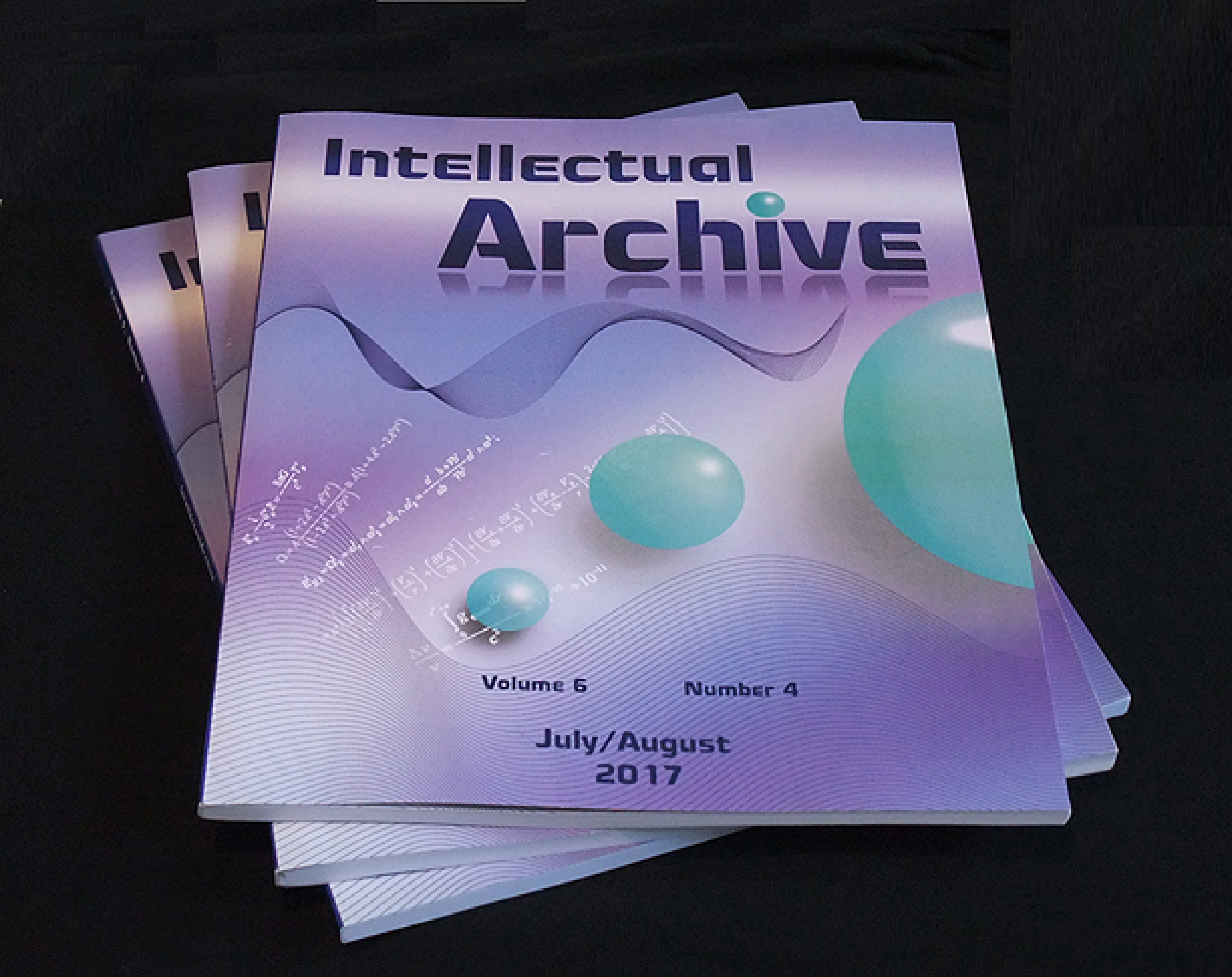
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STOE model of voids in cosmology, charge, point particles, and atomic spectra

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Abstract

The Scalar Theory of Everything (STOE) model of the universe has suggested that the small world has classical analogies that account for quantum effects and that there are only two components of the universe. Therefore, the characteristic of the plenum, hods, and their interactions must yield all the observed effects. The STOE is extended to speculate about other observations. The "voids" in the large-scale structure of the universe are explained in terms of hod magnetism. The characteristics of turbulent flow vortices ib the plenum describe charge. Models that suggest a point particle are describing the Newtonian Spherical property of the plenum rather than a physical dimension of particles. This yields the equation similarity between charge force and gravity force. The atomic line spectra of particle photons result from electrons in plenum troughs. The weird quantum postulates are unnecessary to explain the small-scale.

keywords: Charge, Newtonian Spherical Property, atomic spectra, STOE

1 INTRODUCTION

The Scalar Theory Of Everything (STOE) was developed to model cosmological problems (Hodge 2015d). Hodge (2004) posited the universe was composed of two components and their interaction. The plenum is a continuous medium like the ether or the "space" of general relativity. The plenum causes the inertial mass observations. The hods were two dimensional round surfaces that maintained a plenum density ρ at its surface. A hod induced a discontinuity, flat surface in the plenum. Hods cause the gravitational mass observations. The ρ at the hod surface acts perpendicular to the surface. A property of the plenum is that the plenum, like a fluid, flows from volumes of higher ρ to lower ρ. The equipotential ρ surfaces then are adjacent to the hod surface vary linearly with distance from the hod and become oval then spherical. This is the result of the plenum having the Newtonian spherical property (Hodge 2004, section II.B.2). That is the plenum potential from the hod is isotropic beyond some distance.

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This spherical property implies that the force of $\vec{\nabla}\rho$ can be considered to act at the center of mass point and the plenum density ρ from the surface of the hod obeys the inverse radius law where each equipotential surface has the same total plenum potential over the total equipotential surface.

The plenum waves travel much faster than light. The hods are discrete and tended to travel in straight (Euclidean geometry) paths at the velocity of light through the plenum. The $\vec{\nabla}\rho$ exerts a force on the hod surface that changes the direction of the hod. The ρ at any point is determined by the sum of the effects of all Sources (spiral galaxies), Sinks (elliptical galaxies), and hods in the universe. The varying ρ environment causes the distance between hods in a photon to change. Emergent theory suggests all observations must derive from the characteristics of the components (Hodge 2016c).

The fractal and one–universe principles are a corollary of the Reality Principle (Hodge 2016a). All the mathematics of the models have their analogy in our everyday life (Hodge 2015d). Hodge (2015c, and references therein) expanded on the hod and plenum interaction and particle formation by describing the photon and positing the interaction of the hods and plenum. The characteristics of the plenum, hods, and their interactions have been used to derive the STOE particle[1] photon diffraction model (Hodge 2012). This photon model and a simulation program were developed to yield a diffraction pattern after random particle photons moved a large distance that simulated coherence of light. The computer program involved several iterations, which raises the specter of chaos. However, chaos is avoided by having several feedback conditions that are also in nature. Passing the photons through a slit and matching the screen pattern to a Fraunhofer pattern demonstrated coherence. This model suggested an experiment (Hodge Experiment) involving the varying illumination of coherent light across a slit. The prediction was found to be consistent with the Hodge Experiment. The Hodge Experiment rejected all wave models of light.

The photon model was extended to model neutrinos and electrons in the Stern–Gerlach Experiment (Hodge 2016b). The magnetic observation is a characteristic of hods. The photon column is similar to a bar magnetic (Fig. 1) where the disc magnets simulate the hods. The neutrinos Fig. 2 are a stable structure of photons. The structures are held together by the magnetic properties of the hods. Other structures are possible but are less stable or shorter lived. Likewise, electrons are assemblies of neutrinos. The orientations of magnetic poles explain the observations of electrons in the Stern–Gerlach Experiment (Hodge 2016b). There are two such structures with the same gravitational mass (number of hods) that explains the electron and positron Fig. 3 and Fig. 4.

The direction of movement of these structures is in the direction with the least hod surface area presented. This direction for photons and neutrinos is perpendicular to the page in the figures with zero cross section. Therefore, these particles travel at the largest speed possible in the ρ environment. The electron and positron structures have a surface area presented in all directions.

[1] A distinction is make between a wave packet type model that is called a "photon" and a particle type model.

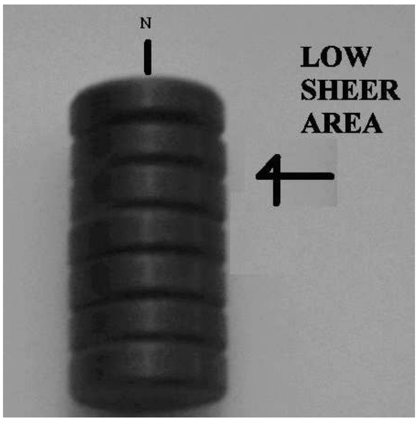

Figure 1: Photon.

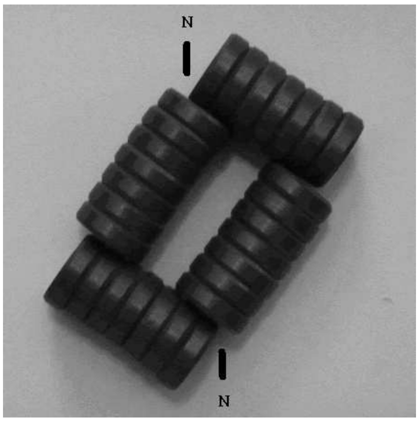

Figure 2: Neutrino.

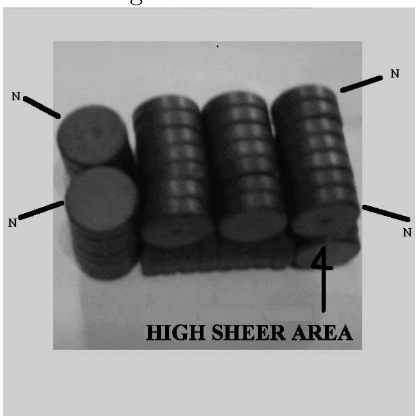

Figure 3: Structure of electron or positron.

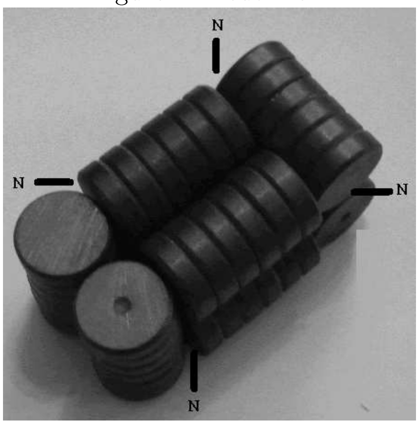

Figure 4: Structure of electron or positron.

Therefore, they travel at less than the speed of the photon. There is a preferred orientation that, with the magnetic directions, causes the observations of the Stern–Gerlach Experiment (Hodge 2016b). This travel orientation is perpendicular to the page. The Stern–Gerlach Experiment observations would not occur without a preferred direction.

Maxwell's Equations are a description of the empirical results of several experiments of electric and magnetic phenomena. They are not an explanation of basic physics. The phenomena are commonly attributed to new hypothetical particles such as a charge, point particles, or attributes of some particles such as electrons. This model has a coulomb force law and acts at the center of mass of particles similar to gravity.

Photons, neutrons, and neutrinos have a neutral charge. Electrons, muons, tau, and quarks have charge attributes. Charges are modeled as generating a coulomb field. The velocity of an electromagnetic signal is the velocity of photons. The coulomb field velocity has been measured to be much faster than light (de Sangro 2012).

Turbulence in fluid flow past surfaces happens when the Reynolds Number is high. Turbulence is a chaotic motion caused by high sheer in the fluid. Current models described turbulence and vortices poorly. The Reynolds Number is the ratio of the kinetic, inertial energy of the fluid relative to the object, and the viscous dampening in a continuous media (fluid). Laminar flow occurs when the fluids flow in parallel layers with no disruption between the layers. Turbulent flow occurs with high Reynolds Number, in volumes with high sheer, and is dominated by inertial forces. The result of turbulent flow is unsteady vortices. The vortices interact with each other, are of varying size, and carry kinetic energy and momentum. Vortices can exist for a relatively long time such as cyclones and tornados. Inviscid flows have very high Reynolds Number. Small–scale turbulent motions are statistically isotropic. Therefore, the statistics of inviscid media, small–scale turbulent motions have a universal character. That is, the characteristics are the same for all such turbulent flows.

"Vortex stretching" is a mechanism characterized by strong three-dimensional vortex generation. The vortices have an increasing velocity in the stretching direction caused by conservation of angular momentum. The vortices are thinned in the direction perpendicular to the stretching direction. Therefore, the vortices may be right–handed or left–handed. Like handed vortices tend to repel or combine into larger vortices. Opposite handed vortices combine to cancel the angular momentum of each other. Larger vortex structures break down into smaller structures.

Atomic line spectra data are light of discrete energy levels emitted and absorbed by atoms. The Hodge Experiment rejects the wave models of this emission.

The classical analog of the walking drop experiments exhibit quantum-like observations (Bush 2015a,b; Borghesi 2017a,b). This analogy was noted in the Hodge Experiment (Hodge 2015c).

This Paper expands the STOE model. The model of photons is discussed in section 2. The model of charge of electrons is discussed in section 3. The model

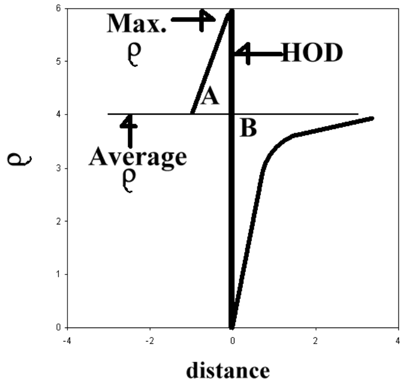

Figure 5: ρ around a hod.

of atomic line spectra is discussed in section 4. The Discussion and Conclusion are in section 5.

2 The photon model

The photon model developed by the STOE suggested the hods are magnetic. If there are only two components of the universe and if electromagnetic signals travel at the speed of light, the hods must cause the electromagnetic signals. The electromagnetic effects result from the traveling magnets inducing an electric field as they travel in accordance with Maxwell's equations. The associated coulomb field must be in the plenum because of the travel speed.

The magnetic property of hods is posited to be caused by different ρ effect on the plenum on each side of the hod as depicted in Fig. 5. The ρ varies linearily with distance close to the hod surface, then the Spherical property of the plenum causes the equipotential ρ surface to become spherical and vary with 1/distance beyond some distance. The $\rho = 0$ on one side is balanced with the universal maximum ρ on the other side. Surrounding the hod is the ρ environment (labeled "average ρ"). The speed of waves in the plenum is much greater than the speed of light (Hodge 2015c). Therefore, the cosmological horizon for plenum effects is much larger than the hod horizon.

If the area "B" in Fig. 5 is greater than the area "A", then the potential net $\vec{\nabla}\rho$ is gravitational. If the area "A" is greater than the area "B", then $\vec{\nabla}\rho$ is repulsive. The latter case may be the mechanism causing the voids (bubbles) in the large-scale, foam-like structure of the universe.

3 The charge model

If the hods account for the magnetic effects of electromagnetic observations, then the plenum accounts for the charge effects in the STOE model.

Chaotic motion is present in the classical scale and cosmological scale. The STOE suggests such motion should be present in the ultra small scale motion, also. The model of photon diffraction suggests possible chaotic effects are balanced by feedback loops.

The plenum has minimal viscosity. Therefore, the plenum has a very high Reynolds Number. The particles of proton and neutrino structure have laminar flow because of the zero cross section presented to the direction of travel. The alternating north pole and south pole of the hods edges have low plenum sheer because the magnetic strength is low at the hod edges (Fig. 1). The electron and positron and larger structures have some cross section presented to the direction of movement. The alternating north pole and south pole of the adjacent hods surfaces create high sheer to passing ρ and $\vec{\nabla}\rho$ (Fig. 3). Therefore, the flow is turbulent. Vortices with a right hand circulation may be from one structure and a left hand circulation from the other structure. The inertial energy carried by the vortices manifest as an increase of the ρ around the vortices.

The vortices in very high Reynolds Number and in high sheer environments become isotropic after some length L scale such as the width of a nucleus. Therefore, particles that generate like vortices may exist within this length scale such as within the nucleus.

Vortices beyond L of a like rotation tend to increase ρ that then acts on the particles to repulse them. Vortices of opposite rotation combine to cancel the rotational inertial kinetic energy. This lowers the ρ between the particles. That is the particles are attracted to each other.

4 Atomic line spectra

Electrons in a field without charge will travel in plenum troughs in material. This suggests a speculation that super conduction may be such an effect. Because the vortices require L to become isotropic, electrons may exist close to each other such as in a nucleus. The nucleus is a gravitational sink in the plenum. This creates concentric waves with troughs in the plenum that are arranged in step increments. Walking drops show a similar arrangement (Bush 2015a, Fig. 1.(b)). The $\vec{\nabla}\rho$ change is small in the troughs around the nucleus. Electrons may travel around in these troughs without release of energy. The trough $\vec{\nabla}\rho$ in the radial direction holds the electron in the trough. The size of the nucleus determines the spacing and depth of the troughs. A further speculation is that the magnetic fields attracts and holds particle photons between the electrons and nucleus. The electrons are held in place by the troughs radially and the photons are not rotating around the nucleus. The troughs farther from the nucleus attract more hods to make higher energy photons. The electrons are also a mass that depresses the ρ in the trough. That is, there is a minimum limit on how far apart the electrons can be (Bush 2015a, Fig. 1.(f) and Fig. 4.). Therefore, several electrons can be in ther same nuclear trough. Electron changing trough This accounts for the required absorption and emission of photons with spectra characteristics.

5 Discussion and Conclusion

The goal is to build a self-consistent model of the universe. Poorly explained observations by other models are part of the STOE. The STOE suggested models of mysterious cosmology observations Hodge (2010).

What kind of experiment yet to be done could distinguish the STOE model from other models? Maxwell's equations are not models. The STOE suggests charge is the result of the $\vec{\nabla}\rho$ environment. The charge is the vortices in the plenum. Therefore, the effect of charge should decrease with decreasing motion or less $\vec{\nabla}\rho$. The spacing of the troughs and the number of electrons in the orbits may provide dimensions for the induced plenum waves.

The Scalar Theory of Everything (STOE) model of the universe has suggested that the small world has classical analogies that account for quantum effects and that there are only two components of the universe. Therefore, the characteristic of the plenum, hods, and their interactions must yield all the observed effects. The STOE was extended to speculate about other mysterious observations. The "voids" in the large-scale structure of the universe are explained in terms of hod magnetism. The characteristics of turbulent flow vortices describe charge. Models that suggest a point particle are describing the Newtonian Spherical property of the plenum rather than a physical dimension of particles. This yields the equation similarity between charge force and gravity force. The atomic line spectra of particle photons result from electrons in plenum troughs. The weird quantum postulates are unnecessary to explain the small-scale.

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Two Approaches to Measurability Conception and Quantum Theory

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Abstract

In the present article in terms of **measurability** conception, introduced in the previous papers of the author, the quantum theory is studied. Within the framework of this conception several examples are investigated in Schrodinger picture, analogs of Fourier transformations are constructed. It is shown how to produce **measurable** the analog of Heisenberg picture. At the end of the article the received results are used for substantiation, of other (more overall) definition of **measurability** conception, which, on the one hand, isn't grounded on Heisenberg Uncertainty Principle and its generalization, being the fundamental provisions of the previous papers of the author, and, on the other hand, it is equally suitable either for non-relativistic, or for relativistic cases.

1 Introduction.

The present work continues the previous papers, published by the author on the issue under research. [1]–[11]. The main idea and target of these works is to construct a correct quantum theory and gravity in terms of the variations (increments) dependent on the existent energies.

