# **Theory of frequency, energy density and fractal structure of the Universe**

## **Introduction**

Modern physics is based on quantum mechanics and general relativity theory (GRT), but their unification **remains** an unsolved problem. We propose an alternative model in which the **frequency of oscillations** is the primary concept determining the energy density. Within this model, Planck's constant plays the role of the **fractalisation coefficient**, determining the scale of physical processes.

## **1. Rethinking the Michelson-Morley experience**

According to the special theory of relativity (STR), the **speed of light in a vacuum is the same for all observers, regardless of their motion**. This means:

* If one observer is travelling at some speed and the other remains at rest, they will both measure the speed of light as c, regardless of their states of motion.
* Even if the object is flying towards or away from the light, the light will still have a velocity c relative to it.

For classical mechanics such an effect could arise if objects have a wave structure and the speed of propagation of these waves would be equal to the speed of light. In this case the propagation speed would be bound to the notion of some medium. There were earlier attempts to link this medium to the ether. The Michelson-Morley experiment showed that there was no ether. But let's look at it in more detail.

Michelson and Morley used an **interferometer**, a device that measures the difference in the speed of light in different directions.

1. **The interferometer consists of:**
   * Light source.
   * A translucent mirror that divides a beam of light into two perpendicular rays.
   * Two mirrors that reflect the rays back.
   * The screen on which the interference pattern is created.
2. **The idea of experience**:
   * If the Earth is moving through the ether, then a beam of light travelling along the motion of the Earth must move faster or slower compared to a beam that is travelling perpendicular to the motion of the Earth.
   * This should cause a **change in the interference pattern** because the phase difference between the rays will change.

**Result**

To the **surprise of the scientists**, **no changes in the interference pattern were observed!** This meant that the **speed of light is the same in all directions**, regardless of the Earth's motion.

And now let's reason a little bit from the other side. Photons and all elementary particles can be just waves of some medium. In such a case the motion of waves will not cause any apparent displacement of the medium. It may cause a wave larger than the elementary particles themselves. Therefore, the concept of wind cannot exist. In that case this experience merely confirms that everything around is just waves of some medium. It is not suggested here to return to the hypothetical concept of ether. It is suggested to consider in this respect the well-known concept of energy. It is no secret that the same gravitational force gradually decreases with distance from the object. Thus, gravitation can be not just a force of attraction, but a manifestation of change of energy density in space. If so, gravitational effects can be explained through redistribution of energy density rather than through curvature of space.

It is important to note that no return to the ether in the classical sense is proposed here. Instead, the concept of energy is considered as the basic physical substance within which all known particles and fields are formed. Energy is not carried by the medium, but creates the structure of space itself.

**Conclusion**

The Michelson-Morley experiment does not prove the absence of medium, but only shows that the Earth **does not create etheric wind** because it itself consists of waves. If elementary particles are waves and matter is their aggregate, then all matter is a **wave structure**.

That means:

* **The speed of light remains the same** because it is a wave, and waves are independent of the motion of their source.
* **No aether is needed** because space already contains an energy structure that behaves like a wave medium.
* **Gravity and energy create a spatial wave** rather than transporting matter, which explains why light propagates the same in all directions.

Thus, the theory of relativity confirms not the absence of medium, but the **wave nature of all matter**, in which light and elementary particles simply follow the laws of wave propagation.

**Why is this so important?**

1. **Changing the understanding of space**
   * Instead of an empty vacuum, we get a **structured space** where waves exist **not in the medium, but in the space itself**.
   * This removes the contradiction between quantum mechanics and relativity.
2. **Explains the constancy of the speed of light**
   * In classical physics, it was impossible to understand why the speed of light is always c.
   * Now this makes sense: **everything is a wave**, and the speed of light is a fundamental property of the wave structure of space.
3. **Creates a new way of looking at mass and gravity**
   * If particles are waves, then **mass and gravity are also wave effects**.
   * This could explain **what dark matter and energy are** if they are the result of the wave behaviour of space.
4. **Confirms relativistic physics, but without the aether**
   * We **do not go back** to the ether, but show that space already contains the **wave structure of energy**.
   * This is completely consistent with STO, but gives a **new interpretation**.

### Possible objections

1️ **Difference between this approach and ether**

**Proposal:**  
*"It is important to emphasise that in this model space is not a static medium, but a dynamic energy density structure. In contrast to the classical ether, it does not create resistance to the motion of objects, but is itself formed by wave processes".*

2 **STO does not require the wave nature of particles**

**Counterargument:** The Special Theory of Relativity (STR) works without the assumption that particles are waves. It explains why the speed of light remains constant using Lorentz transformations rather than wave effects.

**Answer:** But that said, STO doesn't explain why the speed of light should be limiting, and this model gives it a physical meaning - light and particles are already waves, and so their speed is simply limited by the properties of space.

3 **Why then do other waves behave differently?**

**Counterargument:** Water and air are also media where waves propagate, but there the velocities add up (e.g. sound is faster in moving air). Why is light an exception?

**Answer:** Electromagnetic waves **are independent of the medium** because the medium itself is energy, not matter. Light does not need to carry matter, only energy transfer through the **structure of space**.

4 **If everything is a wave, why do particles behave like objects?**

**Counterargument:** We see particles in experiments, measure their trajectories, collide them in accelerators. How can a wave behave as if it were an object?

**Answer:** The fact that energy is transmitted in portions (quanta) may be a natural consequence of the fact that matter waves have a standing structure. If a particle is a standing wave, then it cannot change its state smoothly, but only move between discrete steady states. This explains why in quantum mechanics energy does not change continuously, but only discontinuously.

5 **Why then does quantum mechanics not take this effect into account?**

**Counterargument:** In quantum physics, mass is considered fixed, although photons have zero mass. If mass really changes with acceleration, it would have to show up in experiments.

**Answer: gravitational redshift may be direct evidence that mass is changing**.

### How is gravitational displacement related to the change in mass?

In classical physics, **gravity** is said to **change the frequency of a photon** as it leaves the gravitational pit.

In this approach, it turns out that it **is not just the frequency that changes, but the structure of the wave itself**, and this is **equivalent to a change in mass**.

### Gravitational redshift formula

According to the general theory of relativity (GTR), the change in frequency of a photon when it leaves the gravitational field is described as:

Where:

* ν′ is the modified frequency,
* ν is the initial frequency,
* G is the gravitational constant,
* M is the mass of the body,
* r is the radius from which the photon is emitted.

