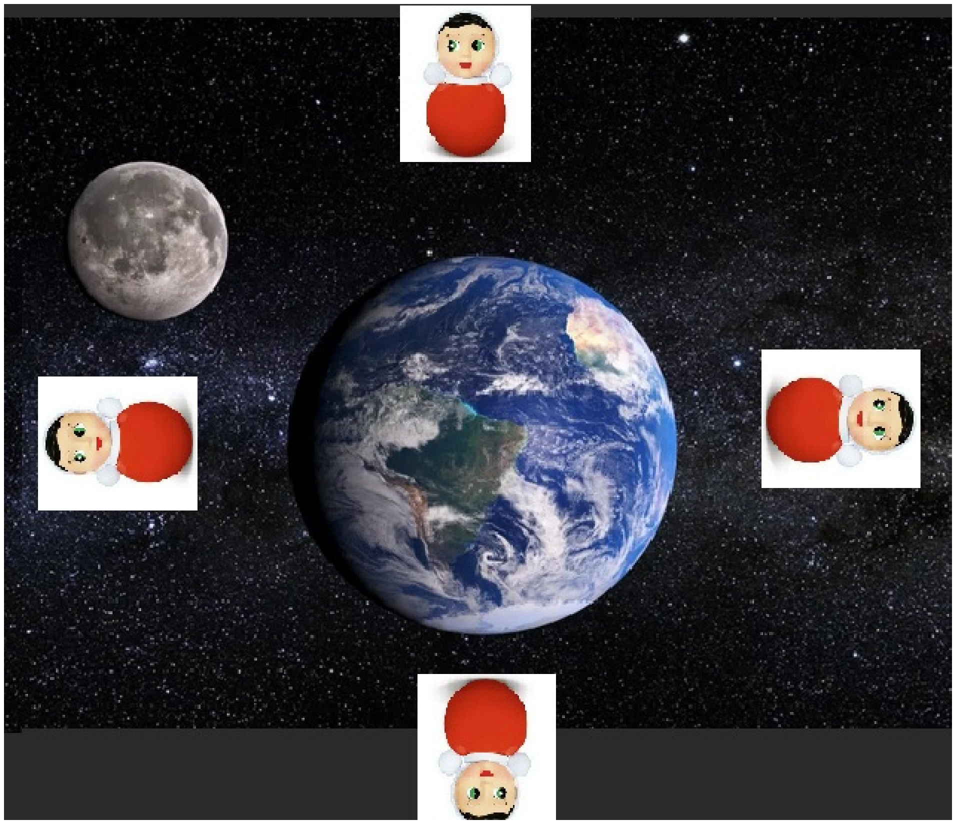

*Fig. 17:* A schematic representation of the Moon's behavior as it moves relative to the Earth

Thus, the Earth's gravitational force not only holds the Moon in its orbit as a satellite, but also causes it to constantly rotate, which consumes energy and may lead to partial cooling of the Earth. On the other hand, the mass of the Moon affects the movement of the Earth's inner core, and the movement of the core leads, due to frictional forces, to the warming of the planet.

The fact that most satellites rotate around their planets, facing them with one side, and the rotation of planets such as Venus and Mercury is synchronized with the movement of the Earth (these two planets face the Earth with one hemisphere when they approach it), indicates that planets interact with each other as bodies with offset centers of mass. In this case, with a liquid, mobile core, this center of mass can move within the solid envelope of the planet.

## IV. Conclusion

For those who have read to this point, you probably noticed that there is nothing particularly difficult about what has been said.

You don't have to be a big expert in the hypotheses and models written in "scientific" books on these topics to understand the essence of the discussed issues. Just a high school level and knowledge of basic physics laws is enough. This is what made Sayed Wady's book appealing, and this is such an approach to research.

The consideration of mathematical models not based on measured data, not on the basis of observed effects, not on real facts, not on known and proven physics laws, and sometimes even contrary to them, cannot lead to any positive results. And sometimes there is not enough data to create more or less realistic models.

The explanation of many natural phenomena by one real, observable, and measurable cause allows to reduce the number of options (hypotheses) arising around the phenomena under consideration. One cause can be studied more thoroughly based on the multi-faceted manifestation of it. A structured Science of Earth emerges, where such sciences as oceanology, geophysics, magnetic field physics, geology, atmospheric physics and similar, are included as branches of the general one. The Science of Earth itself acts as a component part of the Science of the World, in which Earth is considered as one of the objects of research, and many processes related to it and studied, can be transferred to other planets.