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It is clear that such a theory should not involve infinitesimal space-time variations

$$dt, dx_i, i = 1, ..., 3. \tag{1}$$

The main instruments specified in the above mentioned articles was **measurability** conception, introduced in [2].
Within the framework of the conception the theory becomes discrete, but at low energy levels E distant from the plank energies ones $E \ll E_p$ it becomes very close to the initial theory in continuous space-time paradigm.
In the present work quantum mechanics is studied in terms of **measurability** notion. In Sections 2,3 there are a short presentation, specializing and some supplementation of the previous results received by the author in relation to the non-relativistic and relativistic quantum theories.
Hereinafter in Section 4 **measurable** an analog of the Wave function and the Schrodinger Equation is considered, as well as main differential operators, appearing in quantum mechanics, in particular, the Laplace operator. **Measurable** analogs of the **momentum projection operator** and **momentum angular projection operator** are studied.
In terms of **measurability** concept, analogs of Fourier transformations are constructed. It is shown how to produce the **measurable** analog of the Heisenberg picture.
At the end of the article, in Section 5, the received results are used for substantiation, of other (more overall) definition of **measurability** conception, which, on the one hand, isn't grounded on Heisenberg Uncertainty Principle and its generalization, being the fundamental provisions of the previous papers of the author, and, on the other hand, it is equally suitable either for non-relativistic, or for relativistic cases.

2 Measurability Conception

2.1 Primary Measurability in Non-relativistic Case. Brief Reminding

In this Subsection we briefly recall the principal assumptions [2], that underlie further research.

According to **Definition I.** from [2] we call as **primarily measurable variation** any small variation (increment) $\widetilde{\Delta} x_i$ of any spatial coordinate x_i of the arbitrary point $x_i, i = 1, ..., 3$ in some space-time system R if it may be realized in the form of the uncertainty (standard deviation) Δx_i when this coordinate is measured within the scope of Heisenberg's Uncertainty Principle (HUP)[13],[14].
Similarly, we call any small variation (increment) $\widetilde{\Delta} x_0 = \widetilde{\Delta} t_0$ by **primarily measurable variation** in the value of time if it may be realized in the form of the uncertainty (standard deviation) $\Delta x_0 = \Delta t$ for pair "time-energy" (t, E) when time is measured within the scope of Heisenberg's Uncertainty Principle (HUP) too.
Next we introduce the following assumption:
Supposition II. There is the minimal length l_{min} as *a minimal measurement unit* for all **primarily measurable variations** having the dimension of length, whereas the minimal time $t_{min} = l_{min}/c$ as *a minimal measurement unit* for all quantities or **primarily measurable variations (increments)** having the dimension of time, where c is the speed of light.
According to HUP l_{min} and t_{min} lead to P_{max} and E_{max}. For definiteness, we consider that E_{max} and P_{max} are the quantities on the order of the Planck quantities, then l_{min} and t_{min} are also on the order of Planck quantities $l_{min} \propto l_P$, $t_{min} \propto t_P$. **Definition I.** and **Supposition II.** are quite natural in the sense that there are no physical principles with which they are inconsistent.
The combination of **Definition I.** and **Supposition II.** will be called the **Principle of Bounded Primarily Measurable Space-Time Variations (Increments)** or for short **Principle of Bounded Space-Time Variations (Increments)** with abbreviation (PBSTV).

As the minimal unit of measurement l_{min} is available for all the **primarily measurable variations** ΔL having the dimensions of length, the "Integrality Condition" (IC) is the case

$$\Delta L = N_{\Delta L} l_{min}, \tag{2}$$

where $N_{\Delta L} \ > \ 0$ is an integer number.
In a like manner the same "Integrality Condition" (IC) is the case for all the **primarily measurable variations** Δt having the dimensions of time. And similar to Equation (2), we get the for any time Δt:

$$\Delta t \equiv \Delta t(N_t) = N_{\Delta t} t_{min}, \tag{3}$$

where similarly $N_{\Delta t} \ > \ 0$ is an integer number too.

Definition 1(**Primary or Elementary Measurability.**)
(1) *In accordance with the PBSTV let us define the quantity having the dimensions of length or time as* **primarily (or elementarily) measurable***, when it satisfies the relation Equation (2) (and respectively Equation (3))*.
(2)*Let us define any physical quantity* **primarily (or elementarily) measurable***, when its value is consistent with points (1) of this Definition.*

Here HUP is given for the nonrelativistic case. In the next subsection we consider the relativistic case for low energies $E \ll E_P$ and show that for this case **Definition 1** (**Primary Measurability**) keeps its meaning. Further everywhere for convenience, we denote the minimal length $l_{min} \neq 0$ by ℓ and $t_{min} \neq 0$ by $\tau = \ell/c$.

2.2 Primary Measurability in Relativistic Case

In the Relativistic case HUP has the distinctive features ([16],Introduction). As known, in the relativistic case for **low energies** $E \ll E_P$, when the total energy of a particle with the mass m and with the momentum p equals [17]:

$$E = \sqrt{p^2c^2 + m^2c^4}, \tag{4}$$

a minimal value for Δx in general case takes the form ([16],formula(1.3))

$$\Delta q \approx \frac{c\hbar}{E} = \frac{\hbar}{\sqrt{p^2 + m^2c^2}}. \quad (5)$$

Nothing in this case prevents existing minimal length $\ell \neq 0$, and time $\tau = \ell/c$ and execution of the conditions (2) and (3). Particularly, in the equation (2) for $\Delta L = \Delta q$ due to the fact that $E \ll E_P$, we result in the following:

$$\Delta q = N_{\Delta q}\ell; N_{\Delta q} \gg 1. \quad (6)$$

The formula (5) can be rewritten as follows:

$$E \approx \frac{c\hbar}{N_{\Delta q}\ell} \quad (7)$$

And due to the fact that the integral number $N_{\Delta q} \gg 1$, in general, energy E may vary almost continuously, similar as in the canonical theory with $\ell = 0$. The similar equation (7) in this case can be applied for the momentum p from the right side of (5) as well. Obviously, p changes almost continuously. The analogue of (7) equation is easily to produce in the Ultrarelativistic case ($E \approx p$) and in a rest frame of a particle ($E \approx mc^2$). It is absolutely obvious that at **low energies** due to the abovementioned equations we receive almost continuous picture.
Therefore in relativistic case, at least at **low energies** $E \ll E_P$,**Definition 1** (**Primary Measurability**) of the previous subsection keeps its meaning, however, within the framework of the **Uncertainty Principle for Relativistic System** ([16],Introduction).

3 Generalized Measurability

3.1 Generalized Measurability and Generalized Uncertainty Principle

Basic results of this Subsection are contained in [2] and [15].
Further it is convenient to use the deformation parameter α_a. This parameter has been introduced earlier in the papers [18],[19],[20]–[23] as a

deformation parameter (in terms of paper [24]) on going from the canonical quantum mechanics to the quantum mechanics at Planck's scales (Early Universe) that is considered to be the quantum mechanics with the minimal length (QMML):

$$\alpha_a = \ell^2/a^2, \tag{8}$$

where a is the measuring scale. It is easily seen that the parameter α_a from Equation (8) is discrete as it is nothing else but

$$\alpha_a = \ell^2/a^2 = \frac{\ell^2}{N_a^2 \ell^2} = \frac{1}{N_a^2}. \tag{9}$$

At the same time, from Equation (9) it is evident that α_a is irregularly discrete.

It should be noted that, physical quantities complying with **Definition 1** won't be enough for the research of physical systems.

Indeed, such a variable as

$$\alpha_{N_a \ell}(N_a \ell) = p(N_a)\frac{\ell}{\hbar} = \ell/N_a, \tag{10}$$

(where $\alpha_{N_a \ell} = \alpha_a$ is taken from formula (9) at $a = N_a \ell$, and $p(N_a) = \frac{\hbar}{N_a \ell}$ is the corresponding **primarily measurable** momentum), is fully expressed in terms *only* **Primarily Measurable Quantities** of **Definition 1** and that's why it may appear at any stage of calculations, but apparently doesn't comply with **Definition 1**. That's why it's necessary to introduce the following definition generalizing **Definition 1**:

Definition 2. Generalized Measurability
We shall call any physical quantity as **generalized-measurable** or for simplicity **measurable** if any of its values may be obtained in terms of **Primarily Measurable Quantities** of **Definition 1**.

In what follows, for simplicity, we will use the term **Measurability** instead of **Generalized Measurability**. It is evident that any **primarily measurable quantity (PMQ)** is **measurable**. Generally speaking, the contrary is not correct, as indicated by formula (10).

It should be noted that Heisenberg's Uncertainty Principle (HUP) [14] is fair at low energies $E \ll E_P$. However it was shown that at the Planck scale a high-energy term must appear:

$$\Delta x \geq \frac{\hbar}{\Delta p} + \alpha' l_p^2 \frac{\Delta p}{\hbar} \tag{11}$$

where l_p is the Planck length $l_p^2 = G\hbar/c^3 \simeq 1,6\ 10^{-35}m$ and α' is a constant. In [25] this term is derived from the string theory, in [26] it follows from the simple estimates of Newtonian gravity and quantum mechanics, in [27] it comes from the black hole physics, other methods can also be used [29],[28],[34]. Relation (11) is quadratic in Δp

$$\alpha' l_p^2 \, (\Delta p)^2 - \hbar \, \Delta x \Delta p + \hbar^2 \leq 0 \tag{12}$$

and therefore leads to the minimal length

$$\Delta x_{min} = 2\sqrt{\alpha'} l_p \doteq \ell \tag{13}$$

Inequality (11) is called the Generalized Uncertainty Principle (GUP) in Quantum Theory.
Let us show that the **generalized-measurable** quantities are appeared from the **Generalized Uncertainty Principle (GUP)** [25]–[36] (formula (11)) that naturally leads to the minimal length ℓ (13).
Really solving inequality (11), in the case of equality we obtain the apparent formula

$$\Delta p_{\pm} = \frac{(\Delta x \pm \sqrt{(\Delta x)^2 - 4\alpha' l_p^2})\hbar}{2\alpha' l_p^2}. \tag{14}$$

Next, into this formula we substitute the right-hand part of formula (2) for $L = x$. Considering (13), we can derive the following:

$$\Delta p_{\pm} = \frac{(N_{\Delta x} \pm \sqrt{(N_{\Delta x})^2 - 1})\hbar \ell}{\frac{1}{2}\ell^2} = \\ = \frac{2(N_{\Delta x} \pm \sqrt{(N_{\Delta x})^2 - 1})\hbar}{\ell}. \tag{15}$$

But it is evident that at low energies $E \ll E_p; N_{\Delta x} \gg 1$ the plus sign in the nominator (15) leads to the contradiction as it results in very high (much greater than the Planck's) values of Δp. Because of this, it is necessary to select the minus sign in the numerator (15). Then, multiplying the left and right sides of (15) by the same number $N_{\Delta x} + \sqrt{N_{\Delta x}^2 - 1}$, we get

$$\Delta p = \frac{2\hbar}{(N_{\Delta x} + \sqrt{N_{\Delta x}^2 - 1})\ell}. \tag{16}$$

Δp from formula (16) is the **generalized-measurable** quantity in the sense of **Definition 2.** However, it is clear that at low energies $E \ll E_p$, i.e. for $N_{\Delta x} \gg 1$, we have $\sqrt{N_{\Delta x}^2 - 1} \approx N_{\Delta x}$. Moreover, we have

$$\lim_{N_{\Delta x} \to \infty} \sqrt{N_{\Delta x}^2 - 1} = N_{\Delta x}. \tag{17}$$

Therefore, in this case (16) may be written as follows:

$$\Delta p \doteq \Delta p(N_{\Delta x}, HUP) = \frac{\hbar}{1/2(N_{\Delta x} + \sqrt{N_{\Delta x}^2 - 1})\ell} \approx \frac{\hbar}{N_{\Delta x}\ell} = \frac{\hbar}{\Delta x}; N_{\Delta x} \gg 1, \tag{18}$$

in complete conformity with HUP. Besides, $\Delta p \doteq \Delta p(N_{\Delta x}, HUP)$, to a high accuracy, is a **primarily measurable** quantity in the sense of **Definition 1**.

And vice versa it is obvious that at high energies $E \approx E_p$, i.e. for $N_{\Delta x} \approx 1$, there is no way to transform formula (16) and we can write

$$\Delta p \doteq \Delta p(N_{\Delta x}, GUP) = \frac{\hbar}{1/2(N_{\Delta x} + \sqrt{N_{\Delta x}^2 - 1})\ell}; N_{\Delta x} \approx 1. \tag{19}$$

At the same time, $\Delta p \doteq \Delta p(N_{\Delta x}, GUP)$ is a **Generalized Measurable** quantity in the sense of **Definition 2**.

Thus, we have

$$GUP \to HUP \tag{20}$$

for

$$(N_{\Delta x} \approx 1) \to (N_{\Delta x} \gg 1). \tag{21}$$

Also, we have

$$\Delta p(N_{\Delta x}, GUP) \to \Delta p(N_{\Delta x}, HUP), \tag{22}$$

where $\Delta p(N_{\Delta x}, GUP)$ is taken from formula (19), whereas $\Delta p(N_{\Delta x}, HUP)$ from formula (18).

Comment 2.*
From the above formulae it follows that, within GUP, the **primarily measurable** *variations (quantities) are derived to a high accuracy from the* **generalized-measurable** *variations (quantities) only in the low-energy limit $E \ll E_P$*

Next, within the scope of GUP, we can correct a value of the parameter α_a from formula (9) substituting a for Δx in the expression $1/2(N_{\Delta x} + \sqrt{N_{\Delta x}^2 - 1})\ell$.
Then at low energies $E \ll E_p$ we have the **primarily measurable** quantity $\alpha_a(HUP)$

$$\alpha_a \doteq \alpha_a(HUP) = \frac{1}{[1/2(N_a + \sqrt{N_a^2 - 1})]^2} \approx \frac{1}{N_a^2}; N_a \gg 1, \tag{23}$$

that corresponds, to a high accuracy, to the value from formula (9).
Accordingly, at high energies we have $E \approx E_p$

$$\alpha_a \doteq \alpha_a(GUP) = \frac{1}{[1/2(N_a + \sqrt{N_a^2 - 1})]^2}; N_a \approx 1. \tag{24}$$

When going from high energies $E \approx E_p$ to low energies $E \ll E_p$, we can write

$$\alpha_a(GUP) \stackrel{(N_a \approx 1) \to (N_a \gg 1)}{\longrightarrow} \alpha_a(HUP) \tag{25}$$

in complete conformity to *Comment 2*.*
Remark 3.1 What is the main difference between **Primarily Measurable Quantities (PMQ)** and **Generalized Measurable Quantities (GMQ)**? **PMQ** defines variables which may be obtained as a result of an immediate experiment. **GMQ** defines the variables which may be *calculated* based on **PMQ**, i.e. based on the data obtained in previous clause.

Remark 3.2. It is readily seen that a minimal value of $N_a = 1$ is *unattainable* because in formula (19) we can obtain a value of the length l that is below the minimum $l < \ell$ for the momenta and energies above the maximal ones, and that is impossible. Thus, we always have $N_a \geq 2$. This fact was indicated in [18],[19], however, based on the other approach.

The above mentioned formula result to the fact that **generalized measurable** momenta at all energies are the following:

$$p_{1/N} \doteq p(1/N, \ell), N \neq 0 \tag{26}$$

where $\ell = \kappa l_p$ and κ is the constant of order 1.
Therefore, $p_{1/N}$ depends only on three fundamental constants $c, \hbar, G$, constant κ and discrete parameters $1/N$.
However, at $N \gg 1$, i.e. at $E \ll E_p$ imaging $\tau : 1/N \Rightarrow p_{1/N}$ will be almost continuous, which provides high match accuracy of this discrete model coincidence with the initial continuous theory.
The main objective target by the author is to get the quantum theory and the gravitation within the concepts of **primarily measurable** quantities. As in this case the theories become discrete, there will be a need of further lattice representation.

3.2 Space and Momentum Lattices of Generalized Measurable Quantities, and $\alpha - lattice$

In this Subsection are refined and supplemented ed the results from [2],[10]. So, provided the minimal length ℓ exists, two lattices are naturally arising according to the formulas of the previous subsection.
I. At low energies (LE) $E \ll E_{max} \propto E_P$, lattice of the space variation—$Lat_S[LE]$ representing, for sets integers $|N_w| \gg 1$ to within the known multiplicative constants, in accordance with the above formulas for each of the three space variables $w \doteq x; y; z$.

$$Lat_S[LE] = (N_w \doteq \{N_x, N_y, N_z\}), |N_x| \gg 1, |N_y| \gg 1, |N_z| \gg 1. \tag{27}$$

At high energies (HE) $E \to E_{max} \propto E_P$ to within the known multiplicative constants too in accordance with the formulas previous subsection we have the lattice $Lat_S[HE]$ for each of the three space variables $w \doteq x; y; z$.

$$Lat_S[HE] \doteq (\pm 1/2[(N_w + \sqrt{N_w^2 - 1})]); 2 \leq (N_w \doteq \{N_x, N_y, N_z\}) \approx 1. \tag{28}$$

II. Next let us define the lattice momentum variation Lat_P as a set to obtain (p_x, p_y, p_z) for low energies $E \ll E_P$, where all the components of the above sets conform to the space coordinates (x, y, z) are given by corresponding formulae from the previous subsection.
From this it is inferred that, in analogy with point I of this subsection, within the known multiplicative constants, we have lattice $Lat_P[LE]$

$$Lat_P[LE] \doteq (\frac{1}{N_w}), \tag{29}$$

where N_w are integer numbers from Equation (27).
In accordance with formulas (19), (28), the high-energy (HE) momentum lattice $Lat_P[HE]$ takes the form

$$Lat_P[HE] \doteq (\pm \frac{1}{1/2[(N_w + \sqrt{N_w^2 - 1})]}), \tag{30}$$

where N_w are integer numbers from Equation (28).
It is important to note the following.

In the low-energy lattice $Lat_P[LE]$ all elements are varying very smoothly enabling the approximation of a continuous theory.
It is clear that lattices $Lat_S[LE]$ and $Lat_P[LE]$ are lattices **primarily measurable** quantities, while lattices $Lat_S[HE]$ and $Lat_P[HE]$ are lattices **generalized measurable** quantities.