But if a photon is a wave structure, then its mass must depend on the same relationship:

That is, the photon does not just lose frequency - it loses mass equivalent! It has long been known that the higher the frequency of a photon, the higher the mass equivalent. Gravitational redshift is a proof of mass loss when travelling with acceleration.

It is interesting that the energy loss by a photon is similar to the way ordinary particles lose mass at acceleration in relativistic physics. It can mean that the photon in some sense is a limiting case of a particle at which all mass has already "passed" into velocity.

### What does that explain?

Gravitational redshift is not just a "stretching" of the wave, but a **change in its mass**.  
In such a case **mass does change with energy change**, but it is not seen in experiments with particles, because they are accelerated differently. **GR remains true**, but gets a new explanation through the change of wave structure of energy.

Thus, **gravitational redshift is actually experimental evidence that the mass of a photon varies!**

**If all matter is wave structures, it means that the laws governing elementary particles can be repeated on different scales. This regularity can explain the fractal structure of the Universe....**

If everything in the Universe is built according to the same laws, then not only the microcosm but also the macrocosm must obey the same principles. Perhaps galaxies are just scaled versions of elementary particles.....

## 2. Longitudinal Energy Waves in the Propagation Mechanism of Electromagnetic Waves

### Introduction

Electromagnetic waves are typically regarded as transverse, propagating without the need for a medium. However, their finite speed of propagation raises a fundamental question: what happens to energy in space during wave propagation? If energy cannot change instantaneously, then at some point in space, an energy gradient must form. If this is true, then it is logical to assume that electromagnetic waves generate not only transverse but also longitudinal energy oscillations.

### Energy Gradient and Its Consequences

When an electromagnetic wave leaves its source, it alters the energy density in the surrounding space. As the wave propagates, the energy at the source returns to its original value, but at a distance R, the energy remains altered. This means that between these two points, an energy gradient exists, which can propagate as a longitudinal wave. Classical physics does not account for such a phenomenon, but that does not mean it does not exist. Instead, its effects might be too subtle to detect directly.

Put differently, space, initially uniform in its energy distribution, becomes non-uniform after a wave passes. If energy redistributes itself, then a process akin to longitudinal oscillations must be taking place.

### Connection to de Broglie’s Hypothesis

De Broglie proposed that particles exhibit wave-like properties but did not specify a mechanism for their formation. If a standing wave indeed forms the basis of an elementary particle, then one must ask: what exactly generates this wave? If electromagnetic waves induce longitudinal energy oscillations, these oscillations might stabilize the standing wave, thereby forming a particle. Thus, a particle may not be just an abstract probability wave but a real structure in space governed by wave processes.

### Conclusion

Electromagnetic waves are traditionally viewed as purely transverse. However, from the perspective of energy density variation, it becomes clear that transverse oscillations cannot exist in isolation. They inevitably induce longitudinal energy redistribution, opening new avenues for understanding physical processes. Longitudinal energy waves may help explain not only wave propagation but also particle structure and some currently unexplained phenomena. This does not require a revision of established physics but offers a fresh perspective on well-known processes.

# **3. Standing waves of energy density and particle structure**

## **Introduction**

Modern physics describes elementary particles as point objects or perturbations of quantum fields, but another interpretation is possible. This chapter considers the hypothesis that particles are **standing waves of energy density** and their properties can be explained through de Broglie waves.

We will also consider how particle birth can be explained within this model and why the law of conservation of energy leads to the symmetry of matter and antimatter.

## **3.1 Standing waves of energy density and particles**

To date, science does not describe the origin of electric charge. What is its nature? Why is its value constant for elementary particles? Charge does not change its sign or its value regardless of the environment. Why does the mass of a body change when the speed of motion changes, but nothing happens to the charge? What is this parameter - charge?

It is known that:

**1/c = αћ/e²**

where

**e** is the charge of the electron,

***ћ*** is the reduced Planck constant,

***c*** is the speed of light.

One constant is expressed through another constant.

Can be reviewed at the link [(](http://nuclphys.sinp.msu.ru/misc/constants.htm)http://nuclphys.sinp.msu.ru/misc/constants.htm).

The physical quantity that is the inverse of speed is called pace. The pace shows how long it takes you to cover the desired distance.

This parameter is clearly a characteristic of an elementary particle, not an interaction, but a characteristic of the particle. It is clearly related to the rate from the speed of light. Question - what and how is overcome in the particle? What can we talk about?

It is necessary to understand what and where it is moving and why the tempo can take values "+1", "-1" and 0 (I divided the tempo by***αћ/*e²**, because it is all a constant, but I kept the sign of the charge, it will be very useful for us), let it be only numbers that tell us only about the direction. I.e.: "+1" means something is travelling somewhere at the speed of light in one direction, "-1" is movement in the opposite direction, and "0" is as if there is no movement in either direction.

As it was shown in the previous chapter - electromagnetic wave, being transverse, at its propagation gives birth to longitudinal waves of energy at its propagation. These two waves are interconnected. One propagates in the dimension of space, the other in the sphere. Energy fluctuations will occur in independent coordinates. It can also be said that the planes in which these two waves oscillate are orthogonal to each other, which means that to describe the overall process, both of these processes must be taken into account. The two processes will be related, but will be described in their own coordinates.

Since the particle is isolated in the dimension of space, it is logical to assume that it is a standing wave in the dimension of space. The particle is a standing wave, longitudinal, born by the propagation of an electromagnetic wave.

Let's consider a few possible cases. First option:

Fig. 1 The first elementary particle, the neutral, neutrino

The wave has one node. The wave has run once up, and once down. The result is zero. This is the first and neutral particle. Let's assume it's a neutrino. If there is a standing wave node at the centre of the circle, the particle will be neutral. With an odd number of nodes the particle will be neutral, with an even number of nodes the particle will be "charged".

Positron

Electron

Fig. 2 Electron and positron

I will assume that this pair of particles is an electron and a positron. For the electron, the wave has travelled down twice and up once. Two of the beams are negative and one is positive. If we add them up, we get the tempo.

I think this is what characterises the tempo in the case of elementary particles. For the electron, it's -1. For the positron, it's +1.

Thus, the charge is related to the inverse of this characteristic squared. That's why it's a constant. This is true only for standing waves, which can exist indefinitely. The main thing to understand is that it is not the electromagnetic wave itself, but the wave of energy density distribution in the region of space, which the electromagnetic wave created during its propagation.