Thank you for reading. Wishing everyone creative success.

All comments and questions should be sent to danvlad@bk.ru.

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***6. Bookmarks are useful:*** When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

***7. Revise what you wrote:*** When you write anything, always read it, summarize it, and then finalize it.

***8. Make every effort:*** Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

***9. Produce good diagrams of your own:*** Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

***10. Use proper verb tense:*** Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

***11. Pick a good study spot:*** Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

***12. Know what you know:*** Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

***13. Use good grammar:*** Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

***14. Arrangement of information:*** Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

***15. Never start at the last minute:*** Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

***16. Multitasking in research is not good:*** Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

***17. Never copy others' work:*** Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

***18. Go to seminars:*** Attend seminars if the topic is relevant to your research area. Utilize all your resources.

***19. Refresh your mind after intervals:*** Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

***20. Think technically:*** Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

***21. Adding unnecessary information:*** Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

***22. Report concluded results:*** Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

***23. Upon conclusion:*** Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

## Informal Guidelines of Research Paper Writing

***Key points to remember:***

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

**Final points:**

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

*The introduction:* This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

**The discussion section:**

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

**General style:**

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

**To make a paper clear:** Adhere to recommended page limits.

*Mistakes to avoid:*

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.
- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

**Title page:**

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

**Abstract:** This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

*Reason for writing the article—theory, overall issue, purpose.*

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

**Approach:**

- o Single section and succinct.
- o An outline of the job done is always written in past tense.
- o Concentrate on shortening results—limit background information to a verdict or two.
- o Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

**Introduction:**

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

*The following approach can create a valuable beginning:*

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.

**Approach:**

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

**Procedures (methods and materials):**

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

**Materials:**

*Materials may be reported in part of a section or else they may be recognized along with your measures.*

**Methods:**

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

**Approach:**

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

**What to keep away from:**

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.

**Results:**

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

**Content:**

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

**What to stay away from:**

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

**Approach:**

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

**Figures and tables:**

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

**Discussion:**

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

**Approach:**

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

## The Administration Rules

Administration Rules to Be Strictly Followed before Submitting Your Research Paper to Global Journals Inc.

*Please read the following rules and regulations carefully before submitting your research paper to Global Journals Inc. to avoid rejection*.

*Segment draft and final research paper:* You have to strictly follow the template of a research paper, failing which your paper may get rejected. You are expected to write each part of the paper wholly on your own. The peer reviewers need to identify your own perspective of the concepts in your own terms. Please do not extract straight from any other source, and do not rephrase someone else's analysis. Do not allow anyone else to proofread your manuscript.

*Written material:* You may discuss this with your guides and key sources. Do not copy anyone else's paper, even if this is only imitation, otherwise it will be rejected on the grounds of plagiarism, which is illegal. Various methods to avoid plagiarism are strictly applied by us to every paper, and, if found guilty, you may be blacklisted, which could affect your career adversely. To guard yourself and others from possible illegal use, please do not permit anyone to use or even read your paper and file.

## Criterion for Grading a Research Paper (Compilation) by Global Journals

**Please note that following table is only a Grading of "Paper Compilation" and not on "Performed/Stated Research" whose grading solely depends on Individual Assigned Peer Reviewer and Editorial Board Member. These can be available only on request and after decision of Paper. This report will be the property of Global Journals.**

| Topics | Grades | | |
|---|---|---|---|
| | **A-B** | **C-D** | **E-F** |
| ***Abstract*** | Clear and concise with appropriate content, Correct format. 200 words or below | Unclear summary and no specific data, Incorrect form<br><br>Above 200 words | No specific data with ambiguous information<br><br>Above 250 words |
| ***Introduction*** | Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited | Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter | Out of place depth and content, hazy format |
| ***Methods and Procedures*** | Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads | Difficult to comprehend with embarrassed text, too much explanation but completed | Incorrect and unorganized structure with hazy meaning |
| ***Result*** | Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake | Complete and embarrassed text, difficult to comprehend | Irregular format with wrong facts and figures |
| ***Discussion*** | Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited | Wordy, unclear conclusion, spurious | Conclusion is not cited, unorganized, difficult to comprehend |
| ***References*** | Complete and correct format, well organized | Beside the point, Incomplete | Wrong format and structuring |

# INDEX

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