We will expand the space lattice $Lat_S[LE]$ to space-time lattice $Lat_{S-T}[LE]$:

$$\begin{aligned} Lat_{S-T}[LE] \doteq (N_w, N_t), N_w \doteq \{N_x, N_y, N_z\}, \\ |N_x| \gg 1, |N_y| \gg 1, |N_z| \gg 1, |N_t| \gg 1 \end{aligned} \tag{31}$$

Now **primarily** lattice $Lat_{S-T}[LE]$ will be replaced with "$\alpha-lattice$", **measurable space-time quantities**, which will be denoted by $Lat^{\alpha}_{S-T}[LE]$:

$$Lat^{\alpha}_{S-T}[LE] \doteq (\alpha_{N_w\ell}N_w\ell, \alpha_{N_t\tau}N_t\tau) = (\frac{\ell^2}{\hbar}p(N_w), \frac{\ell^2}{\hbar}p(N_t)) = (\frac{\ell}{N_w}, \frac{\tau}{N_t}). \quad (32)$$

In the last formula by the variable $\alpha_{N_t\tau}$ we mean the parameter α corresponding to the length $(N_t\tau)c$:

$$\alpha_{N_t\tau} \doteq \alpha_{(N_t\tau)c}. \quad (33)$$

And $p(N_w)$ it is taken from formula (10), where N_t corresponds formula (32). As low energies $E \ll E_P$ are discussed, $\alpha_{N_w\ell}$ in this formula is consistent with the corresponding parameter from formula (23):

$$\alpha_{N_w\ell} = \alpha_{N_w\ell}(HUP) \quad (34)$$

As it was mentioned in the previous section, in the low-energy $E \ll E_{max} \propto E_P$ all elements of sublattice $Lat_{P-E}[LE]$ are varying very smoothly enabling the approximation of a continuous theory.
It is similar to the low-energy part of the $Lat^{\alpha}_{S-T}[LE]$ of lattice Lat^{α}_{S-T} will vary very smoothly:

$$Lat^{\alpha}_{S-T}[LE] = (\frac{\ell}{N_w}, \frac{\tau}{N_t}); |N_x| \gg 1, |N_y| \gg 1, |N_z| \gg 1, |N_t| \gg 1. \quad (35)$$

In Section 5 of [2] three following cases were selected:

(a) *"Quantum Consideration, Low Energies"*:

$$1 \ll |N_w| \leq \widetilde{\mathbf{N}}, 1 \ll |N_t| \leq \widehat{\mathbf{N}}$$

(b) *"Quantum Consideration, High Energies"*:

$$|N_w| \approx 1, |N_t| \approx 1;$$

(c) *"Classical Picture"*:

$$|N_w| \to \infty, |N_t| \to \infty.$$

Here $\widetilde{\mathbf{N}}, \widehat{\mathbf{N}}$ is a cutoff parameters, defined by the current task [2] and corrected in this paper.
Let us for three space coordinates $x_i; i = 1,2,3$ we introduce the following notation:

$$\Delta(x_i) \doteq \widetilde{\Delta}[\alpha_{N_{\Delta x_i}}] = \alpha_{N_{\Delta x_i}\ell}(N_{\Delta x_i}\ell) = \ell/N_{\Delta x_i};$$
$$\frac{\Delta_{N_{\Delta x_i}}[F(x_i)]}{\Delta(x_i)} \equiv \frac{F(x_i + \Delta(x_i)) - F(x_i)}{\Delta(x_i)}, \tag{36}$$

where $F(x_i)$ is **"measurable"** function, i.e function represented in terms of **measurable** quantities.
Then function $\Delta_{N_{\Delta x_i}}[F(x_i)]/\Delta(x_i)$ is **"measurable"** function too.
It's evident that

$$\lim_{|N_{\Delta x_i}|\to\infty} \frac{\Delta_{N_{\Delta x_i}}[F(x_i)]}{\Delta(x_i)} = \lim_{\Delta(x_i)\to 0} \frac{\Delta_{N_{\Delta x_i}}[F(x_i)]}{\Delta(x_i)} = \frac{\partial F}{\partial x_i}. \tag{37}$$

Thus, we can define a **measurable** analog of a vectorial gradient ∇

$$\nabla_{\mathbf{N_{\Delta x_i}}} \equiv \{\frac{\Delta_{N_{\Delta x_i}}}{\Delta(x_i)}\} \tag{38}$$

and a **measurable** analog of the Laplace operator

$$\boldsymbol{\Delta}_{(N_{\Delta x_i})} \equiv \nabla_{\mathbf{N_{\Delta x_i}}} \nabla_{\mathbf{N_{\Delta x_i}}} \equiv \sum_i \frac{\Delta^2_{N_{\Delta x_i}}}{\Delta(x_i)^2} \tag{39}$$

Respectively, for time $x_0 = t$ we have:

$$\Delta(t) \doteq \widetilde{\Delta}[\alpha_{N_{\Delta t}}] = \alpha_{N_{\Delta t}\tau}(N_{\Delta t}\tau) = \tau/N_{\Delta t};$$
$$\frac{\Delta_{N_{\Delta t}}[F(t)]}{\Delta(t)} \equiv \frac{F(t + \Delta(t)) - F(t)}{\Delta(t)}, \tag{40}$$

then

$$\lim_{|N_{\Delta t}|\to\infty}\frac{\Delta_{N_{\Delta t}}[F(t)]}{\Delta(t)}=\lim_{\Delta(t)\to 0}\frac{\Delta_{N_{\Delta t}}[F(t)]}{\Delta(t)}=\frac{dF}{dt}. \qquad (41)$$

We shall designate for momenta $p_i; i=1,2,3$

$$\Delta p_i=\frac{\hbar}{N_{\Delta x_i}\ell};$$

$$\frac{\Delta_{p_i}F(p_i)}{\Delta p_i}\equiv\frac{F(p_i+\Delta p_i)-F(p_i)}{\Delta p_i}=\frac{F(p_i+\frac{\hbar}{N_{\Delta x_i}\ell})-F(p_i)}{\frac{\hbar}{N_{\Delta x_i}\ell}}. \qquad (42)$$

From where similarly (37) we get

$$\lim_{|N_{\Delta x_i}|\to\infty}\frac{F(p_i+\Delta p_i)-F(p_i)}{\Delta p_i}=\lim_{|N_{\Delta x_i}|\to\infty}\frac{F(p_i+\frac{\hbar}{N_{\Delta x_i}\ell})-F(p_i)}{\frac{\hbar}{N_{\Delta x_i}\ell}}=$$

$$=\lim_{\Delta p_i\to 0}\frac{F(p_i+\Delta p_i)-F(p_i)}{\Delta p_i}=\frac{\partial F}{\partial p_i}. \qquad (43)$$

Therefore, in low energies $E\ll E_P$, i.e. at $|N_{\Delta x_i}|\gg 1; |N_{\Delta t}|\gg 1, i=1,...,3$ in passages to the limit (37),(41),(43) it's possible to obtain from **"measurable"** functions partial derivatives like in case of continuous space-time. That is, the partial derivatives of from **"measurable"** functions can be considered as **"measurable"** functions with any given precision.
In this case the infinitesimal space-time variations (1) are appearing in the limit from **measurable** quantities too

$$(\alpha_{N_{\Delta t}\tau}N_{\Delta t}\tau=\frac{\tau}{N_{\Delta t}}=p_{N_{\Delta t}c}\frac{\ell^2}{c\hbar})\stackrel{N_{\Delta t}\to\infty}{\longrightarrow}dt,$$

$$(\alpha_{N_{\Delta x_i}\ell}N_{\Delta x_i}\ell=\frac{\ell}{N_{\Delta x_i}}=p_{N_{\Delta x_i}}\frac{\ell^2}{\hbar})\stackrel{N_{\Delta x_i}\to\infty}{\longrightarrow}dx_i, 1=1,...,3. \qquad (44)$$

Remark 3.2.1
Thereinafter, as it is mentioned above, we suppose that energies E are low,

i.e. $E \ll E_p$.
Up to the present moment there was a default precondition that all numbers $N_{\Delta x_i}, N_{\Delta t}$ are integral, which means they produce **primarily measurable** spacetime quantities $N_{\Delta x_i}\ell$ and $N_{\Delta t}\tau$. Currently we realize that this limitation is irrelevant, taking into account the fact that unless specially noted otherwise, $N_{\Delta x_i}\ell, N_{\Delta t}\tau$ are **generalized measurable** (or simply **measurable**) quantities. At that, due to the fact that energies E are low $E \ll E_P$ the following condition is preserved:

$$|N_{\Delta x_i}| \gg 1; |N_{\Delta t}| \gg 1, i = 1, ..., 3. \tag{45}$$

Therefore, in the formula (44) momenta $p_{N_{\Delta x_i}}, p_{N_{\Delta t}c}$ from this moment are **generalized measurable** quantities. The evident example of such momenta can be accurate (not approximate) value from the equation (18)

$$p_{N_{\Delta x_i}} = \frac{\hbar}{1/2(N_{\Delta x_i} + \sqrt{N^2_{\Delta x_i} - 1})\ell}; N_{\Delta x_i} \gg 1, \tag{46}$$

It is also obvious that if $N_{\Delta x_i}\ell$ and $N_{\Delta t}\tau$ are **measurable** quantities, then numeric coefficients $N_{\Delta x_i}$ and $N_{\Delta t}$ are also **measurable** quantities.
In this case any **measurable** triplet $N_q = \{N_{\Delta x_i}\}, |N_{\Delta x_i}| \gg 1, i = 1, ..., 3$ corresponds to small **measurable** momentum $\mathbf{p_{N_q}} \doteq \{p_{N_{\Delta x_i}}\}$, with components $p_{N_{\Delta x_i}}, |p_{N_{\Delta x_i}}| \ll P_{pl}$:

$$N_{\Delta x_i} \xrightarrow{\mathbf{p}} p_{N_{\Delta x_i}} = \frac{\hbar}{N_{\Delta x_i}\ell} \tag{47}$$

And vice versa any small **measurable** momentum $\mathbf{p_q}$ with non-zero components $\mathbf{p_q} = \{p_i\}; 0 \neq |p_i| \ll P_{pl}$ corresponds to **measurable** triplet $N_q = \{N_{\Delta x_i}\}, |N_{\Delta x_i}| \gg 1, i = 1, ..., 3$, satisfying the condition (45):

$$p_i \xrightarrow{\mathbf{x}} N_{\Delta x_i} = \frac{\hbar}{p_i\ell} \tag{48}$$

Then, for simplification, instead of $N_{\Delta x_\mu}$ we will use $N_{x_\mu}, \mu = 0, ..., 3$.

4 Quantum Mechanics in Term of Measurable Quantities

4.1 General Remarks on Wavefunction Representation

Now for any coordinate u from the set $q \doteq (x, y, z) \in \mathbb{R}^3$ and some **measurable** quantity $N_u\ell; |N_u| \gg 1$ one can correlate **measurable** quantity $\Delta_{N_u}(u) = \ell/N_u$, and for $N_q \doteq \{N_x, N_y, N_z\}$ – **measurable** product

$$\Delta_{N_q}(q) = |\Delta_{N_x}(x) \cdot \Delta_{N_y}(y) \cdot \Delta_{N_z}(z)| = \frac{\ell^3}{|N_x N_y N_z|} \tag{49}$$

Then it becomes clear that for **measurable** of the wave function $\Psi(q)$, ($\Psi(q)$ is determined within the framework of the concepts of **measurable** of the spatial coordinates q, i.e. all changes of q are **measurable**), we can determine the value

$$|\Psi(q)|^2 \Delta_{N_q}(q), \tag{50}$$

which is the probability that the measurement carried out with the system presents the coordinate value in **measurable** in volume element $\Delta_{N_q}(q)$ of configuration space.
At that, known condition for total probability in the continuous case [14]:

$$\int |\Psi(q)|^2 dq = 1 \tag{51}$$

with any predefined accuracy is replaced by the condition

$$\sum_q |\Psi(q)|^2 \Delta_{N_q}(q) = 1. \tag{52}$$

Actually, due to the equation (44) **measurable** the volume element $\Delta_{N_q}(q)$ of configuration space can be considered as close as it can to dq which means that **measurable** element $q + \Delta_{N_q}(q)$ can be considered close to **nonmeasurable** element $q + dq$.

It is obvious that set of **measurable** functions create space, in which integrals of the continuous theory, if any, are replaced into the correspondent sums for **measurable** values, and dq is replaced onto $\Delta_{N_q}(q)$. This space very close to the correspondent Hilbert space in the continuous theory in limit of large $|N_q|$.
In particular, normalization condition for **measurable** eigenfunction Ψ_n of the given **measurable** physical value f changes from continuous consideration to the **measurable** consideration, as follows:

$$(\int |\Psi_n|^2 dq = 1) \mapsto (\sum_q |\Psi_n|^2 \Delta_{N_q}(q) = 1) \tag{53}$$

We have similarly:

$$\int \Psi\Psi^* dq \mapsto \sum_q \Psi\Psi^* \Delta_{N_q}(q) \tag{54}$$

It is easily noticeable that for spaces **measurable** of the functions, all main properties of the canonical quantum mechanics can be redefinied with the replacement of the integrals by the corresponding sums and dq onto $\Delta_{N_q}(q)$ (as in the formula (53),(54)).

4.2 Schrodinger Equation and Other Equations of Quantum Mechanics in "Measurable" Format

4.2.1 Schrodinger Equation for Free Particle

Let us consider the Schrodinger Equation [14] in terns of **measurable quantities**. As it is shown in the formula (44) taking into account **Remark 3.2.1** in low energies $E \ll E_P$ (i.e. at $|N_{x_\mu}| \gg 1$), the infinitesimal space-time variations $dx_\mu, \mu = 0, ..., 3$ are occurred within the limits of $|N_{x_\mu}| \to \infty$ from **measurable** momenta $p_{N_{x_i}}, (p_{N_t c})$ multiplied by the constant $\frac{\ell^2}{\hbar}, (\frac{\ell^2}{c\hbar})$ which is nothing else than $\ell/N_{x_i}, \tau/N_t$.
Therefore in all cases we should comply to the following conditions: $|N_{x_i}| \gg 1, |N_t| \gg 1; i = 1, ..., 3$

Then **measurable** N_t-*analog* of the derivative **measurable** wavefunction $\Psi(t)$ in the continuous case will be nothing else than

$$\frac{\Delta_{N_t}[\Psi(t)]}{\Delta(t)} \doteq \frac{\Psi(t+\tau/N_t)-\Psi(t)}{\tau/N_t}, \tag{55}$$

and **measurable** N_t-*analog* of the Schrodinger Equation

$$\frac{d\Psi(t)}{dt} = \frac{1}{\imath\hbar}\widehat{H}\Psi(t) \tag{56}$$

will be the following:

$$\frac{\Delta_{N_t}[\Psi(t)]}{\Delta(t)} = \frac{\Psi(t+\tau/N_t)-\Psi(t)}{\tau/N_t} = \frac{1}{\imath\hbar}\widehat{H}_{meas}\Psi(t), \tag{57}$$

where $\widehat{H}_{meas}$ – some **measurable** analog of the Hamiltonian $\widehat{H}$ in the continuous case, which means $\widehat{H}_{meas}$ – operator, expressed in the terms of **measurable** values.
We consider the example of the Schrodinger Equation for a free particle [14]

$$\imath\hbar\frac{\partial}{\partial t}\Psi(\mathbf{r},t) = -\frac{\hbar^2}{2m}\boldsymbol{\Delta}\Psi(\mathbf{r},t), \tag{58}$$

where $\boldsymbol{\Delta} \equiv \nabla\nabla \equiv \frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}+\frac{\partial^2}{\partial z^2}$ is a Laplace operator and m is a particle's mass.
The formula(39) initially considered for the case integral numbers $N_{x_i}, |N_{x_i}| \gg 1$. However, due to **Remark 3.2.1**, it remains right for any **measurable** numbers $N_{x_i}, |N_{x_i}| \gg 1$.
From this formula we can conclude that

$$\lim_{|N_{x_i}|\to\infty} \boldsymbol{\Delta}_{(N_{x_i})} = \boldsymbol{\Delta} \tag{59}$$

Then the condition $|N_t| \gg 1, |N_{x_i}| \gg 1$ allows to state that **measurable** Schrodinger Equation analog (58):

$$\imath\hbar\frac{\Delta_{N_t}}{\Delta(t)}\Psi(\mathbf{r},t) = -\frac{\hbar^2}{2m}\boldsymbol{\Delta}_{(N_{x_i})}\Psi(\mathbf{r},t), \tag{60}$$

at rather large, but finite $|N_t|, |N_{x_i}|$ complies to the Schrodinger Equation in the continuous case with any preset accuracy.
Similary, from the formula for **measurable** momentum value at low energies $E \ll E_P$

$$p_{N_{x_i}} = \frac{\hbar}{N_{x_i}\ell} \tag{61}$$

as well as the equation (38) for **measurable** analog of a vectorial gradient $\nabla_{\mathbf{N_{\Delta x_i}}}$, and the equations (36),(37) leads to the fact that accordance in **measurable** case

$$\mathbf{p_{N_{x_i}}} \doteq \mathbf{p_{N_q}} \mapsto \frac{\hbar}{\imath}\nabla_{\mathbf{N_q}}, \tag{62}$$

can with any preset accuracy reproduce the accordance in the continuous case

$$\mathbf{p} \mapsto \frac{\hbar}{\imath}\nabla \tag{63}$$

As it is for **measurable** energy value

$$E_{N_q} = \frac{p_{N_q}^2}{2m} = \frac{p_{N_x}^2 + p_{N_y}^2 + p_{N_z}^2}{2m} \tag{64}$$

the accordance

$$E_{N_q} \mapsto \imath\hbar\frac{\Delta_{N_t}}{\Delta(t)} \tag{65}$$

reproduces the accordance

$$E \mapsto \imath\hbar\frac{\partial}{\partial t} \tag{66}$$

of the continuous theory.
So,in terms of **measurable** quantities we can get the discrete model as close as it can to the source continuous theory.

From this we can make a direct conclusion that **measurable** wavefunction $\Psi_{meas}(\mathbf{r}, t, \mathbf{N_q}, N_t)$, which has form

$$\Psi_{meas}(\mathbf{r}, t, \mathbf{N_q}, N_t) = Aexp\{\imath(\frac{\mathbf{p_{N_q}r}}{\hbar} - \frac{\mathbf{E_{N_q}r}}{\hbar})\}, \tag{67}$$

where $\mathbf{r}$ and t – **measurable** with an exact accuracy reproduces the correspondent wavefunction $\Psi(\mathbf{r}, t)$ in the continuous case [14].
The certain example is presented above in the text. However, it is absolutely obvious that on its basis we can make more common conclusions.
Measurable analog $\widehat{H}_{meas}$ of Hamiltonian $\widehat{H}$ from the equation (57) has the following form on the common case

$$\widehat{H}_{meas} = \widehat{H}_{meas}(N_q), \tag{68}$$

where N_q is **measurable** and

$$\lim_{|N_q| \to \infty} \widehat{H}_{meas} = \widehat{H}. \tag{69}$$

And as

$$\lim_{|N_t| \to \infty} \frac{\Delta_{N_t}[\Psi(t))]}{\Delta(t)} = \frac{d\Psi(t)}{dt}, \tag{70}$$

then in the common case in the passage to the limit at $|N_q| \to \infty, |N_t| \to \infty$ from **measurable** analog of the Schrodinger equation (57) we can get the Schrodinger equation (56) in the continuous picture.
At that we can suppose that all variables including time t, influencing the wavefunction ψ are **measurable** quantities, the similar supposition is correct for the Hamiltonian $\widehat{H}_{meas}$.
Now we can suppose without losing commonness that the values $|N_q| \gg 1$ are large enough and we can practically think that **measurable** the Hamiltonian analog $\widehat{H}_{meas}$ with an high accuracy is equal to the Hamiltonian in the continuous case

$$\widehat{H}_{meas} = \widehat{H} \tag{71}$$

Then at the fixed large module N_t and **measurable** ψ **measurable** analog of the Schrodinger equation (57) can be solved recurrently

$$\Psi(t+\tau/N_t) = (\frac{\tau}{\imath N_t \hbar}\widehat{H}+1)\Psi(t). \tag{72}$$

Taking as an some initial point t **measurable** value $\psi(t)$ (possibly $t=0$), placing it to the right side (72), and then repeating this procedure but for the calculated value from the left side $\Psi(t+\tau/N_t)$ we can get function $\Psi(t+\Delta t)$ for arbitrary $\Delta t = K\tau/N_t$, where K is any natural number. It is obviously that if N_t- integer number then **primarily measurable variations** in this case will correspondent to the integer $K; K = \mathcal{M}N_t$, where $\mathcal{M}$ – integer number. And as $(E \ll E_P)$, then $|\mathcal{M}| \gg 1$.
Further denoting

$$(\frac{\tau}{\imath N_t \hbar}\widehat{H}+1) \doteq \widehat{U}(\tau/N_t) \tag{73}$$

we receive that

$$\frac{1}{\imath\hbar}\widehat{H} = \frac{\widehat{U}(\tau/N_t)-1}{\tau/N_t} \tag{74}$$