This is the first "charged" particle - electron and positron. In this case, the electric charge is responsible for the rate of change of the wave in a region of space. For standing waves we always know the tempo, it must be an integer from the array of numbers -1, 0 and +1. There are three values in total. The characteristics that will change are the radius of the circumference of the particle and the number of nodes or bunches.

It is worth paying attention to the fact that for matter, "charged" particles in the centre always have a positive value of change in energy density on the space side. The energy density on the space side is increasing, the compression process is going on. For antimatter, it is always negative. The energy of the electromagnetic wave is spent on decreasing the energy density on the side of space, there is a stretching of space. You can see the relationship between tempo and charge. I have omitted the figures. The main thing is to understand the physics of the process.

Consider the following possible particle (both as a wave and as energy regions). Suppose that it is a proton and an antiproton:

proton

antiproton

Fig. 3 Proton and antiproton

It is known that the proton consists of three quarks in the case of the simple model. In fact, this structure can be supplemented by other quarks. This is clearly seen when considering the structure as a wave of changing energy density. Quarks in this case, are nothing but half-waves of curvature of space, half-waves of change of energy density in a region of space. Therefore quarks by themselves cannot exist, the meaning of a standing wave is lost. These half waves are different, three of one sign and two of another. In this case, it turns out that the proton is made up of five quarks. The concept of quark is very convenient for describing the interactions within the atom, will help to describe the sublevels for electrons, will describe the absorption and release of energy in the form of quanta, at the transition of electrons on sublevels, and also allows you to accurately calculate and describe the processes of nuclear reactions.

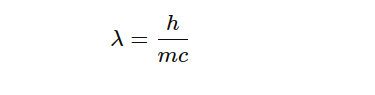
For "charged" particles, some gradient of density change in the region of space is formed at their boundary. The energy density will either increase or decrease. Hence there is an effect of interaction of "charged" particles. Like-minded particles repel, like-minded particles attract. This can be explained by the fact that the total energy density of the surrounding WORLD will try to minimise the distortions created by the density of particles at their boundary.

One should not also forget what the "charged" particle carries in its centre. This is very important. The difference of behaviour of matter and antimatter depends on the last factor. For matter in the centre of the particle there will be an increased energy density in the space area compared to the surrounding WORLD, which will lead to the gravitational effect and macro-objects will be created. In the case of antimatter the process will go the opposite way, all particles will try to "move away" from each other as far as possible. But at the same time antimatter will try to group at some distance from the matter particles. This will happen along the sphere.

A fuller description of these processes, as well as the birth principles of existing interactions, can be found in the philosophical work <https://dzen.ru/a/ZoINoVGeh12vIl-E>or <https://zenodo.org/records/15064958>.

### 3.1.1 De Broglie waves as the basis of particle structure

In the framework of the hypothesis of standing waves of energy density particles can be considered as nodes of such waves. The de Broglie wave associated with a particle does not simply describe its motion, but is **its structural element**. The de Broglie wavelength is determined by the relation:



where:

* h is Planck's constant,
* m is the mass of the particle,
* c is the speed of light.

If a particle is a standing wave, its size must correspond to an integer number of half-waves, which explains energy quantisation.

There was an article written on this topic <https://dzen.ru/a/Z7GBl8tL9DbB2x5L>or <https://zenodo.org/records/14883086>.

### 3.1.2 Fractal structure of particles

If matter is considered from the point of view of waves, we can assume the existence of similar structures, but with different scales. I.e. we can assume a fractal structure of the Universe. This means that at different levels of fractality particles can look like macro analogues of each other. For example, if a neutron is a standing wave with three nodes, then a similar structure can appear on larger scales, for example, in the form of a galaxy. In the following, a formula will be presented that may be able to describe this process.

## **3.2 Particle birth and the law of conservation of energy**

### 3.2.1 How particles are born

In the framework of the proposed model the birth of particles can be represented as a process of local redistribution of energy density. When in vacuum there arise fluctuations of energy density, they can lead to formation of **stable standing waves** which are perceived as particles.

The birth of particles is accompanied by the formation of **matter and antimatter** particles. This follows from the law of conservation of energy: any local fluctuation must be compensated by an equal and opposite fluctuation.

### 3.2.2 Why there is no symmetry breaking of matter and antimatter

It is usually considered that in the Universe there is an excess of matter over antimatter, but in the framework of this model **symmetry breaking is not required**. If a particle is a standing wave of energy density, its antipode may be a **wave with opposite phase**. The difference between matter and antimatter may lie in where the maxima and minima of energy density are located.

In a confined space, the redistribution of energy density will be due to the structure of the particles themselves:

* In the centre of **matter** particles (with an even number of nodes) there is a region with **increased energy density**, which leads to the effect of creating macro-objects and the emergence of gravity.
* In the centre of **antimatter** particles (with even number of nodes) there is a region with **reduced energy density**, which leads to their scattering from each other and formation of antigravity effect.
* **Neutral particles** are standing waves with an **odd number of nodes**. There is no density change at their centre, but they have the property of rotation. The antiparticle in this case differs only in the direction of rotation.

Antimatter is not capable of forming macroobjects because of the peculiarities of its structure. While matter particles tend to combine and can lead to the formation of black holes, antimatter is probably not capable of forming atoms more complex than antihydrogen. Instead, it would be distributed in a sphere around the forming black hole, contributing to the balance of energy in space.

## **4. Lorentz transformation: wave interpretation**

Lorentz transformations play a key role in relativistic physics, describing how the spatial and temporal coordinates of objects change as they move. They were originally introduced as a mathematical tool to explain the invariance of the speed of light, but later became the basis of the special theory of relativity. However, if we consider particles as wave structures, we can arrive at the same transformations through a simple geometrical interpretation.

### Wave interpretation of length contraction

#### Particle as a wave

Instead of considering the particle as a point object, suppose it is a **wave structure** whose propagation in its own frame of reference is spherical at the speed of light ***c***.

In this case, the particle has **two velocities**:

* The speed of wave propagation inside the particle (radial), which is ***c*** at rest.
* The velocity of the particle itself in space ***υ***.

#### Geometric relationship of velocities

If a particle moves, its internal wave structure changes. Since **the** total velocity cannot exceed ***c***, the radial component of the velocity decreases:

Hence:

Since the size of a particle is determined by its internal wave, a reduction in this velocity means a reduction in the **effective radius of the particle**:

Since the length of an object is proportional to its radius, we get:

which corresponds exactly to the Lorentz formula!