Here we, as a matter of course, can suppose that $U(0)=1$ and according (57)

$$\frac{\Delta_{N_t}[\widehat{U}(t')]}{\Delta(t)} \doteq \frac{\widehat{U}(t'+\tau/N_t)-\widehat{U}(t')}{\tau/N_t}, \tag{75}$$

we receive, that

$$\frac{\Delta_{N_t}[\widehat{U}(t')]}{\Delta(t)}|_{t'=0} = \frac{1}{\imath\hbar}\widehat{H} \tag{76}$$

which is in an exact accordance to the known formula in the continuous case

$$\widehat{H} = \imath\hbar\frac{d\widehat{U}(t')}{dt'}|_{t'=0} \tag{77}$$

Operator $\widehat{U}(t')$, satisfying to the equations (73)–(76) can be denoted as $\widehat{U}_{N_t}$. It is trivial implication from the abovementioned formula that

$$\Psi(t+\tau/N_t)=\widehat{U}(\tau/N_t)\Psi(t) \tag{78}$$

The presented calculations can be generalized for non-autonomous systems, when the hamiltonian $\widehat{H},(\widehat{H}_{meas})$ depends on time t, i.e. $\widehat{H}=\widehat{H}(t)$ and the condition (71) is preserved. In this case we can suppose that all values (operators and wavefunction) are **measurable** quantities,therefore we can receive:

$$\Psi(t+\tau')=\widehat{U}(t+\tau',t)\Psi(t),$$
$$\frac{\Delta_{N_t}}{\Delta(t)}\Psi(t)=\frac{\Delta_{N_t}[\widehat{U}(t+\tau',t)]}{\Delta(\tau')}|_{(\Delta(\tau')=\tau/N_t)}\Psi(t)=\frac{1}{\imath\hbar}\widehat{H}(t)\Psi(t),$$
$$\widehat{H}(t)=\imath\hbar\frac{\Delta_{N_t}[\widehat{U}(t+\tau',t)]}{\Delta(\tau')}|_{\Delta(\tau')=\tau/N_t} \tag{79}$$

Obviously, in the present equation one can reproduce all main formulas of the continuous case replacing dt onto τ/N_t, particular:

$$\widehat{U}^{\dagger}(t+\tau/N_t,t)=(\widehat{1}+\frac{\tau}{N_t}\frac{\widehat{H}}{\imath\hbar}+o(\frac{\tau}{N_t}))^{\dagger}=\widehat{1}-\frac{\tau}{N_t}\frac{\widehat{H}^{\dagger}}{\imath\hbar}+o(\frac{\tau}{N_t})=$$
$$=\widehat{U}^{-1}(t+\tau/N_t,t)=(\widehat{1}+\frac{\tau}{N_t}\frac{\widehat{H}}{\imath\hbar}+o(\frac{\tau}{N_t}))^{-1}=\widehat{1}-\frac{\tau}{N_t}\frac{\widehat{H}}{\imath\hbar}+o(\frac{\tau}{N_t}) \tag{80}$$

What is the meaning of changing dt onto τ/N_t and transition from continuous case to discrete case in the terms of **measurable quantities**? It is assumed that the following **Hypothesis** is valid :

at low energies $E\ll E_P$, i.e. at $|N_t|\gg 1$ for any wavefunction $\Psi(t)$ exists such natural number $\mathbf{N}(\psi),|\mathbf{N}(\psi)|\gg 1$ which is dependent from $\Psi(t)$ with unimprovable approximation of the Schrodinger equation (56) by the discrete equation (57). Of course, obviously, that $1\ll|N_t|\leq|\mathbf{N}(\psi)|$.

4.2.2 The Linear Momentum Operator

It is known, the task for eigenvalues and eigenfunctions of momentum projection $\hat{p}_{x_i}$ in case of continuous space-time can be reduced to the differential equation [37]:

$$-\imath\hbar\frac{\partial\Psi(x_i)}{\partial x_i} = p_{x_i}\Psi(x_i). \quad (81)$$

One can find continuous single-valued and bounded solutions of this equation of all real values of p_{x_i} in the interval $-\infty < p_{x_i} < \infty$ with eigenfunctions

$$\Psi_p(x_i) = Aexp(\imath\frac{p}{\hbar}x_i). \quad (82)$$

Thus there is one eigenfunction (no degeneracy) for each eigenvalue $p_{x_i} = p$. As it was stated above, in the **measurable** case under consideration in the left side (82) for some **measurable** fixed $|N_{x_i}| \gg 1$ replacing occurs

$$\frac{\partial}{\partial x_i} \mapsto \frac{\Delta_{N_{x_i}}}{\Delta(x_i)} \quad (83)$$

and the eigenvalues $p_{N_{x_i}}$ of the operator $\hat{p}_{x_i}$ become discrete numbers N_{x_i}

$$p_{N_{x_i}} = \frac{\hbar}{N_{x_i}\ell}, |N_{x_i}| \gg 1 \quad (84)$$

but due to the condition $|N_{x_i}| \gg 1$ we receive **discrete** spectrum of operator $\hat{p}_{x_i}$, which is **almost continuous**.
Taking into account that at $|N_{x_i}|$ large enough with any preset accuracy we have

$$\frac{\Delta_{N_{x_i}}}{\Delta(x_i)} = \frac{\partial}{\partial x_i}, \quad (85)$$

and taking into account the formula (84), we can get the analog of formula (82) in the considered case

$$\Psi_{p_{N_{x_i}}}(x_i) = Aexp(\imath\frac{x_i}{N_{x_i}\ell}) \quad (86)$$

This shows that for the fixed x_i the correspondent discrete set of eigenfunctions also changes almost continuously.

It should be noted that the condition $-\infty < p_{x_i} < \infty$ in this case is non-correct, because

$$((p_{x_i} = p_{N_{x_i}}) \to \pm\infty) \equiv (|N_{x_i}| \to 1), \tag{87}$$

which contradicts to the condition $|N_{x_i}| \gg 1$.
However, for the real task the abstract condition $|N_{x_i}| \gg 1.$ is always replaced by some certain condition

$$|N_{x_i}| \geq \mathbf{N}_* \gg 1. \tag{88}$$

Then the condition $-\infty < p_{x_i} < \infty$ in the continuous case is replaced in the studied case with the condition $p_{-\mathbf{N}_*} \leq p_{x_i} \leq p_{\mathbf{N}_*}$ with the separated point $p_{x_i} = 0$, which is evidently doesn't belong to the equation (84) at the finite N_{x_i}.
It is clear that the case $N_{x_i} = \pm\infty$ appropriate of the point $p_{x_i} = 0$ is the degenerate case, that is why if we would like to consider the finite N_{x_i} the condition (88) should be replaced with the condition

$$\mathbf{N}^* \geq |N_{x_i}| \geq \mathbf{N}_* \gg 1. \tag{89}$$

and then $p_{x_i} \in [p_{-\mathbf{N}_*}, p_{-\mathbf{N}^*}] \bigcup [p_{\mathbf{N}^*}, p_{\mathbf{N}_*}]$
Further, we denote as $\Delta_{\mathbf{N}_*,\mathbf{N}^*}(p_{x_i})$ intervals union

$$\Delta_{\mathbf{N}_*,\mathbf{N}^*}(p_{x_i}) \doteq [p_{-\mathbf{N}_*}, p_{-\mathbf{N}^*}] \bigcup [p_{\mathbf{N}^*}, p_{\mathbf{N}_*}], \tag{90}$$

and as $\Delta_{\mathbf{N}_*}(\mathbf{p})$

$$\Delta_{\mathbf{N}_*,\mathbf{N}^*}(\mathbf{p}) = \prod_i \Delta_{\mathbf{N}_*,\mathbf{N}^*}(p_{x_i}) \tag{91}$$

4.2.3 The z-component of the Angular Momentum $\hat{L}_z$

In the accepted quantum mechanics the task of eigenvalues and eigenfunctions of angular momentum operator $\hat{L}_z$

$$\hat{L}_z = -\imath\hbar(x\frac{\partial}{\partial y} - y\frac{\partial}{\partial x}) \tag{92}$$

is reduced to the differential equation solution [37]

$$-\imath\hbar\frac{\partial\Psi(\phi)}{\partial\phi}=L_z\Psi(\phi), \tag{93}$$

where $0\leq\phi\leq 2\pi$.
In the considered case we can suppose that $\phi=\phi(x,y,z)$–**measurable** function from variables x,y,z, having in case of continuity well defined partial derivative for each of them.
It is obvious that substitution into the formula (37) $F(x_i)=\phi(x,y,z)$ gives

$$\lim_{|N_{\Delta x_i}|\rightarrow\infty}\frac{\Delta_{N_{\Delta x_i}}[\phi(x,y,z)]}{\Delta(x_i)}=\lim_{\Delta(x_i)\rightarrow 0}\frac{\Delta_{N_{\Delta x_i}}[\phi(x,y,z))]}{\Delta(x_i)}=\frac{\partial\phi}{\partial x_i}. \tag{94}$$

On the abovementioned basis we can state that there is **measurable** function $\Delta\Psi/\Delta\phi$ and we have

$$\lim_{\Delta\phi\rightarrow 0}\frac{\Delta\Psi}{\Delta\phi}=\lim_{|N_{\Delta x_i}|\rightarrow\infty}\frac{\Delta\Psi}{\Delta\phi}=\frac{\partial\Psi}{\partial\phi}, \tag{95}$$

where $\Delta\phi(x_i)=\sum_i(\phi(x_i+\Delta x_i)-\phi(x_i))$ and **measurable** increments Δx_i are taken from the formula (36).
Taking into account that for enough large $|N_{x_i}|$ with an high accuracy $\Delta_{N_{x_i}}/\Delta(x_i)=\partial/\partial x_i$ and $\Delta\Psi(\phi)/\Delta\phi=\partial\Psi(\phi)/\partial\phi$ we conclude that the equation (93) with an high accuracy can be used in **measurable** case for $\phi(x,y,z))$ **measurable** function from **measurable** $\{x,y,z\}$.
Then the solution (93) are presented as an exponent

$$\Psi(\phi)=Aexp(\imath\frac{L_z}{\hbar}\phi), \tag{96}$$

where $\phi=\phi(x,y,z)$–**measurable** function from **measurable** variables x,y,z.
At that, eigenfunctions for discrete spectrum $L_z=\hbar m; m=0,\pm 1,\pm 2,...$ of operator $\hat{L}_z$ as in the continuous case will be

$$\Psi_m(\phi)=(2\pi)^{-1/2}e^{\imath m\phi}, \tag{97}$$

where ϕ is a **measurable** quantity.
However, at normalization condition in the continuous case [37], in the present form the integral is replaced by the sum:

$$(\int_0^{2\pi} |\Psi_m|^2 d\phi = 1) \Rightarrow (\sum_{0 \leq \phi \leq 2\pi} |\Psi_m|^2 \Delta(\phi) = 1), \tag{98}$$

where $\Delta(\phi)$ is taken from the formula (95).

4.3 Position and Momentum Representations and Fourier Transform in Terms of Measurability

Now, using the formulas of the previous sections we can analyze in terms of **measurably** quantities issue of quantum representations and the Fourier transformation. Scalar (inner) product in position representation in the continuous case is determined by the equation [14],[38]:

$$(\varphi_1, \varphi_2) = \int_{R^3} \varphi_1^*(\mathbf{x}) \varphi_2(\mathbf{x}) d\mathbf{x} \tag{99}$$

Both operators of coordinates $\mathbf{x_j}$ and momentum $\mathbf{p_j}$,$(j = 1, 2, 3)$ in position representation are introduced by the equations [14]:

$$\begin{aligned} \mathbf{x_j}.\varphi(\mathbf{x}) &= x_j \varphi(\mathbf{x}), \\ \mathbf{p_j}.\varphi(\mathbf{x}) &= -\imath\hbar \frac{\partial}{\partial x_j} \varphi(\mathbf{x}) \end{aligned} \tag{100}$$

In the abovementioned denotations $\mathbf{x} = q$ is taken from the formula (49) therefore integral from the equation (100) is replaced by the sum

$$(\varphi_1, \varphi_2)_{meas} = \sum_{\mathbf{x} \in R^3} \varphi_1^* \varphi_2 \Delta_{N_\mathbf{x}}(\mathbf{x}), \tag{101}$$

where $\mathbf{x}$ – **measurable** coordinates.
It is clear that the passage to the limit takes place

$$\lim_{N_{x_i} \to \infty} (\varphi_1, \varphi_2)_{meas} = (\varphi_1, \varphi_2) \tag{102}$$

where $\{N_{x_i}\} = N_q$ from the equation (49) and at enough large $\{N_{x_i}\} = N_q$ with high precision

$$(\varphi_1, \varphi_2)_{meas} = (\varphi_1, \varphi_2) \tag{103}$$

In the considered case the first equation from (100) is preserved for all **measurable** values of the left and right side, while the second one is replaced by

$$\begin{aligned} \mathbf{p_{N_{x_j}}}.\varphi(\mathbf{x}) = -\imath\hbar\frac{\Delta_{N_{x_j}}}{\Delta(x_j)}\varphi(\mathbf{x}) \doteq \\ \doteq -\imath\hbar\frac{\varphi(x_{i\neq j}, x_j + \ell/N_{x_j}) - \varphi(\mathbf{x})}{\ell/N_{x_j}}, \end{aligned} \tag{104}$$

where $\mathbf{p_{N_{x_j}}}$ – **measurable** momentum j-component presented as follows:

$$p_{N_{x_j}} = \frac{\hbar}{N_{x_j}\ell}. \tag{105}$$

And the function $\varphi(x_{i\neq j}, x_j + \ell/N_{x_j})$ differs from $\varphi(\mathbf{x})$ only with its "shift" to ℓ/N_{x_j} in j-component.
From the formulas above and, particularly, the formula (37), we can make a clear supposition that in this case of low energies $E \ll E_P$, i.e. at $|N_{x_j}| \gg 1$ with an high precision we have

$$\frac{\Delta_{N_{x_j}}}{\Delta(x_j)} = \frac{\partial}{\partial x_j}. \tag{106}$$

Then, due to the formula (104)–(106) in the case of low energies $E \ll E_P$ for **measurable** quantities with an high precision we get

$$[\mathbf{x}, \mathbf{p}].\varphi(\mathbf{x}) = \mathbf{xp}.\varphi(\mathbf{x}) - \mathbf{px}.\varphi(\mathbf{x}) = \imath\hbar\varphi(\mathbf{x}) \tag{107}$$

In momentum representation in the continuous picture:

$$\begin{aligned} \mathbf{x_j}.\varphi(\mathbf{p}) = \imath\hbar\frac{\partial}{\partial p_j}\varphi(\mathbf{p}), \\ \mathbf{p_j}.\varphi(\mathbf{p}) = p_j\varphi(\mathbf{p}) \end{aligned} \tag{108}$$

In the **measurable** case the second equation (108) for **measurable** momenta remains unchanged. According to the formula (42) and (43) in the **measurable** case in the first equation from (108) a replacement takes place

$$\frac{\partial}{\partial p_j} \mapsto \frac{\Delta_{p_j}}{\Delta p_j}, \tag{109}$$

where

$$\begin{aligned} p_j \doteq p_{N_{x_j}} &= \frac{\hbar}{N_{x_j}\ell}; \\ \frac{\Delta_{p_j}\varphi(\mathbf{p}))}{\Delta p_j} \equiv \frac{\varphi(\mathbf{p}+p_j)-\varphi(\mathbf{p})}{p_j} &= \frac{\varphi(\mathbf{p}+\frac{\hbar}{N_{x_j}\ell})-\varphi(\mathbf{p})}{\frac{\hbar}{N_{x_j}\ell}}, \end{aligned} \tag{110}$$

and $\varphi(\mathbf{p}+p_j)$ differs from $\varphi(\mathbf{p})$ with the value p_j only in j-component.
Then from the expression (43) due to the fact $|N_{x_j}| \gg 1$ with an high exactness we get

$$\frac{\Delta_{p_j}}{\Delta p_j} = \frac{\partial}{\partial p_j} \tag{111}$$

Now let us consider $[\mathbf{x}, \mathbf{p}].\varphi(\mathbf{p})$ in momentum representation. Taking into account the formula (111) we receive

$$\begin{aligned} [\mathbf{x}_j, \mathbf{p}_j].\varphi(\mathbf{p}) \; &= \mathbf{x}_j\mathbf{p}_j.\varphi(\mathbf{p}) - \mathbf{p}_j\mathbf{x}_j.\varphi(\mathbf{p}) = \\ &= \imath\hbar(\varphi(\mathbf{p}) + p_j\frac{\varphi(\mathbf{p}+p_j)-\varphi(\mathbf{p})}{p_j} - \\ &\quad -p_j\frac{\varphi(\mathbf{p}+p_j)-\varphi(\mathbf{p}}{p_j}) = \\ &= \imath\hbar.\varphi(\mathbf{p}). \end{aligned} \tag{112}$$

Thus, the expressions (106)–(112) show that

$$[\mathbf{x}_i, \mathbf{p}_j] = \imath\delta_{ij}\hbar \tag{113}$$

takes place in **measurable** case both in position representation and momentum representation.

In the continuous picture the Fourier transformation has the following form [38]:

$$\varphi(\mathbf{x}) = (\frac{1}{2\pi\hbar})^{3/2} \int_{R^3} e^{\frac{\imath}{\hbar}\mathbf{px}} \varphi(\mathbf{p}) d\mathbf{p} \tag{114}$$

And the operator $\mathbf{p_j}$ applied to the formula (114), gives [38]:

$$\mathbf{p_j}.\varphi(\mathbf{x}) = -\imath\hbar\frac{\partial}{\partial x_j}\varphi(\mathbf{x}) = -\imath\hbar\frac{\partial}{\partial x_j}(\frac{1}{2\pi\hbar})^{3/2} \int_{R^3} e^{\frac{\imath}{\hbar}\mathbf{px}} \varphi(\mathbf{p}) d\mathbf{p} =$$
$$= (\frac{1}{2\pi\hbar})^{3/2} \int_{R^3} e^{\frac{\imath}{\hbar}\mathbf{px}} p_j \varphi(\mathbf{p}) d\mathbf{p} \tag{115}$$

However, as it was indicated in the formulas (87),(88) in the considered **measurable** case of low energies the $|\mathbf{p}|$ values are bounded, therefore $\mathbf{p}$ doesn't fill in all space R^3, and belongs only to its part $\Delta_{\mathbf{N}_*,\mathbf{N}^*}(\mathbf{p})$ (formula (91)).
That is why the integral in the equation (114) should be replaced by the sum:

$$\varphi_{meas}(\mathbf{x}) = (\frac{1}{2\pi\hbar})^{3/2} \sum_{\mathbf{p}\in\Delta_{\mathbf{N}_*,\mathbf{N}^*}(\mathbf{p})} e^{\frac{\imath}{\hbar}\mathbf{px}} \varphi_{meas}(\mathbf{p}) \Delta_p(p_{N_\mathbf{x}}), \tag{116}$$

where $\mathbf{x}$,$\mathbf{p}$ and $\varphi_{meas}(\mathbf{p})$ are **measurable** quantities and

$$\Delta_p(p_{N_\mathbf{x}}) = \prod_j p_{N_{x_j}}, \tag{117}$$

where $p_{N_{x_j}}$ is taken from the equation (110).
And as $|N_{x_j}| \gg 1$, then in the limit $|N_{x_j}| \rightarrow \infty$ the sum in the right side of the equation (116) is replaced by the integral that's why, with an high precision, we receive

$$(\frac{1}{2\pi\hbar})^{3/2} \int_{\Delta_{\mathbf{N}_*,\mathbf{N}^*}(\mathbf{p})} e^{\frac{\imath}{\hbar}\mathbf{px}} \varphi(\mathbf{p}) d\mathbf{p} = \tag{118}$$
$$= (\frac{1}{2\pi\hbar})^{3/2} \sum_{\mathbf{p}\in\Delta_{\mathbf{N}_*,\mathbf{N}^*}(\mathbf{p})} e^{\frac{\imath}{\hbar}\mathbf{px}} \varphi_{meas}(\mathbf{p}) \Delta_p(p_{N_\mathbf{x}})$$

It should be noted that in this case the domain of the function changes only for the momenta. Due to the abovementioned equations it is tapered: $\{\mathbf{p} \in R^3\} \mapsto \{\mathbf{p} \in \Delta_{\mathbf{N}_*,\mathbf{N}^*}(\mathbf{p})\}$. For coordinates it remains $\{\mathbf{x} \in R^3\}$.
The function $\varphi(\mathbf{p})$ in the continuous case is the following form [38]:

$$\varphi(\mathbf{p}) = (\frac{1}{2\pi\hbar})^{3/2} \int_{R^3} e^{-\frac{\imath}{\hbar}\mathbf{px}} \varphi(\mathbf{x}) d\mathbf{x} \tag{119}$$

As the definition domain in the position representation remains the same $\{\mathbf{x} \in R^3\}$, then for **measurable** case $\varphi_{meas}(\mathbf{p})$ has the following form

$$\varphi_{meas}(\mathbf{p}) = (\frac{1}{2\pi\hbar})^{3/2} \sum_{R^3} e^{-\frac{\imath}{\hbar}\mathbf{px}} \varphi_{meas}(\mathbf{x}) \Delta_{N_\mathbf{x}}(\mathbf{x}), \tag{120}$$

where $\mathbf{x} = q$ from the formula (49), i.e.

$$\Delta_{N_\mathbf{x}}(\mathbf{x}) = \prod_j \Delta_{N_{x_j}}(x_j) = \frac{\ell^3}{N_x N_y N_z} \tag{121}$$

In this case due to the condition $|N_{x_j}| \gg 1$ we produce the following:

$$(\frac{1}{2\pi\hbar})^{3/2} \int_{R^3} e^{-\frac{\imath}{\hbar}\mathbf{px}} \varphi(\mathbf{x}) d\mathbf{x} \approx (\frac{1}{2\pi\hbar})^{3/2} \sum_{R^3} e^{-\frac{\imath}{\hbar}\mathbf{px}} \varphi_{meas}(\mathbf{x}) \Delta_{N_\mathbf{x}}(\mathbf{x}), \tag{122}$$

where all values in the right side of (122) are **measurable**.
Thus, the equations (116) and (120) are analogues of direct and inverse Fourier transformation in terms of **measurable** quantities or better to say of **measurable** of the direct and inverse Fourier transformation.
In the present formalism we can easily produce **measurable** analog of the equation (115) with replacement $\mathbf{p_j} \mapsto \mathbf{p_{N_{x_j}}}$,$\partial/\partial x_j \mapsto \Delta_{N_{x_j}}/\Delta(x_j)$,$\varphi(\mathbf{x}) \mapsto \varphi_{meas}(\mathbf{x})$ and $\int_{R^3} \mapsto \sum_{\Delta_{\mathbf{N}_*}(\mathbf{p})}$.
Similar for the corresponding replacement in **measurable** variant it is possible to receive the analogue of the accordance

$$\mathbf{x_j}.\varphi(\mathbf{p}) \mapsto \imath\hbar \frac{\partial}{\partial p_j} \varphi(\mathbf{p}) \tag{123}$$

in the continuous picture.

Here it is necessary to make some important explanations:

Commentary 4.3.

4.3.1. As we considered minimal length ℓ and time τ at Plank level $\ell \propto l_p, \tau \propto t_p$, The use of the **measurable** quantities $\ell/N_{x_i}; i = 1, ..., 3$ and τ/N_t at $|N_{x_i}| \gg 1, |N_t| \gg 1$ as a replacement of dx_i, dt in the continuous case is absolutely correct and justified. Actually, as in this case ℓ has the order $\approx 10^{-33} cm$, then ℓ/N_{x_i} will have the order of $\approx 10^{-33-\lg|N_{x_i}|} cm$, which is, without doubts, will exceed any practical computations precision. The similar statement is true for the value τ/N_t as well, where τ has the order of Plank time t_p, i.e. $\approx 10^{-44} sec$. For this reason, it is correct to use $p_{N_{x_i}}$ instead of dp_i and $\Delta_{N_{x_i}}/\Delta(x_i), \Delta_{N_t}/\Delta(t), \Delta_{p_i}/\Delta p_i$ instead of $\partial/\partial x_i, \partial/\partial t, \partial/\partial p_i$, accordingly, in the continuous case.

4.3.2. For the sake of generality in **Remark 3.2.1** we supposed that N_{x_i}, N_t are **generalized measurable** quantities. However, due to $|N_{x_i}| \gg 1, |N_t| \gg 1$ we can regard without loss of generality the numbers N_{x_i} and N_t as **primarily measurable** quantities. It is clear that

$$[N_{x_i}] \leq N_{x_i} \leq [N_{x_i}] + 1, \tag{124}$$

where $[\aleph]$ defines the entier of number $\aleph$. Then $|N_{x_i}|^{-1}$ gets into the interval with the points $|[N_{x_i}]|^{-1}$ and $|[N_{x_i}] + 1|^{-1}$ (which is larger among these numbers and which is less depends on sign of the number N_{x_i}). In any case we have $|N_{x_i}^{-1} - [N_{x_i}]^{-1}| \leq |([N_{x_i}] + 1)^{-1} - [N_{x_i}]^{-1}| = |([N_{x_i}] + 1)[N_{x_i}]|^{-1}$. In any case, the difference between ℓ/N_{x_i} and $\ell/[N_{x_i}]$ (accordingly between $\Delta_{N_{x_i}}/\Delta(x_i)$ and $\Delta_{[N_{x_i}]}/\Delta(x_i)$ and so on) is almost insignificant. The similar computations are correct for τ/N_t and $\tau/[N_t]$ as well.

4.3.3a. It should be noted that despite the fact that in **measurable** case there is an analogue of direct and inverse Fourier transformation set by the equations (116) and (120) the difference between position and momentum representations is significant. Indeed, the first one has all three dimensional space R^3 as domain definition, while the second one has some part of finite sizes $\Delta_{\mathbf{N}_*,\mathbf{N}^*}(\mathbf{p})$, "cut out" in three dimensional space $\Delta_{\mathbf{N}_*,\mathbf{N}^*}(\mathbf{p}) \subset R^3$

4.3.3b. Significant difference between position representation and momentum representation in **measurable** case lays in their different nature in this formalism. Position representation in this case is formed, in general, the same as the correspondent representation in the continuous case. Momentum representation in **measurable** case , as it follows from the formulas **Remark 3.2.1** is formed in the basis of **measurable variations** in the position representation.
It should be noted that as ℓ with an accuracy up to multiplicative constant corresponds to l_p, and $p_{N_{\mathbf{x}}}$ with an accuracy up to multiplicative constant corresponds to $\ell/N_{\mathbf{x}}$ (formula (44)), then the summing measures in **measurable** case in the equations (116) and (120) in momentum and position spaces also match with an accuracy up to multiplicative constant

$$\Delta_{N_{\mathbf{x}}}(\mathbf{x}) = \frac{\ell^6}{\hbar^3}\Delta_p(p_{N_{\mathbf{x}}}) \tag{125}$$

4.3.4. It can be easily noticed that the abovementioned formalism of the Schrodinger picture's studying in terms of **measurability** can be applied for Heisenberg picture [14],[38]. Indeed, in the paradigm of the continuous space and time the motion equation for Heisenberg operators $\hat{L(t)}$ are as follows [14],[38]:

$$\frac{d\hat{L}(t)}{dt} = \frac{\partial \hat{L}(t)}{\partial t} + [\hat{H}, \hat{L}(t)], \tag{126}$$

where $\hat{H}$ – Hamiltonian and $[\hat{H}, \hat{L}(t)] = \frac{1}{\imath\hbar}(\hat{L}(t)\hat{H} - \hat{H}, \hat{L}(t))$–quantum Poisson bracket [38].
In **measurable** case quantum Poisson bracket preserves its form for **measurable** quantities inside it. $\partial\hat{L}(t)/\partial t$ is replaced to $\Delta_{N_t}[\hat{L}(t)]/\Delta(t)$, where the operator $\Delta_{N_t}[\hat{L}(t)]/\Delta(t)$ can be produced from the equation (75) with the replacement $\widehat{U}(t')$ onto $\hat{L}(t)$ at $|N_t| \gg 1$.
Then the analogue (126) in **measurable** case will be the equation:

$$\frac{\tilde{\Delta}_{N_t}[\hat{L}(t)]}{\Delta(t)} \doteq \frac{\Delta_{N_t}[\hat{L}(t)]}{\Delta(t)} + [\hat{H}, \hat{L}(t)], \tag{127}$$

It is clear that

$$\lim_{|N_t|\rightarrow\infty}\frac{\tilde{\Delta}_{N_t}[\hat{L}(t)]}{\Delta(t)}=\frac{d\hat{L}(t)}{dt}. \tag{128}$$

Thus, at enough large $|N_t|$ the equation (127) matches with the equation (126) with the high accuracy.

5 More Overall Measurability Definition

Now, basing on the abovementioned information, we can give the definition **measurability**, which is, as we concern, is more general that the initial one.
We, as it was performed before, begin with some minimal (universal) unit for length measurement ℓ, which corresponds to some maximal energy $E_\ell = \frac{\hbar c}{\ell}$ and universal time measurement unit $\tau = \ell/c$. Without the loss of generality we can consider ℓ and τ at Plank level, i.e. $\ell = \kappa l_p, \tau = \kappa t_p$, where numeric constant κ is order of 1. Consequently, $E_\ell \propto E_p$ with the suitable coefficient of proportionality.
We intentionally use in this case for ℓ and τ besides the phrase "minimal measurement unit" the phrase "universal measurement unit" as well, because in our case it presents full coverage of its sense.
Now we shall consider in the space of the momenta $\mathbf{P}$ the domain defined by the conditions

$$\mathbf{p}=\{p_{x_i}\}, i=1,..,3; P_{pl}\gg|p_{x_i}|\neq 0, \tag{129}$$

where P_{pl}–Plank momentum. Then we can easily calculate the numeric coefficients N_{x_i}

$$\begin{aligned} N_{x_i} &= \frac{\hbar}{p_{x_i}\ell}, or \\ p_{x_i} &\doteq p_{N_{x_i}} = \frac{\hbar}{N_{x_i}\ell} \\ &|N_{x_i}| \gg 1, \end{aligned} \tag{130}$$

where the last part of the equation (130) is determined by the formula (129).

Definition 1*

1*.1 Let's call the momenta $\mathbf{p}$, set by the formula (129) **primarily measurable**, if all numbers N_{x_i} from the equation (130) are integer numbers.
1*.2 Let's call any variation of Δx_i coordinates x_i and Δt of time t for energies $E \ll E_p$ as **primarily measurable**, if

$$\Delta x_i = N_{x_i}\ell, \Delta t = N_t\tau, \tag{131}$$

where N_{x_i} satisfies the condition **1*.1** and $|N_t| \gg 1$ – natural number.
1*.3 Let us define any physical quantity **primarily or elementarily measurable** at low energies $E \ll E_p$, when its value is consistent with points **1*.1** and **1*.2** of this Definition.

Further for the sake of convenience we denote the momenta domain, satisfying the conditions (129) (or (130)) as $\mathbf{P}_{LE}$..
In Commentary **4.3.2** it is shown that at low energies $E \ll E_P$ ($|N_{x_i}| \gg 1$) **primarily measurable** of momenta are enough to, with the high accuracy, produce all domain of momenta $\mathbf{P}_{LE}$.
This means that in the abovementioned domain the discrete set **primarily measurable** of momenta $p_{N_{x_i}}; i = 1, ..., 3$, (where N_{x_i}-natural number, and $|N_{x_i}| \gg 1$), changes almost continuously, practically covering the whole this domain.
That is why further $\mathbf{P}_{LE}$ means the domain consisting of **primarily measurable** momenta, satisfying the conditions of the formula (129) (or (130)).

Then the boundaries of the region $\mathbf{P}_{LE}$ are determined by the condition (89) for each coordinate

$$\mathbf{N}^* \geq |N_{x_i}| \geq \mathbf{N}_* \gg 1,$$

where large positive numbers $\mathbf{N}^*, \mathbf{N}_*$ are determined by the task solvable. The choice of number $\mathbf{N}^*$ has particular importance. If $\mathbf{N}^* < \infty$, then it is clear that the studied momenta lay within $\mathbf{P}_{LE}$. If to make a precondition that $\mathbf{N}^* = \infty$, then for $\mathbf{P}_{LE}$ we should add for each coordinate x_i "non-intrinsic" (or "singular") point $p_{x_i} = 0$ (we name these cases **degenerate**). In any case for each coordinate x_i the boundaries of $\mathbf{P}_{LE}$ are as follows:

$$p_{\mathbf{N}^*} \leq |p_{N_{x_i}}| \leq p_{\mathbf{N}_*} \tag{132}$$

Therefore, for distinctness we can note $\mathbf{P}_{LE}$ with certain boundaries set by the formula (132) per $\mathbf{P}_{LE}[\mathbf{N}^*, \mathbf{N}_*]$.

It is obvious that in such formalism **small** increments for any component $p_{N_{x_i}}$ of momentum $\mathbf{p} \in \mathbf{P}_{LE}$ are momentum values $p_{N'_{x_i}}$, for which $|N'_{x_i}| > |N_{x_i}|$. And then, incrementing $|N'_{x_i}|$ we can receive **as much as desired small** increments for momenta $\mathbf{p} \in \mathbf{P}_{LE}$.

Therefore in this case the definition of "measurable partial derivative" for momentum $p_{N_{x_i}}$ shall be correct, denoted in the equation (42) and (43) through $\frac{\Delta_{p_{N_{x_i}}}}{\Delta p_{N_{x_i}}}$. As it was shown in the equations (42) and (43) and due to the contents of the previous paragraph at the values of $|N_{x_i}|$ large enough, with any predetermined precision the equality $\frac{\Delta_{p_{N_{x_i}}}}{\Delta p_{N_{x_i}}} = \frac{\partial}{\partial p_i}$ takes place (for example formula (111)).

Obviously, that **primarily measurable** measurements Δx_i of coordinates x_i and Δt of time t from **1*.2** of **Definition 1*** can't be considered as small variations of space and time. Still, the equation (44) and its application in the further text of the article gives us a basis to state that space and time values

$$\frac{\tau}{N_t} = p_{N_t c}\frac{\ell^2}{c\hbar}$$
$$\frac{\ell}{N_{x_i}} = p_{N_{x_i}}\frac{\ell^2}{\hbar}, 1 = 1, ..., 3, \tag{133}$$

are small values and, as it is shown, in (44) they can be as small as desired at enough large values of $|N_{x_i}|, |N_t|$. Here $p_{N_{x_i}}, p_{N_t c}$ are corresponding **primarily measurable** momenta.

It is clear that space and time quantities $\frac{\tau}{N_t}, \frac{\ell}{N_{x_i}}$ won't be **primarily measurable** space-time quantities despite the fact that they, with up to constant accuracy are equal **primarily measurable** momenta.

Therefore, the following definition makes sense:

Definition 2*.(Generalized Measurability in Low Energies).
We shall call any physical quantity at low energies $E \ll E_p$ as **generalized-measurable** or for simplicity **measurable** if any of its values may be obtained in terms of **Primarily Measurable Quantities** of **Definition 1***.

Now, withdrawing the restriction $P_{pl} \gg |p_{x_i}|$ in the equation (129) nd, the same option, $|N_{x_i}| \gg 1$ in the formula (130), i.e. considering momenta space **p** at **all energies scales**

$$\begin{aligned} \mathbf{p} = \{p_{x_i}\}, i = 1, .., 3; |p_{x_i}| \neq 0; \\ N_{x_i} = \frac{\hbar}{p_{x_i}\ell}, or \\ p_{x_i} \doteq p_{N_{x_i}} = \frac{\hbar}{N_{x_i}\ell}, \\ 1 \leq |N_{x_i}| < \infty, or \quad E \leq E_\ell \end{aligned} \tag{134}$$

we we introduce the following definition

Definition 3*(Primarily and Generalized Measurability at All Energies Scales).
3*.1. Let us call the momenta **p**, set by the formula (134) **primarily measurable**, of all numbers N_{x_i} from this formula (134) are integer.
3*.2. Any variation Δx_i of coordinates x_i and Δt of time t at all energies scales $E \leq E_\ell$ can be called **primarily measurable**, if

$$\Delta x_i = N_{x_i}\ell, \Delta t = N_t\tau, \tag{135}$$

where N_{x_i} satisfy the condition **3*.1** and the integer number N_t are within the interval of $1 \leq |N_t| < \infty$.
3*.3. Let us define any physical quantity **primarily or elementarily measurable** at all energies scales $E \leq E_\ell$, when its value is consistent with points **3*.1** and **3*.2** of this Definition.
3*.4. Finally, we shall call any physical quantity at all energies scales $E \leq E_\ell$, as **generalized-measurable** or for simplicity **measurable** if any

of its values may be obtained in terms of **Primarily Measurable Quantities** of points **3*.1–3*.3** in **Definition 3***.

"Non-intrinsic" points, at the values $|N_{x_i}| = \infty$ and $|N_t| = \infty$ can be added to the equation (134) and **Definition 3*** accordingly, as at the low energies case.
As it was shown above **Primarily Measurable Momenta** practically cover all momenta region $\mathbf{P}_{LE}$ at low energies $E \ll E_p$ (or same $E \ll E_\ell$). However, this is no longer the case at **all energies scales** $E \leq E_\ell$.
Therefore the main target of the author is quantum theory construction at all energies scales $E \leq E_\ell$ in terms of **measurable** (or same **primarily measurable**) quantities of **Definition 3***.
In this theory the values of physical quantity $\mathcal{G}$ can be represented as the numeric function $\mathcal{F}$ as follows

$$\mathcal{G} = \mathcal{F}(N_{x_i}, N_t, \ell) = \mathcal{F}(N_{x_i}, N_t, G, \hbar, c, \kappa), \tag{136}$$

where N_{x_i}, N_t–integer numbers from the formula (134),(135) and $G, \hbar, c$ are fundamental constants. The last equality in (136) is determined by the fact that $\ell = \kappa l_p$ and $l_p = \sqrt{G\hbar/c^3}$.
If $N_{x_i} \neq 0, N_t \neq 0$ (**non-degenerated** case), then it is clear that (136) can be rewritten as follows:

$$\mathcal{G} = \mathcal{F}(N_{x_i}, N_t, \ell) = \tilde{\mathcal{F}}((N_{x_i})^{-1}, (N_t)^{-1}, \ell) \tag{137}$$

And then at low energies $E \ll E_p$, i.e. at $|N_{x_i}| \gg 1, |N_t| \gg 1$ the function $\tilde{\mathcal{F}}$ is the function from variables, changing practically continuously, despite the fact that these variables run over discreet set of the values. It can be naturally supposed that $\tilde{\mathcal{F}}$ changes fluently, (it means practically continuously). As a result we get the model with discrete nature which as it is shown above, with an high accuracy reproduces the known theory in the continuous space-time.
Obviously, at low energies $E \ll E_p$ the formula (137) can be presented as follows:

$$\begin{aligned}\mathcal{G} = \mathcal{F}(N_{x_i}, N_t, \ell) = \tilde{\mathcal{F}}((N_{x_i})^{-1}, (N_t)^{-1}, \ell) = \\ = \tilde{\mathcal{F}}_{\mathcal{P}}(p_{N_{x_i}}, p_{N_{tc}}, \ell),\end{aligned} \tag{138}$$

where $p_{N_{x_i}}, p_{N_{tc}}$ are **primarily measurable** momenta from formula (44).
It should be noted that the approach to the concept **measurability**, set forth in present Section is much more overall, then in Sections 2,3 for two reasons:
a)it is not connected directly with Heisenberg Uncertainty Principle and its generalizations;

b)it can be successfully used both for the non-relativistic case [14] and for the relativistic case [39].