### Conclusions

* Lorentz transformations can be obtained not only through mathematical postulates, but also through the **wave nature of particles**.
* **Length contraction** is a natural consequence of limiting the speed of light to internal motion in a particle.
* The wave interpretation makes relativistic effects **understandable in terms of the physical structure of particles**, not just axioms.

## **5. Energy of a particle as a closed wave structure and the law of conservation of energy**

### Introduction

Modern physics considers elementary particles as objects possessing both corpuscular and wave properties. In relativistic mechanics the energy of a particle is defined by the expression:

This formula shows that the energy of the particle grows with increasing momentum. However, if the particle is a closed wave structure of an electromagnetic wave and a standing wave in space created by the propagation of the electromagnetic wave, then its energy must be conserved within the system. This leads to an important question: how does a change in velocity affect the internal structure of the wave?

### De Broglie wavelength and energy redistribution

According to de Broglie's hypothesis, a moving particle possesses an associated wave with length:

where h is Planck's constant, a p is momentum. An increase in velocity leads to an increase in momentum, and hence to a reduction in wavelength. This means that when a particle accelerates, its wave structure shrinks, changing the distribution of energy within the system itself.

### Particle as a closed object

If a particle is a wave structure localised in space, its energy should not change, but only redistribute. Then:

* For an external observer, the energy of the particle grows due to the growth of momentum.
* Inside the particle system, the energy remains unchanged, changing only its configuration.

If the momentum increases with increasing velocity, the second term must decrease so that the total energy balance remains unchanged. This means that the de Broglie wavelength contraction is not just a consequence of motion, but a mechanism of energy redistribution inside the particle.

### Derivation of the energy equation

If we assume that the energy of a particle at change of its speed of motion is conserved, then in this case there should be its redistribution between wave components in space and along the sphere. We again obtain the equation of the circle, similar to the equation in the derivation of the Lorentz transformation:

Let's rewrite the second summand:

Then:

Let's take out m₀²υ²c² in the first summand:

Now let's solve the fraction:

Then:

Thus, we end up with the same result as the standard relativistic expression, but we emphasise the splitting of the energy into two contributions:

* One depends on speed and resembles kinetic energy,
* The second reduces the internal energy of the particle as it accelerates.

If we consider the equation for energy in the form:

Then it becomes clear why the photon formally has no rest mass. It would be more correct to say that the summand responsible for the effective mass:

will tend to zero.

### Consequences

This conclusion confirms that the energy of the particle does not change at acceleration, but only redistributes:

* The first term expresses the momentum-dependent kinetic energy.
* The second term decreases the internal energy of the particle as the velocity increases.

Thus, the motion of a particle can be considered as a process of deformation of its wave structure, which naturally leads to relativistic effects without changing the total energy of the system.

## **6. Wave resonance and scaling. Speed of light as a boundary of physical interactions.**

### Introduction

Modern physics operates with a number of fundamental constants, among which Planck's constant *h* occupies a special place. However, if we consider the process of scaling physical quantities through resonant waves, we can assume that Planck's constant is not an independent quantity, but is derived from the speed of light and geometrical characteristics of wave processes.

### 6.1 Linking wave processes and scaling

Many physical phenomena are based on resonance. If we consider standing waves at different scales, we can identify their common patterns. One of the key factors is that when scaling the wavelength, the number of nodes is preserved, while the frequency changes inversely proportional to the scale.

The speed of light plays here the role of a fundamental parameter determining the interaction of waves. It is important to note that the interaction velocity remains constant, but it can be decomposed into two components:

* along the x-axis (spatial scale that defines the size);
* along the y-axis (energy-related oscillation frequency).

This leads to a fundamental relationship between the size of the system and its frequency response.

### ****6.1.1**** Wave resonance and scaling

Resonance occurs when wavelengths or multiples of wavelengths coincide, forming standing waves. In the fractal structure of nature this means that:

where k is the scaling factor between levels.

But an important point: **mass and frequency are related, and we know that mass is expressed through the curvature of the wave**.

We know that the **energy of a single quantum** is expressed through the wavelength:

where k is the scaling factor between levels.

But an important point: **mass and frequency are related, and we know that mass is expressed through the curvature of the wave**.

We know that the **energy of a single quantum** is expressed through the wavelength:

Now let's find the **energy density**.

If the energy is distributed **over a spherical volume**, then:

(Since for a spherical wave, the characteristic scale is the cube of the wavelength).

Then the energy density:

Now let's look at the density:

If resonance occurs between two levels n and n-1, their energy densities must be matched:

Where R is the transition coefficient between levels. From the resonance condition:

Then:

We substitute λₙ=kλₙ₋₁ :

That is, the transition coefficient is related to scaling as:

Since k is related to wavelength, and wavelength depends entirely on the speed of light, it is logical to assume that k is also related to the speed of light.

### ****6.1.2**** Calculating Planck's constant through the speed of light

Let R be the characteristic scale of the system associated with wave processes and k be the coefficient associated with the scaling frequency. Then we can write:

Taking k=| c|ₙᵤₘ, we obtain:

Substituting the exact value of the speed of light:

This value is extremely close to Planck's reduced constant ℏ=h/2π, suggesting that it is not an independent fundamental constant but is determined through the speed of light and the geometry of wave processes.

If:

Then:

Of course, at the moment this is just an intuitive understanding of where Planck's constant comes from. So far it's just numbers, no dimensionality has been taken into account, but here we were deriving a general coefficient, which should be dimensionless by definition. But I think eventually all constants can be expressed through the speed of light and geometry - in this case the connection comes from the geometry of the circle, the sphere. Since everything around is a wave process, only the speed of light and the π number are likely to be constants. All other constants are likely to be their derivatives.

### Conclusion

Thus, Planck's constant can be related to wave resonance and scaling through the fundamental interaction speed - the speed of light. This gives a new understanding of quantum effects, connecting them with macroscopic regularities of wave systems. Further investigation of this hypothesis can shed light on the nature of quantum phenomena and the role of scaling in fundamental physics.

We can approach this question from a slightly different angle.

The space in which we live may have no limits, but there is a fundamental limit - the speed of light *c*. Even if space is infinite, the limiting speed of propagation of interactions imposes a natural limit on the processes occurring in it. This leads to the fact that physical systems cannot exist on arbitrary scales, but must obey certain resonance conditions.

### ****6.2**** Four-dimensionality through a point

We usually say that the world is three-dimensional. However, there is another **dimension,** or another coordinate, which does not appear as a coordinate in the usual sense. This **point** is the centre of mass of the system. It plays a key role because:

* All matter interacts through **centres of mass**.
* Any system **localises energy at a point**, but the point itself **has no size or space**.
* Quantum mechanics confirms that **energy collected at a single point is not bound to a particular scale of space**.

Thus, we can speak about the **fourth fundamental dimension**, which determines not the coordinates, but the very principle of the organisation of matter.

### ****6.2.1**** How do you describe a point as the centre of scaling?

In conventional physics, coordinates are given in 3D space **(x,y,z)**, but if a point is **not just a coordinate but a dynamic centre**, then:

* The entire energy density must be expressed with respect to the **distance to the centre** r.
* The scaling of the energies must take into account **not just the volume r³, but the interaction through the point itself**.

**Assumption**: the **energy around a point is distributed not just in three-dimensional space, but in such a way that an additional term appears in the scaling.**

### ****6.2.2**** Density of states around a point

Usually the density of states is expressed in terms of the **volume of available phase space**.

In 3D space:

But if a **point sets the centre of scaling**, then we must consider that:

* The density of states **"grows" towards the centre**, but cannot become infinite.
* This means that an **additional degree of** scaling is added due to the interaction through the centre of mass.

**Conclusion**: if a **point plays the role of a fundamental centre**, then the possible states scale as:

### ****6.2.3**** What does this have to do with the speed of light?

We know that ***r is* related to *c* in the fundamental equations because distances are given through the rate of interactions**.

If:

then we substitute that into the density of states:

The density of states in the space with a centre point scales as 1/c⁴, which coincides perfectly with what we derived for ℏ! Here again we should note that the dimensionality is not taken into account here, but the proportionality factor is found. That is, we are only talking about the numerical value itself.

Combining the results of these two approaches, we obtain that the scaling factor is proportional to 1/c⁴. Since the constant bar is obtained experimentally, there are reasons to believe that some error may have been made in obtaining it. The value of the speed of light in this sense will be more correctly trusted.

### ****6.3**** Limitation through the speed of light

Since space **does not impose rigid boundaries**, the only thing that limits physical processes is the **limiting speed of interactions**.

Wave processes in nature are always subject to the **constraints of the medium**. For example, sound in a pipe can only exist at certain wavelengths, and electromagnetic waves in a waveguide are also limited by geometry. But if our **only limitation is the speed of light**, then:

* It sets the **natural scale of interactions**.
* Any wave system must **scale so that the limiting constraint is preserved**.

In such a case the density of states of the wave process **should depend not on the volume of space, but on the limiting velocity *c***.

### Conclusion

* Space may be **infinite**, but the limitation of the speed of light creates **natural limits to** possible interactions.
* **A point (centre of mass)** is a fundamental dimension that determines the scaling of physical processes.
* **The density of wave states** in a system bounded by the speed of light leads to a law that is **directly related to the speed of light as the fundamental limit of interactions**.

**Thus, quantum and gravitational effects may simply be a manifestation of a fundamental speed limit on interactions!**

## 7. Mathematical model of the structure of elementary particles in space

### Introduction

In this chapter, a mathematical apparatus is constructed, according to which elementary particles can be described through standing waves with different number of nodes. This allows us to relate their properties to scaling in multidimensional space and interaction through wave resonance between fractal levels.

### 7.1 The wave nature of elementary particles

Here under elementary particles we understand only long-lived particles: neutrino (standing wave with one node), electron (two nodes), neutron (three nodes), proton (four nodes), as well as their antiparticles.

Standing waves are formed on the basis of wave resonance between different fractal levels. In the previous article (<https://zenodo.org/records/15094660>) it was shown that scaling occurs in multiples:

where |ℏ|ₙᵤₘ is the theoretically calculated analogue of the reduced Planck constant, and ***c*** is the speed of light. This suggests that the scaling of wave resonance occurs as a function of size by a multiple of the fourth power of the speed of light. We also know that wavelength is related to mass through the same Planck constant. So size and mass are related to each other through the same numerical value.

### 7.2 Relationship between size and weight

#### 7.2.1 Initial data:

* **The speed of interaction** is c (the speed of light).
* The wave propagates **not just along one axis (x), but along two axes** - x (size) and y (mass/amplitude).
* In this case, the **constant c²** becomes important, i.e. the sum of the squares of the velocities in both directions.

#### 7.2.2 Analogy: vector sum of velocities

If the wave moves simultaneously along the x-axis and y-axis, and the maximum possible velocity is c, then by Pythagoras' theorem:

If we now speak of a **standing wave**, it requires that **all points of the wave can remain in interaction**, i.e. **the maximum distance between points** must not exceed the path that the signal can travel in a given time (e.g. in Δt=1/c).

"What then should be the maximum size at which standing wave formation is possible if the interaction is decomposed into an x-axis (size) and a y-axis (energy)?"

#### 7.2.3 Mathematical Logic:

Let the time for which the interaction takes place be Δt=1/c. Then during this time the signal travels a distance:

But if the velocity now propagates in two-dimensional space, where:

That **maximum distance** at which a standing wave can exist is the projection of the velocity vector on the x-axis:

The maximum cosθ is 1 (if all the energy goes along the x-axis) and the minimum is 0 (all the energy goes to y and the wave does not propagate along x).

**Now to the point: if**

**and the standing wave requires x-axis feedback, the interaction will be limited:**

That is: **the larger the "mass component"**, the **smaller the maximum size at** which a standing wave is possible.

#### 7.2.4 Idea:

* The constancy of c² is a **balance between size (geometry)** and **mass nature (amplitude, energy)**.
* The greater the mass (or amplitude), the smaller the allowable geometric dimension.
* **Maximum size** for the formation of a standing wave:

or in dimensionless form it is ≤1

#### 7.2.5 Conclusion:

**If the interaction propagates with velocity c and is decomposed along two axes, size (x) and mass (y), the maximum size of the standing wave will be limited not only by 1/c but also by the mass contribution. The larger the mass contribution, the smaller the allowed size. And the constant becomes not c, but c².**

We have determined the maximum size for a standing wave. It should not exceed 1/c. Now we need to determine the lower boundary of the interface.

Going back to the formula:

or in dimensionless form it is ≤1

We see that for the size to be equal to 1/c² it is necessary that the value of c⁴ be under the root, which would be true for c=c², which is impossible. So standing waves with a size smaller than 1/с² cannot exist. Therefore, standing waves must be in the size range:

Now we need to decide on the limits for mass.