6 Final Comments and Further Perspectives

6.1. Thus, at all energies scales we get some model (which should be constructed) depending on the same discrete parameters, which is at low energies E far from Planck $E \ll E_p$ is very close to the initial theory, that is why it reproduces with an high accuracy, all main results of canonic quantum theory in continuous spacetime. At high (Planck) energies $E \approx E_p$ the abovementioned discrete model will present new results.
The author supposes that this model will be deprived principal drawbacks of canonical quantum theory – ultraviolet and infrared divergences [39]. It will be finite at all orders of the perturbation theory and due to this reason it won't need renormalization [39].

6.2. The formula (44) and (133) show that **measurable** analogues small and infinitesimal space-time quantities coincide (up to constants) with the **primarily measurable** momenta.
This allows for gravity [40] to state the same problem as it was stated for the quantum theory in the paragraph **6.1.**:

Construction of **measurable** model of gravity, depending on the same discrete parameters N_{x_i}, N_t, which is at low energies $E \ll E_p$ is practically continuous and "very close" to General Relativity, and at high energies $E \approx E_p, (E \approx E_\ell)$ it will present the correct quantum theory without ultraviolet divergences.

Hovewer, the phrase "very close" in the last item doesn't mean exact correspondence of the abovementioned model with General Relativity [40]. According to my assumption in the studied model there should be no the "nonphysical" solutions of the General Relativity (for example, the solutions involving the **Closed Time-like Curves** (CTC) [41]–[44]).

6.3. At the moment each of the abovementioned theories – Quantum Theory and Gravity, considered within continuous space-time are presented by various theories at low energies $E \ll E_p$ and at high energies $E \approx E_p$. Therefore let us summarize the points **6.1.** and **6.2.** as follows:

In **measurable** format each of theories (quantum theory and gravity) will be unified theory at all energies scales $E \leq E_\ell$. Word "unified" means that at all energies scales they should be determined by the same discrete set of parameters N_{x_i}, N_t and constants $G, \hbar, c, \kappa$.
The main problem in this case will be correct determination and computations of functions $\mathcal{F}$ and $\tilde{\mathcal{F}}$ from formula (136)–(138).
In Subsection 3.1 within the framework of Generalized Uncertainty Principle we have already determined function $\mathcal{F}$ for all **measurable** momenta $p_{i,\mathbf{meas}}; i = 1, .., 3$ at **all energies scales** $E \leq E_\ell$ by formula (18),(19):

$$p_{i,\mathbf{meas}} = \mathcal{F}(N_{x_i}, \ell) = \frac{\hbar}{1/2(N_{x_i} + \sqrt{N_{x_i}^2 - 1})\ell}. \qquad (139)$$

Conflict of Interests

The author declares that there is no conflict of interests regarding the publication of this paper.

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Universe (Part 4). Relations Between Charge, Time, Matter, Volume, Distance, and Energy

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Abstract

In given article author has summarized and corrected a theory [1 -3] which allows derivation of the unknown relations between the main parameters (energy, time, charge, distance, volume, matter) in the Universe. He finds also the quantum (minimal values) of energy, time, charge, distance, volume and matter and he applied these quantum for estimations of quantum volatility and the estimation of some values of our Universe and received both well-known and new unknown relations.
Author offers possibly valid relations between charge, time, matter, charge, volume, distance, and energy. The net picture derived is that in the Universe exists ONLY one substance – ENERGY. Charge, time, matter, volume, fields are evidence of this energy and they can be transformed one to other. Author gives the equations which allow to calculate these transformation like the famous formula $E = mc^2$. Some assumptions about the structure of the Universe follow from these relations.
Most offered equations give results close to approximately known data of Universe, the others allow checking up by experiment.
Key words: Universe, time, matter, charge, volume, distance, energy, limits of specific density of energy, matter, pressure, temperature, intensity of fields, collapse of space and time into point.

1. Introduction

In the theoretical physic the next fundamental constants presented in Table 1 are important .

Table 1: Fundamental physical constants

Constant	Symbol	Dimension	Value in SI units with uncertainties
Speed of light in vacuum	c	$L\,T^{-1}$	2.99792458×10^{8} m s^{-1}
Gravitational constant	G	$L^3\,M^{-1}\,T^{-2}$	$6.67384(80)\times10^{-11}$ m^3 kg^{-1} s^{-2}
Reduced Planck constant	$\hbar = h/2\pi$ where h is Planck constant h = 6.625 068 76(52)$\times10^{-34}$	$L^2\,M\,T^{-1}$	$1.054571726(47)\times10^{-34}$ J s
Coulomb constant	$(4\pi\varepsilon_0)^{-1}$ where ε_0 is the permittivity of free space ε_0 = 8.854 187 817…$\times10^{-12}$	$L^3\,M\,T^{-2}\,Q^{-2}$	k = $8.9875517873681764\times10^{9}$ kg m^3 s^{-2} C^{-2}*(exact by definitions of ampere and meter)*
Boltzmann constant	k_B	$L^2\,M\,T^{-2}\,\Theta^{-1}$	$1.3806488(13)\times10^{-23}$ J/K

Where are: L = length, M = mass, T = time, Q = electric charge, Θ = temperature.

If we take these constants as base units, we get the Planks units:

Table 2: Base Planck units

Name	Dimension	Expression	Value (SI units)
Planck length	Length (L)	$l_P = \sqrt{\frac{\hbar G}{c^3}}$	1.616 199(97) × 10^{-35} m
Planck mass	Mass (M)	$m_P = \sqrt{\frac{\hbar c}{G}}$	2.176 51(13) × 10^{-8} kg
Planck time	Time (T)	$t_P = \frac{l_P}{c} = \frac{\hbar}{m_P c^2} = \sqrt{\frac{\hbar G}{c^5}}$	5.391 06(32) × 10^{-44} s
Planck Charge	Electric charge (Q)	$q_P = \sqrt{4\pi\varepsilon_0 \hbar c}$	1.875 545 956(41) × 10^{-18} C
Planck temperature	Temperature (Θ)	$T_P = \frac{m_P c^2}{k_B} = \sqrt{\frac{\hbar c^5}{G k_B^2}}$	1.416 833(85) × 10^{32} K

From data Table 2 we can receive the derived Planck units (Table 3).

Table 3: Derived Planck units

Name	Dimension	Expression	Approximate SI equivalent
Planck area	Area (L^2)	$l_P^2 = \frac{\hbar G}{c^3}$	2.61223 × 10^{-70} m^2
Planck volume	Volume (L^3)	$l_P^3 = \left(\frac{\hbar G}{c^3}\right)^{\frac{3}{2}} = \sqrt{\frac{(\hbar G)^3}{c^9}}$	4.22419 × 10^{-105} m^3
Planck momentum	Momentum (LMT^{-1})	$m_P c = \frac{\hbar}{l_P} = \sqrt{\frac{\hbar c^3}{G}}$	6.52485 kg m/s
Planck energy	Energy (L^2MT^{-2})	$E_P = m_P c^2 = \frac{\hbar}{t_P} = \sqrt{\frac{\hbar c^5}{G}}$	1.9561 × 10^{9} J
Plank force	Force (LMT^{-2})	$F_P = \frac{E_P}{l_P} = \frac{\hbar}{l_P t_P} = \frac{c^4}{G}$	1.21027 × 10^{44} N
Planck power	Power (L^2MT^{-3})	$P_P = \frac{E_P}{t_P} = \frac{\hbar}{t_P^2} = \frac{c^5}{G}$	3.62831 × 10^{52} W

Planck density	Density ($L^{-3}M$)	$\rho_P = \frac{m_P}{l_P^3} = \frac{\hbar t_P}{l_P^5} = \frac{c^5}{\hbar G^2}$	5.15500×10^{96} kg/m^3
Planck energy density	Energy density ($L^{-1}MT^{-2}$)	$\rho_P^E = \frac{E_P}{l_P^3} = \frac{c^7}{\hbar G^2}$	4.63298×10^{113} J/m^3
Planck intensity	Intensity (MT^{-3})	$I_P = \rho_P^E c = \frac{P_P}{l_P^2} = \frac{c^8}{\hbar G^2}$	1.38893×10^{122} W/m^2
Planck angular frequency	Frequency (T^{-1})	$\omega_P = \frac{1}{t_P} = \sqrt{\frac{c^5}{\hbar G}}$	1.85487×10^{43} s^{-1}
Planck pressure	Pressure ($L^{-1}MT^{-2}$)	$p_P = \frac{F_P}{l_P^2} = \frac{\hbar}{l_P^3 t_P} = \frac{c^7}{\hbar G^2}$	4.63309×10^{113} Pa
Planck currency	Electrictric currency (QT^{-1})	$I_P = \frac{q_P}{t_P} = \sqrt{\frac{4\pi\epsilon_0 c^6}{G}}$	3.4789×10^{25} A
Planck voltage	Voltage ($L^2MT^{-2}Q^{-1}$)	$V_P = \frac{E_P}{q_P} = \frac{\hbar}{t_P q_P} = \sqrt{\frac{c^4}{4\pi\epsilon_0 G}}$	1.04295×10^{27} V
Planck impedance	Resistance ($L^2MT^{-1}Q^{-2}$)	$Z_P = \frac{V_P}{I_P} = \frac{\hbar}{q_P^2} = \frac{1}{4\pi\epsilon_0 c} = \frac{Z_0}{4\pi}$	29.9792458 Ω

Universal units do not depend from Earth units. That is suitable for the Universe communication. They also give the more simple physical equations.

2. Theory. Relation between charge, time, matter, volume, distance and energy.

The author presents an original theory, which allows derivation of unknown relations between main parameters in a given field of nature. He applies his hypotheses to theory of Universe. The next well-known constants used in his equations are below:

$$c = 2.997925 \cdot 10^8\ m/s; \quad e = 1.60219 \cdot 10^{-19}\ C; \quad G = 6.6743 \cdot 10^{-11}\ m^3/kg \cdot s^2\ ; \tag{1}$$

$$\varepsilon_0 = \frac{1}{36\pi \cdot 10^9} = 8.854188 \cdot 10^{-12}\ \frac{F}{m}; \quad k = \frac{1}{4\pi\varepsilon_0} = 8.987551787 \cdot 10^9\ \frac{kg \cdot m^3}{s^2 C^2} \quad \frac{Jm}{C^2};$$

$$\mu_0 = 4\pi \cdot 10^{-7} = 1.2566 \cdot 10^{-6}\ \frac{N}{A^2}; \quad h = 6.6261 \cdot 10^{-34}\ \frac{kg \cdot m^2}{s}, \quad Js; \quad \hbar = h/2\pi = 1.054571 \quad Js;$$

$$\sigma = 5.67032 \cdot 10^{-8}\ W/m^2K^4, \quad \pi = 3.141592654, \quad k_B = 1{,}3806503 \cdot 10^{-23}\ J \cdot K^{-1};$$

where c is speed of light in vacuum, m/s; e is electronic charge, C; G is a Newton gravitation constant, Nm^2/kg^2; ε_o is electric constant, F/m; μ_o is magnetic constant, H/m; h is Planck constant, J·s; σ is Stefan – Boltzmann constant, W/m^2K^4 ; k_B is Boltzman constant, J/K; F - farad; N - newton; A – amper; K – kelvin.

The author postulated the following relations:

1. Relations between time , matter , volume , distance, specific density of matter and energy :

$$T=\frac{G}{c^5}E,\quad T=\frac{G}{c^3}M,\quad T=c^{-1}v^{1/3},\quad T=\frac{R}{c},\ T=\frac{(kG)^{1/2}}{c^3}Q,\quad T=G^{-1/2}\rho_M{}^{-1/2}, \qquad (2)$$

$$\text{or}\quad T=2.755956\cdot 10^{-53}E,\quad T=2.47693\cdot 10^{-36}M,\quad T=2.874464\cdot 10^{-26}Q,$$

$$T=3.33564\cdot 10^{-9}R,\quad T=1.2240865\cdot 10^{5}\rho^{-1/2},$$

where T is time in sec; E is energy in J; M is mass, kg; v is volume in m^3; R is distance, m; ρ_M is specific density of matter in given volume, kg/m^3, Q is charge, C. (Only the first 4-5 digits are right in all our formulas).

The dimensional theory is employed; that way these relations are obtained to within a constant factor. That factor may be derived from experiment. If we use the Plank units, this factor equals 1 in many cases. This factor has been neglected in cosmology and high-energy physics. But these equations cannot be derived ONLY from dimensional theory because dimensional theory does not contain the physical constants.

Equations (2) may be written in form

$$E=\frac{c^5}{G}T,\quad M=\frac{c^3}{G}T,\quad v=c^3T^3,\quad R=cT,\quad Q=\frac{c^3}{(kG)^{1/2}}T,\quad \rho_M=1/(GT^2), \qquad (3)$$

$$or\quad E=3.628505\cdot 10^{52}T,\quad M=4.037256\cdot 10^{35}T,\quad Q=3.4789094\cdot 10^{25}T,\quad \rho=1.5\cdot 10^{10}/T^2.$$

From these equations follow some interesting propositions. Time is energy, Time depends upon mass, volume, length, electric charges and density of matter. If time simultaneously produced the positive and negative charges, the total charge is zero. Time can create the energy, mass, distance, volume change and the density of matter in the Universe or the energy produce time, matter, distance, volume and charge (positive and negative simultaneously).

2. Relations between volumes, energy, matter, time, and distance

$$v=\frac{4\pi}{3}\left(\frac{GE}{c^4}\right)^3,\quad v=\frac{4\pi}{3}c^3T^3,\quad v=\frac{4\pi}{3}\frac{G^3}{c^9}M^3,\quad v=\frac{4\pi}{3}R^3, \qquad (4)$$

$$or\quad v=2.2630235\times 10^{-132}E^3,\quad v=1.1286275\times 10^{26}T^3,\quad v=1.715109\times 10^{-81}M^3,$$

where v is volume of 3-demantional space, m^3.

3. Relations between matter, time, volume, distance, energy, charge and temperature are

$$M=\frac{c^3}{G}T,\quad M=\frac{c^2}{G}v^{1/3},\quad M=\frac{c^2}{G}R,\quad M=\frac{1}{c^2}E,\quad M=\left(\frac{k}{G}\right)^{1/2}Q,\quad M_1=\frac{k_B}{c^2}t, \qquad (5)$$

$$M=4.0369797\times 10^{35}T,\quad M=1.34659\times 10^{27}v^{1/3},\quad M=1.34659\times 10^{27}R,$$

$$M=1.16047\times 10^{10}Q,\quad M_1=2.316404\times 10^{-40}t.$$

where t is temperature, K; k_B is Boltzmann constant, J/K; v is volume, m^3; M_1 is mass of one atom/particle, kg.

4. Relations between distance and time, matter, charge, energy and matter density

$$T=\frac{R}{c},\quad M=\frac{c^3}{G}T=\frac{c^2}{G}R,\quad Q=\frac{c^3}{(kG)^{1/2}}T=\frac{c^2R}{(kG)^{1/2}},\quad E=\frac{c^5}{G}T=\frac{c^4R}{G},\quad \rho_M=\frac{1}{GT^2}=\frac{c^2}{GR^2}. \tag{6}$$

5. We can receive from equations (2) - (4) the expressions for the energy from time, volume, distance, mass and charge

$$E=\frac{c^5}{G}T,\quad E=\frac{c^4}{G}v^{1/3},\quad E=\frac{c^4}{G}R\ ,\quad E=\left(\frac{k}{G}\right)^{1/2}c^2Q,\quad E=c^2M\ ,\quad E_1=k_Bt. \tag{7}$$

$$E=3.62825745\cdot10^{52}T,\quad E=1.21022562\cdot10^{44}v^{1/3},\quad E=1.2102562\cdot10^{44}R\ ,$$

$$E=1.04297\cdot10^{27}Q,\ E=8.98755\cdot10^{16}M,\quad E_1=1\cdot38066\cdot10^{-23}t\ .$$

Here t is temperature, K; v is volume, m^3; E_1 is energy of one atom/particke, J.

Fifth equation in (7) is the well-known relation between energy and matter. This relationship follows from

(2) – (4) as a special case. This indirectly confirms the correctness of the equations (2) – (6) as a special

case.

6. The relations between the density of matter, energy, charge and time (frequency) are following:

$$\rho_M=\frac{1}{G}\frac{1}{T^2},\quad \rho_M=\frac{1}{G}v^2,\quad \rho_E=\frac{h}{c^3}\frac{1}{T^4},\quad \rho_E=\frac{h}{c^3}v^4,\ \rho_E=\frac{hc}{R^4}, \tag{8}$$

$$\rho_E=\frac{c^2}{GT^2},\ \rho_Q=\left(\frac{hc}{k}\right)^{1/2}\frac{1}{T^3},\quad \rho_Q=\left(\frac{hc}{k}\right)^{1/2}v^3,$$

Where ρ_M , ρ_E, ρ_Q are density of matter, energy and charge respectively, kg/m^3, J/m^3, C/m^3; v (Greg) is frequency, 1/s.

3. Application to current Universe

Let us estimate the real size and parameters (mass, radius, time, density, etc.) of the Universe. We can make it if we accurately know at least one of its parameters.

Thus, the most reliable parameter is the lifetime of the Universe after the Big Bang. Estimates of the observed mass and radius are growing all the time. Estimation of the time specified is about 14 billion years now (13.75±0.17 billion years). Check up all numbers.

$$M=\frac{c^3}{G}T\ ,\quad E=\frac{c^5}{G}T\ ,\quad R=cT,\quad v=\frac{4}{3}\pi R^3\ ,\quad \rho_M=\frac{1}{GT^2}\ ,$$

$$or\quad M=4.0369787\cdot10^{35}T,\quad E=3.62825745\cdot10^{52}\ J,$$

$$R\approx3\cdot10^8T\ ,\quad \rho_M=1.5\cdot10^{10}/T^2. \tag{9}$$

Substitute in (9) the age of Universe after Big Bang (T=14 billions years = 4.4·10^{17} sec) we receive:

$$M = 1.78 \cdot 10^{53}\ kg > 1.4 \cdot 10^{53} kg, \quad E = 1.6 \cdot 10^{70}\ J,$$
$$R = 1.32 \cdot 10^{26}\ m < 4.4 \cdot 10^{26}\ m, \quad v = 10^{79}\ m^3, \quad \rho_M = 7.75 \cdot 10^{-26}\ kg/m^3 > 10^{-26}\ kg/m^3. \qquad (10)$$

In right side of the inequality (9) is given the estimations of universal parameters made by other researchers. They are very different. The author took average or approximate values.

As you see the values received by offered equations and other methods have similar magnitudes. The mass of the Universe is little more because we do not see the whole Universe (only the closer bodies). The estimation of radius is more than light can travel in the time since the origin of the Universe. It is possible the Universe in initial time had other physical laws than now or the expansion of space may account for this. The difference of space density is result of the old methods that do not include invisible matter, dark matter and dark energy.