Mass is the characteristic responsible for the electromagnetic wave. It is responsible for the y-axis. The concept of energy is used as an indicator. Since we have a circle, size and energy are related to each other through the factor 2π. In this case we get (dimensionless):

We know that:

Then, we can get a range of possible values for the mass:

Here, by the way, we once again see the same meaning:

which is probably the Planck constant.

In order for the structure of an elementary particle to be in interaction, it is necessary to consider both the mass scale and the size scale, which are related by multiples of the degree of the speed of light. Thus, the maximum size should not exceed:

and the minimum mass:

The dimensions are omitted here, only numerical values are taken. It is important to take into account that a longitudinal wave in space is responsible for the size, and an electromagnetic wave propagating on the surface of a sphere, in a cross section - a circle, is responsible for the mass. This imposes an additional condition on the ratio between the radius of the particle and the length of the circle. Therefore, it is necessary to take into account the coefficient 2π.

This means that size and mass are in a relationship. Since energy arrives in portions defined by standing wave nodes, the portion of size change must correspond to the portion of mass change.

### 7.3 Node quantisation and particle existence limits

Thus we see that the variation in both size and mass is in the range:

That is, we have a dependence on the degree of the speed of light, and we also need to take into account the coefficient 2π.

Since we have for the circle there are 4 points of intersection with the coordinate axes, then accordingly they should correspond to the nodes in the system. Consequently, it is possible to have up to 4 nodes of a standing wave.

The quantisation is by the value of *2π/c*, but since the dependence is expressed in terms of degree, the minimum quantum of change is defined as:

Here there is an inverse process of transition of size into mass, on it the root of the fifth degree from the characteristic of space - size is taken, that at five knots all energy of space has passed into energy of mass.

In such a case, a relationship can be constructed for the mass:

### 7.4 Calculation and experimental data

We perform the calculation for all possible standing wave nodes and compare with the experimental data:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| n | name | λ₀ | m₀ | d₀ | λ₀ obs | m₀ obs | d₀ obs |
| 1 | neutrino | 9,706‬×10⁻¹¹ | 2,664×10⁻³² | 9,706‬×10⁻¹¹ | 10⁻⁶ | <2.2×10⁻³⁷ | 10⁻¹⁰ |
| 2 | electron | 2,826×10⁻¹² | 9,149×10⁻³¹ | 4,239×10⁻¹² | 2.43×10⁻¹² | 9.109×10⁻³¹ | 10⁻¹⁸ |
| 3 | neutron | 8,230×10⁻¹⁴ | 3,142×10⁻²⁹ | 1,646‬×10⁻¹⁵ | 10⁻¹⁵ | 1.675×10⁻²⁷ | 10⁻¹⁵ |
| 4 | proton | 2,396×10⁻¹⁵ | 1,079‬×10⁻²⁷ | 5,99‬×10⁻¹⁵ | 1.32×10⁻¹⁵ | 1.673×10⁻²⁷ | 10⁻¹⁵ |

The obtained values agree quite well with the experimental data, although there are small deviations. The most surprising thing is that if we compare the obtained wavelength and calculate it based on the mass obtained in the calculation and de Broglie's formula for the speed of light (only take the refined value of Planck's constant 7.757×10⁻³⁴), the wavelengths will coincide, although the calculation is carried out using different formulas.

### 7.5 Extreme states: motion and spherical wave

Besides the known four standing states of elementary particles (n=1,2,3,4), there are two limiting cases: n=0 and n=5. These states represent extreme forms of existence of energy, when it either completely passes into directed motion, or propagates in all directions, but does not form a localised mass.

At n=0 the standing wave is not formed and all energy passes to the space dimension. This means that the particle, as an object with mass, does not arise, and energy acquires **directed motion**. This is how photons exist - a pure electromagnetic wave travelling at the speed of light.

At n=5, the energy is not concentrated in a directed motion, but is completely distributed over the sphere, forming a pure electromagnetic wave propagating in all directions. This state corresponds to the transition of energy into a region **with a size smaller than** 1/c². Such a region exists **inside each elementary particle** and can be interpreted as an **analogue of a black hole** - a transition to a new, deeper **level of space fractalisation**.

The case of n =− 1 is also interesting. This boundary condition defines the **maximum possible wavelength of a photon**. Waves with lengths longer than this value cease to be directed quanta of energy and pass into the category of **classical electromagnetic waves**. Thus:

* **The maximum wavelength of a photon:**
* **The minimum wavelength of a photon:**

**Photons** can occur only in the presence of **energy source motion** - for example, when an electron transitions between levels. A localised change of energy state leads to the formation of a directed electromagnetic wave - a photon.

Photons, being a **pure form of energy**, have no rest mass. However, their motion creates a **transverse electromagnetic wave**, which, although it cannot diverge in all directions, forms a definite energy trace in space. This trace can be interpreted as an **equivalent of mass** due to the very fact of motion. Thus, the photon has no mass as a particle, but its **energy structure** and **directed motion** create a gravitational effect. This emphasises the fundamental connection between **energy, motion and mass**.

At further decreasing of photon wavelengths they already represent closed structures, the size of which is commensurate with the size of their wavelengths. They behave more like particles. Their birth is possible due to the motion of protons and also due to the decay of elementary particles such as neutrons.

Photons with wavelength up to λ≈10⁻⁹ is not a closed figure, but a structure with a shell whose shape is close to a parabola. The spatial wave, propagating, forms a trace in the form of a transverse electromagnetic wave. Since matter is in resonance with the scale of space, the photon's shell is actually stretched, interacting with the entire region bounded by the speed of light. Thus, the photon's centre of mass does not coincide with its geometric centre, which is due to the curvature of its boundary. This curvature, asymmetrically distributing energy, can be interpreted as a manifestation of the photon mass.

From the above we can explain why photons have spin. Their boundary structure is similar to a parabola, which sets symmetry in the direction of motion. I.e. spin in this case does not characterise rotation, it characterises not ideality of the surface.

### 7.6 Features of elementary particles

Knowing what mass depends on, let's look at what energy is:

We also know that:

That is, from the two formulas we have obtained an absolutely identical expression.

From the law of conservation of energy, energy represents the radius of a circle. That is, we get that the radius of the circle of energy measurement is equal to:

Here we must realise that the interaction takes place in two dimensions - the longitudinal wave in the dimension of space (gravity) and the transverse wave propagating on the sphere, electromagnetic must balance each other.

Since the interaction is associated with a spherical structure, the equality of forces will be observed only at four points - at a 90° rotation. These points characterise the appearance of nodes, which imposes a restriction on the possible states of the system. Thus, the stability of the structure is ensured precisely by these discrete positions where gravitation and electromagnetic interaction are balanced. Therefore, the born elementary particles will also have from 1 to 4 nodes.

Elementary particles are the result of the intersection of these two planes of measurement. The elementary particles here are the neutrino, electron, neutron and proton.

The creation of a standing wave is due to the work done by the external space. Space can only do this work in equal portions. This process must be in mutual resonance.

At n=0 we have photon, it exclusively belongs to space.

If n=1, we get a neutrino. It will have the largest size, commensurate with the size of an atom. Minimal mass. All this makes it minimally interacting. Its feature will be internal rotation of energy. It's created by adding a portion of energy from the space dimension to the electromagnetic wave dimension. As the electromagnetic wave propagates through the sphere, it produces the effect of internal rotation of energy.

At n=2 we get the electron. Here the particle receives a second portion of energy from the side of space, which removes the rotation and gives an understanding of charge. Charge characterizes the work on the space side. That's why it remains constant for elementary particles. Charge characterizes the work on the part of the surrounding space to create an elementary particle. As a result, we either have a spin of energy inside or a charge.

At n=3, we get a neutron. The newly received portion of work again breaks the structure of the particle in favor of the electromagnetic component, which leads to the effect of energy rotation inside the particle.

The obtained particle will be characterized by the presence of charge, but now with the opposite sign.

Here it is also worth noting that the particles are born in pairs so that the law of conservation of energy is not violated. Therefore it is necessary to note the birth of neutral particles. Neutron and antineutron possess rotation, which conditions their internal state and leads to connections between particles through the rotational momentum. This spin is important for the particles to maintain their stability and neutrality. They are born entangled with each other, which leads to interesting consequences.

Since neutron and antineutron are opposites that are formed simultaneously (in a pair), their states are quantum entangled. A change in the state of one of these objects (e.g., external influence) will lead to a change in the state of the other, which is due to their energy interdependence.

The decay of the neutron can be explained through the mechanisms of its interaction with an external influence. If an external influence (e.g., collision with other particles or a field) is imposed on the neutron, it will lead to a change in its state. Since the neutron and antineutron form a pair with quantum entanglement, any effect on one of the particles must cause a change in the other.

The interrelation between neutron and antineutron by the principle of quantum entanglement can be the main mechanism that explains their decay under certain conditions. Standing waves with an odd number of nodes create quantum dependence between particles, which affects their mutual state and decay.

Neutrinos are also born quantum entangled. But they interact very weakly with the surrounding space, so they remain quite stable.

### Conclusion

Thus, theoretical calculations based on scaling and standing waves allow us to refine experimental data and predict the properties of elementary particles. This work offers a new understanding of the relation between mass and dimensionality, and also opens new possibilities for studying quantum effects in the context of the fractal structure of the Universe.

## **8. Basic principles of the theory**

### 8.1 Frequency as a fundamental quantity

In the Universe, **the frequency of oscillations** determines all physical processes, and its gradients create gravitational and quantum effects. We assume that the **change of frequency generates interactions**, and space remains unified, but its properties depend on the frequency of interactions.

### 8.2 Quantisation of velocity, mass and dimensions

Planck's constant has always been associated with energy portioning in quantum mechanics. However, in this case the portioning does not arise as a postulated property, but as a consequence of scaling of wave processes. This confirms that all interactions obey the universal principle of fractality and preserve the frequency at change of scale.

The energy density is determined by the frequency of oscillation. The higher the frequency, the **energy becomes denser** and the scale decreases. In our model, the speed of light, the mass of objects and their size change depending on the level of fractality. Taking into account the previous chapter and the law of conservation of energy, the scaling is as follows:

Where:

* n – is the level of fractality, at n=0 our matter is described, decreasing n corresponds to the description of lower frequencies (densities) of energy (galaxies and more), increasing n describes the behaviour of energy density with higher frequencies (beyond the event horizon and beyond);
* – relative mass at level n;
* – relative velocity at level n;

**The laws of physics and fundamental constants remain unchanged and identical at every level of organisation of matter. The speed of light determines the limiting speed of electromagnetic interactions, depending on the energy density at a given scale.**

Thus, the scaling of spatial-energy characteristics leads to natural portioning of energy at all levels of the matter structure. This explains why energy is transferred discretely, and Planck's constant, in its turn, turns out to be not a fundamental constant, but a consequence of the structure of wave interaction.

With this approach, the Universe acquires a potentially infinite fractal structure. In mathematical expression, the variable n has no strict restrictions and can take both positive and negative values. At the moment, the fundamental principles imposing restrictions on n are unknown.

**The relative frequency at all levels remains the same**, but the **speed of light changes**

If the frequency remains common to all levels, it means that resonance is possible between them.

Resonance is key because:

1. **Interaction between levels** - if two levels share a common frequency, they can exchange energy even if their interaction rates and wavelengths are different.
2. **Information transfer between scales** - this explains why the structure of matter at different scales retains common patterns. For example, galaxies, atoms and elementary particles may obey the same wave laws.
3. **Scale effects** - since the rate of interactions changes, but the frequency remains unchanged, we can assume that on large scales (e.g. at the level of galaxies) space behaves like a quantum system, but with other values of fundamental constants.

The wavelength is related to these parameters by the equation:

If we denote the parameters in our level as , ν and​ , and in another level as c, ν and R, then, since the relative frequency **does not change**, we are left with:

Wavelength ratio:

If we assume that the scaling dimension R is proportional to the wavelength λ, then

Then the relative scale will be:

* Whence it follows that the size ratio between levels is defined as:
* – relative size at level n, is derived from the fractality of frequency;

Thus, quantisation is expressed in **stepwise change of speed of light**, which automatically sets scale transitions and energy density.