The main fields are acceleration, gravity, electric, magnetic and photon/radiation. Density of energy in given point of these fields compute by equations:

$$w_a = \frac{1}{G}\frac{a^2}{2}, \quad w_g = \frac{1}{G}\frac{g^2}{2}, \quad w_e = \varepsilon_0 \frac{E^2}{2}, \quad w_m = \mu_0 \frac{H^2}{2}, \; w_{en} = \frac{\varepsilon_0 E^2 + \mu_0 H^2}{2} \quad w_r = \frac{\sigma}{c} t^4,$$
$$w_E = \frac{1}{c^2 G T^2}, \quad w_E = \frac{1}{c^2 G}\nu^2, \quad w_E = hc\frac{1}{R^4}, \quad \rho_Q = \left(\frac{h}{kc^5}\right)^{1/2} \frac{1}{T^3}, \quad \rho_Q = \left(\frac{h}{kc^5}\right)^{1/2} \nu^3. \qquad (11)$$

where w_a is density of acceleration energy, J/m^3; w_g is density of gravitation energy, J/m^3; w_e is density of electric energy, J/m^3; w_m is density of magnetic energy, J/m^3; w_{em} is density of beam energy J/m^3; w_r is density of radiation energy, J/m^3; w_E is time energy density, J/m^3; ρ_Q is time charge density, Q/m^3; a is acceleration, m/s^2; g is gravitation , m/s^2; $\sigma = 5.67032 \cdot 10^{-8}$ is Stefan – Boltzmann constant, W/m^{2}K^4 ; E is electric intensity, V/m or N/C; H is magnetic intensity, T (tesla) or Vs/m^2 or Wb/m^2; t is temperature , K; T is time, sec. The formulas show the energy density depends from temperature and time: R is distance to singular point, m.

Full energy, W, we find by integration of density to a full volume.

$$W = \int_v w dv$$

These computations in analytical form we can take as relating to simple geometric figures as, for example, the spherical forms of fields.

Note: In many cases, the light speed “c” in the equations (2)-(11) may be changed in conventional speed V. That means we can verify the formulas (2)-(11) and find the correct constant factor.

4. Quanta of energy, charge, time, matter, volume, and distance.

It is known the energy of photon is

$$E_q = h\nu, \quad h = 6{,}626068 \cdot 10^{-34} \quad Js: \quad \hbar = h/2\pi = 1.0541571 \cdot 10^{-34} \quad Js \qquad (12)$$

where ν is frequency, 1/s (ν = 1, 2, 3, …). The minimal quantum of photon energy is when ν = 1, $E_q = 6.626068 \cdot 10^{-34}$ J (13)

Let us substitute (13) into (2)-(11), we receive the quanta of time, mass, length, volume (size) and charge:

$$T_q = \frac{G}{c^5} E_q = 1.82624 \cdot 10^{-86}\ s, \quad M_q = \frac{E_q}{c^2} = 7.37249 \cdot 10^{-51}\ kg,$$
$$R_q = \frac{G}{c^4} E_q = 8.62713 \cdot 10^{-45}\ m, \quad v_q = R_q^3\ \ m^3, \tag{14}$$
$$Q_q = \left(\frac{G}{k}\right)^{1/2} \frac{1}{c^2} E_q = 6.330261 \cdot 10^{-61}\ C,$$

where v_q is quantum of volume, m^3.

5. Heisenberg uncertainty principle

Heisenberg uncertainty principle are

$$\Delta I \cdot \Delta R \ge \hbar / 2, \quad \Delta E \cdot \Delta T \ge \hbar / 2, \quad \hbar = h / 2\pi, \tag{15}$$

where ΔI, ΔR, ΔE, ΔT are uncertainty of momentum, length, energy and time respectively.

Substitute into (14) the quanta (15) we receive the following the uncertainties the main quanta (15)

$$\Delta T_q = \frac{h}{2E_q} = \frac{1}{2}\ \ s, \quad \Delta R_q = \frac{h}{2\Delta I} = \frac{h}{2c \cdot \Delta M_q} = \frac{hc^2}{2cE_q} = \frac{1}{2} c \quad m \tag{16}$$

As you see, the uncertainties of quanta are large. These maximum values ΔE, ΔR, appears when are appeared in the first quantum of time T_q . The ΔM, ΔQ not appeared yet. They are equivalent the given ΔE.

The probability serve of inequality (15) is normal. If we take (15) in the more common form

$$\Delta I \cdot \Delta R \ge h, \quad \Delta E \cdot \Delta T \ge h, \tag{17}$$

the multiplier 1/2 in equations (16) become 1 and $\Delta R = c$. That means the speed in the first quantum of time equals the light speed.

Note: For getting the values (2)-(17) we also used the dimension theory and some of them may be defined with accuracy the constant factor. This factor equals 1 in many cases, if we use as base the Planck's units.

5. Main Results and Discussion

Main result of this research (part 4) is correction part 1-3 and equations with result that energy can be the universal source of Universe (see Eq.(7)). Energy can produce time, mass, charge and volume. The same role/factor also can act as time (see Eq. (2)). All main components of Universe (size, matter, energy, volume, time, charge) are closely connected and can transform from one to another.

That means at the foundation of the Universe is ONE factor, which creates our diverse world.

The reader can ask: How we can convert time to energy? I can ask a counter question: The equation $E = Mc^2$ (here M is mass) was open about hundred years ago. In that (past) time nobody could answer: How to convert the matter into this huge energy using this equation? Only tens of years later the scientists opened that certain nuclei of atoms can convert one to another, significantly change their mass and emit or absorb such quantity of energy. In 2006 the author offered the method which can convert any matter to energy with according to the equation $E= Mc^2$ [5] – [6].

In Universe (Part 1)[1] author has developed a theory, which allows derivation of the unknown relations between main parameters (energy, time, volume, matter) in Universe. In next part 3 he added charge as main parameter in this theory. He finds also the quantum (minimal values) of energy, time, volume and matter and he applied these quantum for estimations of quantum volatility and the estimation of some values of our Universe and received both well-known and new unknown relations.

Only time and experiments can confirm, correct, or deny the proposed formulae.

The authors other works closest to this topic are presented in references [1] – [8].

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Short biography of Bolonkin, Alexander Alexandrovich (1933-)

Alexander A. Bolonkin was born in the former USSR. He holds doctoral degree in aviation engineering from Moscow Aviation Institute and a post-doctoral degree in aerospace engineering from Leningrad Polytechnic University. He has held the positions of senior engineer in the Antonov Aircraft Design Company and Chairman of the Reliability Department in the

Clushko Rocket Design Company. He has also lectured at the Moscow Aviation Universities. Following his arrival in the United States in 1988, he lectured at the New Jersey Institute of Technology and worked as a Senior Scientist at NASA and the US Air Force Research Laboratories.

Bolonkin is the author of more than 250 scientific articles and books and has 17 inventions to his credit. His most notable books include The Development of Soviet Rocket Engines (Delphic Ass., Inc., Washington , 1991); Non-Rocket Space Launch and Flight (Elsevier, 2006); New Concepts, Ideas, Innovation in Aerospace, Technology and Human Life (NOVA, 2007); Macro-Projects: Environment and Technology (NOVA, 2008 LIFE; Human Immortality and Electronic Civilization, 3-rd Edition, (Lulu, 2007; Publish America, 2010): LIFE. SCIENCE. FUTURE (Biography notes, researches and innovations). Scribd, 2010, 208 pgs. 16 Mb.; Innovations and New Technologies. Lulu, 2013. 309 pgs. 8 Mb. http://viXra.org/abs/1307.0169.

Home page: http://Bolonkin.narod.ru.

Assessment of the Formation of a Student's Personal Physical Culture

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Ternopil National Pedagogical University named after Volodymyr Hnatyuk

Abstract

The article deals with the formation of the student's personal physical culture of the Ternopil National Pedagogical University named after V. Hnatyuk, which is estimated for the eight components.

The purpose of the research is to substantiate the state of the formation of the personal students' physical culture.

On the basis of data analysis of the experiment, it was found that the general level of formation of a student's personal physical culture before the experiment, on average, was between 31 and 32 points, and corresponded to a low level. After completing the forming experiment, the average score in the experimental group is 60 points and corresponds to the average level, while the average score of the personal physical culture of students who were engaged in the control group, increased by only 14 points and remained at the lower-middle level.

Key words: physical culture, physical education, personal physical culture, student.

Topicality. Laws of Ukraine "On Physical Culture and Sports" [7], "On Higher Education" [8], set the task for specialists in the theory and methodology of physical education in relation to the formation of the physical culture of the personality. The problem of the formation of personal physical culture, as a social phenomenon, is inextricably linked with the need to determine its level in general and the formation of some individual components.

The modern rhythm of life demands from young people more and more stresses of forces. Nervous, mental and physical overloads associated with the mastery of complex modern technology, professional and everyday stresses lead to the disorder of metabolism, overweight, and the emergence of cardiovascular diseases. In addition, the volume of motor activity of a young person during the day is minimized. Student needs higher physical activity and preparation. Nowadays, to solve the problem of increasing the volume of motor activity cardinally by passing the means of physical culture, is practically impossible [1].

The task of a PE specialist is the formation of a student's personal physical culture through his / her self-knowledge and self-determination in the physical culture and health activity. The student should be able to evaluate and compare his / her personal physical culture with that one of peers [2].

Considering that the student's physical activity includes not only motor activity, but personality's development as well, that is manifested in the unity of physical and spiritual perfection, it is appropriate to consider it as a combination of cognitive, motivational and behavioral components that ensure the formation of a student's personal physical culture.

Scientists [1; 4; 5; 6] distinguish some separate components of person's individual physical culture. In fact, at the same time, there is no scientific research on the importance of the components of personal students' physical culture in higher educational establishments, that served as the basis for our study.

The purpose of the research: to determine the level of formation of the students' personal physical culture.

Object of research: students' personal physical culture in higher educational establishments.

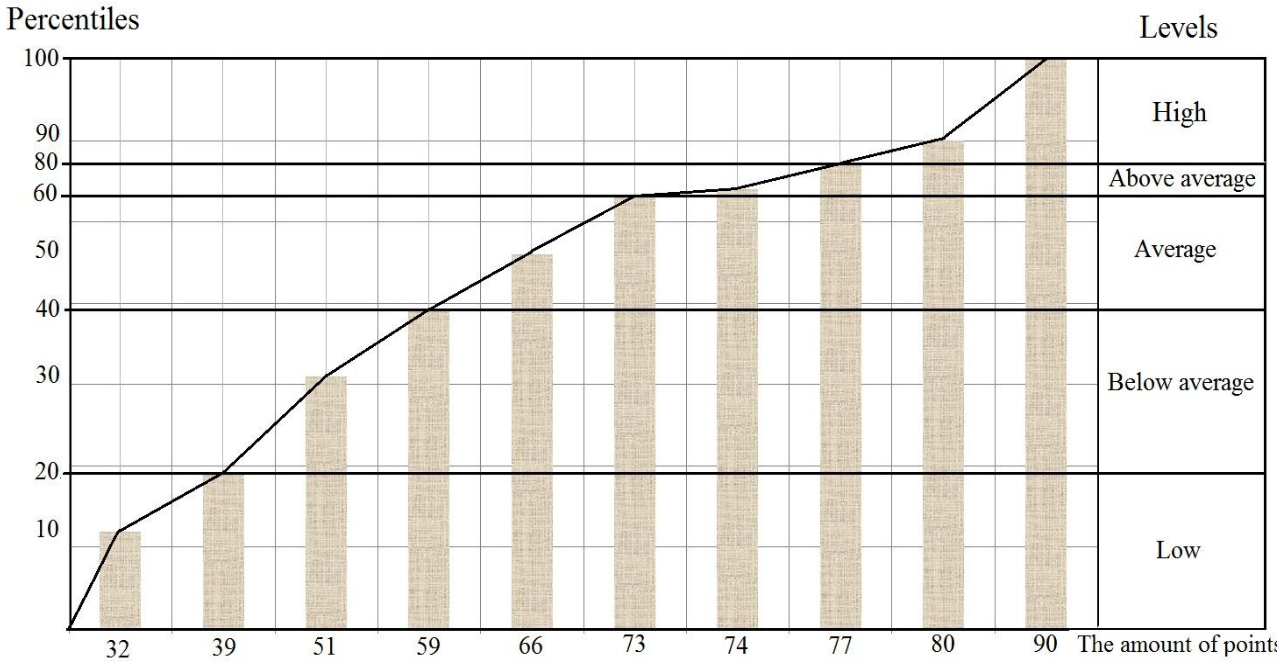
Subject of research: components of students' personal physical education and level of their formation.

The research tasks are formulated according to the purpose of the study**:**

1. To analyze the state of the problem at the scientific and pedagogical level.
2. To determine the level of the formation of the students' personal physical culture.

Presenting of the main material. An assessment of the student's personal physical culture was carried out during the academic year 2015-2017 with the students of the Ternopil National Pedagogical University named after Volodymyr Hnatyuk. 125 students took part in the research. Two groups were chosen for analysis: a control group (64 students) which studied according to the traditional methods without focusing on the formation of a student's personal physical culture and an experimental group (61 students) in which the class was conducted in order to form a student's personal physical culture, through the formation of individual components [4]: attending physical education classes, independent doing physical exercises, level of formation of motor qualities, level of physical health, skills and abilities, knowledge, participation in physical culture and health events and visiting the sports section.

The percentile methodology of evaluation was used in assessing of the students' personal physical culture.



Picture 1. The percentile scale of an assessment of the student's personal physical culture

According to the recommendations of Metivirg et all (after Leder L.) [3], it is recommended to assign values to a low level of personal physical culture that are available for more than 90% of students, to a below average level - 70 - 89%, to an average level - 45 - 69% , to an above average level - 30 - 44% and to a high level – for less than 16% of students (Picture 1).

The percentile scale is formed according to one hundred points scale (from 0 to 100, where zero is of a low value). Estimation from 0 to 39 points refers to the zone of low results, 40- 59 points - to the below average zone ; 60 - 73 points - to the average zone; 74 – 80 points - to the above average zone and 81 - 100 points – to the high zone.

The received results of the molding experiment are presented in Table 2.

Analyzing the general level of the formation of the student's personal physical culture, we found out that on average, before the experiment, it was within the range of 31-32 points and corresponded to a low level (Table 1).

Table 1

The state of students' personal physical education in 2015-2016 academic year *before experiment* (♀– n =125)

Indexes		M_x	S_{ms}	Level
Control group	n=64	31,78	15,59	Low
Experimental group	n=61	32,18	12,83	Low

After the experiment, the average score, shown in the experimental group, is 60 points and corresponds to the average level of the formation of personal physical culture.

Table 2

The state of the formation of students' personal physical education in 2016-2017 academic year *after the experiment* (♀– n =125)

<table>
<tr><td colspan="2" rowspan="2">Indexes</td><td colspan="3">The amount of points scored for the indicator
(Taking into account the coefficient of significance)</td></tr>
<tr><td>M_x</td><td>S_{ms}</td><td>Level</td></tr>
<tr><td>Control group</td><td>n=64</td><td>46,50</td><td>20,86</td><td>Below average</td></tr>
<tr><td>Experimental group</td><td>n=61</td><td>60,70</td><td>19,29</td><td>Average</td></tr>
<tr><td colspan="2" rowspan="2">P</td><td colspan="2">$P \leq 0,001$</td><td rowspan="2"></td></tr>
<tr><td colspan="2">$P \leq 0,001$</td></tr>
</table>

Speaking about the average components' indicators of the formation of students' personal physical culture, the changes were mainly observed in the indicator of motor qualities. If the results of the study to reflect in percentages, then before the experiment, the formation of motor skills, shown by the students of the control group and the experimental group, were in the range of 28-29% of the maximum possible, and after its completion - 60-61% in the experimental group and 44-45 % in control one.

Summarizing the foregoing, we can make the following conclusions: analysis of literature has revealed individual components of the personal physical culture; it was assessed the formation of the students' personal physical culture and found a positive effect of approbation results of the research's forming experiment. So, before the experiment the students of the Ternopil National Pedagogical University named after Volodymyr Hnatyuk in the control and experimental groups had a low level of personal physical culture, and after the end of the forming experiment in the experimental group the level of personal physical culture was at an average level. It gives us the reason to speak about the positive effect of the experimental technique over the traditional one.

Further perspectives of our study include the development of a program of formation of personal physical culture for the students in special medical groups and for those ones from the other non-pedagogical universities.

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Realization of Pedagogical Conditions for the Formation of General Scientific Competence of the Future Bachelors of Machine Engineering Specialties

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Abstract

The article reveals the expediency of applying pedagogical conditions for the formation of general scientific competence of the future bachelors of machine engineering specialties. It is indicated that their implementation will positively influence not only the professional qualities of future bachelors, but also the formation of world outlook positions, moral beliefs, and the nature of thinking. It indicates the promotion of the development of spirituality and a common culture, the ability of interpersonal communication.

Keywords: future bachelors of machine engineering specialties, the results of education, natural-science training.

Introduction. Formation of professional competence of the future bachelors of machine engineering specialties is the most important factor of improving the quality of pedagogical activity in the university and the preparation of a competitive specialist. The content of the modern education system is aimed at ensuring the formation of multifunctional knowledge, skills and professionally important components of professional competence. Mastering new information technologies, the ability to adapt to the accelerated pace of scientific and technological progress and any production, will lead to the achievement of the desired result. Developed and proposed early pedagogical conditions [3, p. 49-56], in our opinion, will positively influence not only the professional qualities of future bachelors, but also the formation of ideological positions, moral beliefs, the nature of thinking, promote the development of spirituality and a common culture, and the ability to interpersonal communication.

Formulation of the problem. In the conditions of the higher education system transition to two-level training of specialists, a new education paradigm is realized. The training of future specialists in the technical field in the aspect of forming professional competence and providing readiness for professional activity acquires new significance. All these processes are focused on the implementation of the requirements of the Bologna process, the standards of a new generation, changes in the content of engineering education, mastering professionally oriented qualities of engineer training [2, p. 153]. Specialists in the field of engineering pedagogy, teachers of fundamental, technical and socio-humanitarian disciplines strive to clarify the optimal conditions for training specialists in technical specialties and ensuring their high competitiveness. In our country, there are certain factors that can positively influence the problem of raising the level and role of the component of natural-science training in engineering education.

Statement of the main material. The future bachelors of machine engineering specialties are now oriented to receive professional training characterized by a high degree of scientific, technical and industrial importance. Ability to use knowledge in professional work; master the methods of cognition, self-improvement allow to freely navigate in the information space. A young specialist after graduating from a higher education institution needs constant self-improvement in order to manage production and technological processes in the future [1, p. 363].

According to the training program of specialists in machine engineering specialties, it is necessary to study the disciplines of professional, natural-science and professionally-oriented training. Chemistry as an academic discipline of natural-science training provides the teacher with ample opportunities for selecting system-forming factors. At the same time, a student can form the content of the course and choose the nature of the material presentation, in which the system maximizes the level of heuristic abilities of students, provides a deep understanding of the systemic integrity of the main provisions of the course. The vision of the unity of opportunities for the practical use of the acquired knowledge in future professional activity and developed skills is an important characteristic of the professional competence of a modern engineer.

The interaction of a chemistry teacher with teachers of professional educational disciplines is not only useful, but also multifaceted. On the one hand, it enriches the knowledge of a chemistry teacher with the features of applying this knowledge in the field of machine engineering. This makes his/her lectures, practical and laboratory studies more interesting and informative for students in terms of their future specialty. On the other hand, this interaction makes it possible for teachers of other disciplines to attract with students to motivate them to study chemistry. At the lectures the teacher explains the possible use of various materials and technologies used in machine engineering, drawing attention to the fact that these properties are studied in more detail in the course of inorganic chemistry.

An additional condition for the future specialist of machine engineering profile to study chemistry is the understanding that the knowledge of chemistry creates certain competitive advantages compared to those future colleagues who do not understand the importance of these disciplines for successful professional activity and for their own creative self-realization. Thus, the personality of the teacher is already in itself a powerful factor that encourages students to study the academic discipline that he/she teaches.

It is well known that even a bad system is better than the absence of system. The orientation of the educational process on a deep understanding of the essence of the material being studied is directly related to the systemic nature of the presentation. It ensures the inclusion and activation of associative thinking of students in the course of their educational activities. Applying the basic didactic idea of Sukhomlinsky V.A. "Teaching without coercion" removes a sense of fear among students in class, strengthens their confidence in their abilities and capabilities. It makes them relaxed and free, which makes it possible to realize their abilities, laid down from childhood. As a result, there is a real opportunity to develop and maximize the creative potential of each student; the desire for further, wider learning of the teaching material from childhood. Understanding also contributes to the development of logical thinking, disciplines it, and raises its culture and productivity. "In order not to turn a child into a storehouse of knowledge, a storehouse of truths, rules and formulas, one must teach him to think. The very nature of children's consciousness and children's memory requires that a baby sees the bright surrounding world with its laws and it should not be closed for a moment "[5, p. 258].

The innovative orientation of the training of specialists provides for the orientation of the teaching and upbringing process on acquaintance of students with innovative high technologies, as well as with unresolved problems and directions for finding possible alternatives to their solution. At the same time, students are encouraged to seek innovative solutions, and appropriate skills are formed. But even more important is that they are gradually developing a general innovative direction of thinking and showing its strategic character.

The general democratization of public life, the broad opportunities for access to information gradually change the role of the teacher. At the same time, teacher’s purely educational functions of explaining the material to students, the answers to their questions to a certain extent, reinforce teacher's educational impact. This is not manifested in instructive conversations, but in culture and behavior, in the manner that teacher holds, in attitude towards students and in the nature of communication with them. All this contributes not only to the students' successful mastering of educational material, but also to their personal development and socialization.

Given the significant potential hazards of many chemicals and technologies, the future bachelor of machine engineering specialties should be well aware of the potential for their adverse impact on people and the environment and provide reliable protection against it. This is how a student understands one of the main tasks of the modern engineer - the need to maintain a stable balance in the system "man - society - nature - technology". At the same time, understanding of personal responsibility for the life and health of both current and future generations is strengthened.

In the process of providing the basic level of chemical preparation of students, the quality of students' studies in other disciplines was constantly monitored after studying the course of general chemistry, the experience of other teachers was analyzed, and the students were questioned. The information obtained thus confirmed our assumptions, allowed us to clarify certain provisions and improve the methods, techniques and pedagogical technologies used in the teaching of general and inorganic chemistry for students.

Therefore, those personal qualities that they can develop as a result of the creation and observance of the examined pedagogical conditions have a serious positive impact on all further educational and cognitive activities and students' behavior, on their attitude to learning and knowledge. Thus, they lay the foundations of professional and social competence; an understanding is formed of the need for a good quality education as the most important factor of their competitiveness in an extremely complex modern labor market and labor as one of the prerequisites of life success.

The proposed pedagogical conditions simultaneously perform an important educational function. Indeed, students get the opportunity to form their own teamwork skills, master the basics of business communication. The discipline of thinking and its culture help them to realize their creative personal potential more fully. We consider it extremely important to note that in the long-term socio-economic crisis that Ukraine is experiencing, it is important for the student to get a good fundamental education, since after graduating from the university, he may not find a job in his specialty. In addition, today the worldwide trend of social and professional mobility of people, especially those with higher education, is becoming increasingly clear.

"Professional managerial skills are vital for the engineer, because they allow you to systematically analyze a problem situation, determine the ways and means of its optimal solution. Decision making is an important function of managers at all levels. Effective decisions and actions aimed at their implementation are possible only on condition of adequate awareness of the essence of a concrete situation" [4, p. 14]. Therefore, it is important to teach students the culture of business communication and the principles of teamwork, since it will be necessary for them in almost any sphere of modern life.

In addition to the above results of changing students' attitudes toward chemistry and its study, it is important to note the changes in the level and quality of their knowledge. There is a reason to assert that these changes were also the result of the observance of the pedagogical conditions formulated in accordance with the pedagogical theory and verified in the practice of education. When enrolling in machine engineering specialties of higher educational institutions in Ukraine, the assessment of the school's knowledge of applicants in chemistry is not taken into account. Therefore, before the course is studied, the input control of the determination of residual knowledge of inorganic chemistry is carried out.

We assessed its results with three levels of knowledge: high - above 85 points out of 100, average - from 65 to 84 points and low - below 64 points. According to the results of the entrance control, 6% of students showed a high level of knowledge of the school chemistry course, an average level of 18% and a low level of 76%. After studying the university course of general chemistry in the performance of the given pedagogical conditions and, naturally, as a result of their application, the results have changed significantly. A high level of knowledge showed 36% of students, middle - 52% and low - only 12% of students. For comparison, we present the results of the progress of students of other non-chemical specialties who studied chemistry in the traditional system. These results were kindly provided to us by other teachers. On a sample of 312 people, only 27 people (9%) had a high level of knowledge, an average of 75 people (24%) and a low level of 210 people (67%). The results of the research showed a positive dynamics in the formation of the level and quality of students' knowledge after studying the course of general chemistry, which proves the effectiveness of the revealed pedagogical conditions and methods of their implementation in the educational process of the university.

Conclusions. Based on the fundamental principles and principles of pedagogy and reliably tested experimentally on a large sample of students, this study allows us to draw the following conclusions.

1. The future bachelor of machine engineering specialties should have a high fundamental component, which will provide an opportunity to develop and successfully use innovative high technologies based on new physical effects and nanomaterials. In addition, knowledge of fundamental disciplines will contribute to students' successful professional mobility.

2. Insufficient level of knowledge in the chemistry during school preparation of students, causes not enough interest of future specialists to study the subject in the first year of education, and consequently leads to a lack of understanding and the importance of obtaining knowledge. Ensuring the necessary level of their general scientific competence requires the creation and consistent implementation of appropriate pedagogical conditions.

3. Realization of the proposed pedagogical conditions, will allow forming the basic professional competence of future bachelors of machine engineering specialties in the process of natural-science preparation, clear ideological positions of moral principles and beliefs, development of general and professional culture, apply the results of education to European standards.

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Text-Creation Possibilities of the Word in the Process of Forming Skills to Create Texts by Primary School Students

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Abstract

In this article, the author has provided a framework for teachers to understand the goals and types of activities for supporting children at each level of early text-creation development. The problem of text-creation by preschool students is examined from the standpoint of text-creating opportunities with linguistic means. Focused attention on the word as the minimum unit of any thought; characterized its possibilities which are connected with its communicative potential, therefore the ability of the word can be realized in communication (text-creation) on the basis of associative connections, figurative and metaphorical means, synonyms and antonyms, which are used for defining an expression of thought and avoiding repetitions, elaboration of the word. They help brighter to described the objects, events, better to express a reflection. Determined that the text-creation possibilities of different parts of the language are related with their morphological and syntactic qualities. Text-creation possibilities of the verb are characterized by temporal verbs meanings, indicating the dynamics of events, emphasizing their duration, expressing the state of the subject or described phenomena at the time of observation on them, and give a possibility to distinguish one action, etc.

Key words: text-creation, create-abilities, a word, figurative meaning of the word, synonyms, antonyms, parts of speech, temporal forms of the verbs.

Актуальність. Одним із важливих завдань освіти є забезпечення належного рівня мовленнєвому розвитку школярів. Його реалізація поліпшуватиме процес входження учнів в навколишні життєві реалії, сприятиме багатогранному самовиявленню й самореалізації, формуванню навичок володіння словом, мовою, мовленням у різноманітних ситуаціях спілкування. Пріоритетом державної політики, визначеним Державним стандартом, чинними програмами з мови, є формування мовної особистості, людини комунікативно компетентної, здатної й готової до спілкування в будь-якій життєвій ситуації і в різних сферах суспільного життя. Нині стратегічним завданням реформування змісту мовної освіти є вироблення системи комунікативних умінь і навичок, найскладнішими серед яких є вміння створювати власні висловлювання під час спілкування.

Проблема текстотворення цікавить багатьох спеціалістів, зокрема психолінгвістів, лінгводидактів. У психологічній літературі розкриваються питання породження і розуміння тексту (Н.Болотнова, Н.Валгіна, І.Гальперін, М.Доблаєв, М.Жинкін, І.Зимня, О.Леонтьєв та ін.). У методичних працях М.Баранова, М.Вашуленка, Н.Голуб, О.Горошкіної, Н.Ipполітової, В.Капінос, Л.Кратасюк, Т.Ладиженської, М.Львова, В.Статівки описується надійна система роботи з текстом. У численних дослідженнях зауважується, що перед формуванням умінь створювати тексти учні повинні засвоїти текстотворчі можливості мовних одиниць. Для вираження думку в процесі спілкування, як правило, використовується комплекс мовних одиниць різного рівня. Серед них вагоме значення має слово. Тому *метою* статті є аналіз текстотворчих можливостей цього мовного засобу.

Виклад основного матеріалу. Слово – це «самостійна, наділена одним або кількома граматичними значеннями одиниця мови, яка передає одне чи більше лексичних значень, легко відтворюється і є будівельним матеріалом для речення» [25, с. 152]. Воно слугує засобом повідомлення знань про предмети, ознаки, процеси та відношення, що потрапляють у сферу номінації (називання) [23, с. 38] і є «основною одиницею найменування фактів дійсності, а також сприймань, думок, почуттів людини, викликаних цими фактами» [1, с. 1].

Одиницю мови можна приймати за слово лише в тому випадку, коли її зовнішня форма поєднується із внутрішнім змістом (лексичним значенням). Лексичне значення (семантика) слова – це співвіднесеність слова із певним поняттям, тобто із «усезагальною думкою про предмети, явища і факти об’єктивної дійсності, що виникають у свідомості мовців під час вживання певної лексичної одиниці» [5, с. 54]. Воно посідає не аби яке місце в створенні тексту, оскільки людина в мовленнєвому акті оперує не окремими словами, а семантичними полями, з яких вона вибирає їх, щоб висловити свою думку (В.Звягінцев).

О.Лурія відмічає, що одне і те ж слово може реалізовувати в мовленні різні значення, набувати різних смислових й емоційно-експресивних відтінки [11]. М.Мікулінська відмічає, що «знання значення кожного слова для розуміння лексичного змісту речення необхідне; незнання (нерозуміння) значення хоча б одного слова може привести до повного нерозуміння речення або до спотвореного розуміння змісту всього тексту» [12, с. 54].

Текстотворчі можливості слова, як зазначає Н.Болотнова, зв’язані з його комунікативним потенціалом [4, с. 276], що передбачає закріплення у свідомості носіїв мови вживати слова співвідносячи їх в певною ситуацією спілкування.

Можливість лексичних одиниць брати участь у комунікації (текстотворенні) реалізується на основі асоціативних зв'язків. Механізм асоціаціації передбачає зв'язок між певними об'єктами або явищами [24, с. 191]. На думку І.Гальперіна, ці зв'язки виникають «у силу властивості нашій свідомості зв'язувати викладене вербально з накопиченим досвідом» [6, с.45]. І далі науковець пише: «Автор зв'язує не предмети або явища дійсності, а образи, якими ці предмети, явища зображуються» [6, с. 80]. Ф. де Сосюр зазначає, що «будь-яке слово може викликати в пам'яті все, що здатне тим або іншим способом з ним асоціюватися» [17, с. 155-159]. Іншими словами до кожного слова-стимула можна підібрати слова-реакції, які дають уявлення про нього, тобто асоціюються з ним. Виникають ці слова на основі різних асоціацій. Так, Ф. де Соссюр вважає, що «асоціативна спільність між словами може здійснюватися як за змістом, так і за формою, або за формою, або за змістом» [17, с. 155–159]. Ш.Баллі, ґрунтуючись не на семантичній близькості асоціатів, а на типах асоціацій, описує ближні і далекі асоціації. З точки зору вченого, «небо швидше наводить на думки про зірку, хмару, колір, ніж про дорогу або про будинок» [2, с. 151]. А.Клименко виділяє фонетичні, словотвірні, парадигматичні, синтагматичні, тематичні, цитатні, граматичні асоціації [8]. З позиції В.Бєляніна, при інтерпретації відповідей асоціативного експерименту слід виокремлювати, насамперед, синтагматичні і парадигматичні асоціації. При синтагматичних асоціаціях граматичний клас слів-стимулів виявляється відмінним від граматичного класу слів-реакцій (небо – блакитне, машина їде). При парадигматичних асоціаціях слова-реакції належать до того ж граматичного класу, що і слова-стимули (стіл – стілець, батько – мати). Вчений виділяє також родо-видові відносини (тварина – кішка) [3, с. 78]. Нам імпонує ця думка, оскільки вважаємо, що молодші школярі в першу чергу наведуть приклади слів-реакції парадигматичних асоціацій, у зміст яких входять синонімічні і антонімічні зв'язки (друг – товариш, приятель, ворог), а також синтагматичних асоціацій, що передбачають сполучуваність слова на основі його лексико-семантичних властивостей з іншими словами в мовленні (друг – добрий, вірний).

На основі асоціативних зв'язків реалізується переносне значення слова. Наявність схожості між поняттями (предметами, ознаками, діями) є передумовою того, що одна назва використовується для найменування іншого поняття. Тому важливо показати учням, що перенесення найменування відбувається за схожістю різних ознак: за подібністю форми (дзвіночок – квітка, дзвіночок – металевий сигнальний інструмент), кольору (каштанове волосся – волосся кольору плоду каштана), за місцем розташування (хвіст коня і хвіст потягу), за призначенням (двірник – працівник, який підтримує порядок і чистоту на подвір'ї, двірник – пристрій для механічного витирання скла автомобіля) тощо.

Отже, формуючи вміння створювати тексти, доцільно навчити учнів використовувати переносне його значення, асоціативні ряди, тобто групу слів-реакцій на ключове слово, оскільки, чим багатше і різноманітніше асоціації, тим виразнішими й цікавішими будуть їх твори.

Іншою лексичною одиницею, яка здатна в контексті змінити одне слово на інше, не змінюючи змісту висловлення, є синоніми. В тексті, як відмічає І.Ющук, вони застосовуються для «точного вираження думки та уникнення повторення тих самих або однокореневих слів» [25, с. 184]. Виходячи з цього, синоніми виконують функцію заміщення й уточнення (Л.Новіков).

Синоніми в рамках текстотворення конкретизують можливий смисловий потенціал слова і його тематичну орієнтацію. Наявність їх у тексті відбиває аналітичну глибину і точність мислення. Вони збагачують текст, роблять його виразним. Створюючи висловлювання, автор намагається передати щонайтонші нюанси спостережуваних фактів, підбираючи кожного разу найдоречніше слово для адекватного вираження відповідних представлень в конкретних мовленнєвих ситуаціях.

Отже, багатство та виразність синонімів створює необмежені можливості для їх цілеспрямованого відбору й уважного вживання в тексті. В безлічі близьких за значенням слів у побудові творів автор використовує те єдине, яке вданому контексті стане найбільш виправданим.

У лексичній системі сучасної мови слова пов'язані між собою не тільки синонімічними, але й антонімічними відносинами, основою яких є протилежні слова [25, с. 175]. Робота з ними під час текстотворення розширює уявлення дітей про слово, допомагає вточнити його значення. Знаходячи словосполучення із словами протилежного значення, учні глибше розуміють багатозначність слова (свіжа сорочка –

брудна сорочка).

Таким чином, лексику мови утворюють слова з переносним значення, синоніми й антоніми, що дають змогу майстру під час створення тексту зробити його зрозумілим і яскравим.

У текстотворенні, крім лексичних особливостей, важливе значення мають різні частини мови. Їх текстотворчі можливості тісно пов'язані з їх морфологічними і синтаксичними якостями. У морфологічному плані частини мови «грають тільки ті ролі, що відповідають їх ознакам та узгоджуються з їх властивостями». Так, текстотворча роль іменника полягає в представлені предметності, тобто вказувати на предмет; прикметника – позначати ознаки; дієслова – вказувати на дії, стани, властивості; числівника – числа, кількість, їх послідовність чи порядок; займенника – уникати повторень; сполучники – для зв'язку між частинами речень.

Особлива роль у створенні тексту відводиться дієслову. Як частина мови воно вказує на динаміку і розвиток подій, виступає засобом зв'язку речень у тексті. Текстотворчі можливості дієслова характеризуються видо-часовими формами. Особливе значення має час дієслова, що «виражає відношення дії до моменту мовлення» [18, с. 377]. Дія протікає в трьох планах: «1) одночасно з моментом мовлення, 2) до моменту мовлення, 3) після моменту мовлення – тобто в теперішньому, минулому і майбутньому плані» [18, с. 377]. Відповідно цьому, «дієслова мають значення минулого, теперішнього і майбутнього часу» [18, с. 377]. Зазначимо, що в процесі спілкування виражається співвіднесеність видо-часових форм дієслів щодо моменту мовлення. Так, в оповіданнях і міркуваннях одночасно можуть застосовуватися різні часові форми. Динаміку подій в оповіданні найбільш повно передають дієслова минулого часу» [7, с. 70] переважно зі «значенням дії, що змінюється» [20, с. 289], також «дієслова, що вказують на початок дії (почали, стали), виникнення» [22, с. 154]. Дієслова минулого часу недоконаного виду дають можливість виділити одну дію, підкресливши її тривалість.

У текстах-описах використовуються дієслова одного часу, що демонструють перерахування ознак предмету або явища. Найбільш частотні, за твердженням Т.Трошевої, «описи з єдиним планом теперішнього часу або з єдиним планом минулого часу» [20, с. 267]. Дієслова теперішнього часу, як правило, виражають тривалий стан предмета;

дієслова недоконаного виду минулого часу вказують на стан описаних явищ у момент спостереження за ними.

Вважаємо, що молодших школярів доцільно ознайомити з уживанням часових форм дієслів в різних типах тексту [9].

Висновки. Отже, у синтаксичному плані текстотворча роль частин мови дуже близька до морфологічних властивостей, але не повторює їх. У синтаксисі частини мови займають позицію членів речення, у тексті – представляють смислові (іноді досить складні) компоненти мовлення.

Таким чином, робота над словом включає не тільки розширення словника, але й виховання в дітей уваги до лексичних особливостей слів, їх асоціативних зв’язків, часових форм дієслів. Це дасть змогу особистості зробити свій текст зв’язним, виразним і правильним.

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Компаній Олена. Текстотворчі можливості слова в процесі формування вмінь створювати тексти молодшими школярами.

Розглядається проблема текстотворення молодшими школярами з позиції текстотворчих можливостей мовних засобів. Зосереджено увагу на слові, як мінімальній одиниці будь-якої думки; охарактеризовано його можливості, що зв'язні з комунікативним потенціалом, тому можливість слова брати участь у комунікації (текстотворенні) реалізується на основі асоціативних зв'язків, переносного значення слова, синонімів та антонімів, які застосовуються для точного вираження думки та уникнення повторень тих самих або однокореневих слів, конкретизують слово, допомагають яскравіше змалювати контрастні предмети, події, виразніше висловити думку. Встановлено, що текстотворчі можливості різних частин мови тісно пов'язані з їх морфологічними (в тексті грають тільки ті «ролі», які відповідають їх ознакам та узгоджуються з їх властивостями) та синтаксичними якостями (займають позицію членів речення як смислові компоненти мовлення). Текстотворчі можливості дієслова характеризуються видо-часовими формами, що вказують на динаміку подій, підкреслюють їх тривалість, виражають стан предмета або описаних явищ у момент спостереження за ними, дають можливість виділити одну дію тощо.

Ключові слова: текстотворення, текстотворчі можливості, слово, переносне значення слова, синоніми, антоніми, частини мови, видо-часові форми дієслів.

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