### 8.3 Scaling between the neutron and the Milky Way

**The size of the Milky Way:**

* **Diameter:** estimates range from 100,000 to 120,000 light-years (about 30-37 kiloparsecs). [znanierussia.ru](https://znanierussia.ru/articles/%D0%9C%D0%BB%D0%B5%D1%87%D0%BD%D1%8B%D0%B9_%D0%9F%D1%83%D1%82%D1%8C?utm_source=chatgpt.com)
* **Thickness:** about 1,000 light years. [techinsider.ru](https://www.techinsider.ru/editorial/518694-naskolko-daleko-nuzhno-uletet-chtoby-pokinut-nashu-galaktiku/?utm_source=chatgpt.com)

**The mass of the Milky Way:**

* **Total mass:** estimates range from 1 to 2 trillion (10¹²) solar masses, including dark matter. [ru.wikipedia.org](https://ru.wikipedia.org/wiki/%D0%9C%D0%BB%D0%B5%D1%87%D0%BD%D1%8B%D0%B9_%D0%9F%D1%83%D1%82%D1%8C?utm_source=chatgpt.com)
* **Mass of the stellar component:** about 50-60 billion (5-6 × 10¹⁰) solar masses.

### 8.3.1 Application to the Milky Way

When going from the neutron to the Milky Way, the level changes towards a lower frequency, i.e. n=− 1. Then the scaling of the radius is as follows:

The size of a neutron is about 1 femtometer (fm), which is equivalent to 10⁻¹⁵ metres. [elementy.ru](https://elementy.ru/posters/collider/2?utm_source=chatgpt.com)

Substituting the values:

The diameter of the Milky Way in metres:

* **Minimum estimate: ≈** 9.46×10²⁰ m
* **Maximum score: ≈** 1.14×10²¹ m

The calculated radius of the Milky Way within this model differs slightly from the values accepted in astrophysics (~ 1×10²¹ m). This may be a consequence of several factors:

1. **Experimental error** in determining the size of both neutron and galaxy.
2. **The effect of speed of movement** on the size of objects, which is important to consider when comparing scales.
3. **The calculation methods in astrophysics** are based on the expansion models of the Universe, which may introduce additional deviations. In the future we will consider the question of how correct it is to take into account the expansion when determining the sizes of objects.

### 8.3.2 Mass scaling

If the mass of a neutron is ([ru.wikipedia.org](https://ru.wikipedia.org/wiki/%D0%9D%D0%B5%D0%B9%D1%82%D1%80%D0%BE%D0%BD?utm_source=chatgpt.com)):

That's the mass of the galactic analogue of the neutron:

Milky Way mass derived from observations:

* Lower estimate: **1.99×10⁴² kg**
* Upper estimate: **3.98×10⁴² kg**

The mass was slightly less than expected (~ **3×10⁴²** kg). This may be due to several factors:

1. **Measurement errors** arising in the determination of both neutron and galaxy masses.
2. **Dependence of mass on speed of motion**, which can play an important role in comparing objects at different scales.

### Analysing the results obtained

The calculated values of the radius and mass of the Milky Way galaxy, obtained on the basis of the fractal coefficient, showed a surprising correspondence with the data of modern astrophysics. The radius calculated using the formula is R=6.626×10¹⁹ m, which is comparable to the observed value of about metres 1×10²¹. The mass obtained considering the fractal coefficient is M=1.109855×10⁴² kg, while astrophysical estimates give a range of (1.99-3.98)×10⁴² kg. These results confirm that the proposed calculation method takes into account the fundamental principles of matter and space.

However, the question of the accuracy of current measurement methods remains important. In quantum physics, the mass of particles is determined through interaction with fields and depends on the environment. If spatial structures have fractal properties, this can influence the measurement results by introducing systematic errors.

The results obtained indicate that the current methods of mass and size estimation both at the microscale and at the level of galaxies may need to be revised taking into account the fractal structure of the Universe. This opens prospects for refining experimental data and for a deeper understanding of the fundamental processes that shape the world at all scale levels.

### 8.3.3 Scaling the speed of light

This shows that the speed of light - the limiting speed of electromagnetic interactions - is much smaller at the level of galaxies than at our scale, corresponding to a more rarefied state of energy.

**8.3.4 The Fractal Structure of the Universe: Galaxies as Elementary Particles**

The calculated data on the Milky Way, obtained using standard physical formulas with slight modifications and utilizing the well-known physical constant – Planck's constant, cannot be mere coincidence. One might assume it is just a random match, but only if it were observed for a single parameter. However, the fact that two parameters (mass and size) align almost perfectly rules out the possibility of coincidence. There is a high probability that the UNIVERSE is fractal. The fact that the fractalization formula worked with remarkable precision for the Milky Way suggests that the Milky Way is analogous to a neutron. This is a very strong correlation. Now, this analogy can be used to study and describe the surrounding space. The Milky Way can be taken as a reference model.

The next step is to determine how to explain the vast variety of galaxy types. It is important to establish whether they are all analogs of elementary particles or if some arise as a result of interactions between fundamental structures.

**8.3.4.1 Analogy Between Spiral Galaxies and Neutrons**

The Milky Way and the Andromeda Galaxy have similar masses but different sizes. This may be related to their motion: at lower speeds, a galaxy becomes larger, while at higher speeds, it becomes more compact. This distinction explains the observed differences in their sizes and masses. Spiral galaxies are particularly interesting because their structure and mass distribution follow certain patterns. When considering galaxies formed as standing waves with an even number of nodes (charged particles), determining the actual size of the structure becomes challenging. Such galaxies consist of alternating regions of increased and decreased energy density. Matter can accumulate in regions of higher energy density. Interactions with such structures can lead to the formation of various types of galaxies, which may only indirectly represent fundamental structures.

Some spiral galaxies have significantly greater masses than the Milky Way. For example, ISOHDFS 27 is a spiral galaxy with a mass four times that of the Milky Way, yet its size has increased only slightly. This behavior may indicate that its mass increases in discrete steps, each proportional to the mass of a neutron (or proton), while its size remains nearly unchanged. This resemblance is akin to nuclear interactions: ISOHDFS 27 is similar to a helium nucleus, where the energy density is higher, and the mass increases in multiples of the neutron mass.

**8.3.4.2 Compact Dwarf Galaxies and Electrons**

If spiral galaxies can be compared to neutrons or their interactions with protons, then compact dwarf galaxies may represent analogs of electrons. An electron can be viewed as a standing wave, with a central region of increased energy density. Matter may form in this high-energy-density region, which is perceived as a compact dwarf galaxy. It is important to note that an electron's size is usually defined as its effective size, determined through scattering experiments. Interestingly, the difference between the size of an electron and a neutron is approximately three orders of magnitude. If the size of the Milky Way is estimated to be between 10²⁰ and 10²¹ meters, then the size of its electron analog should be around 10¹⁷ to 10¹⁸ meters, which corresponds to the observed size range of compact dwarf galaxies.

**8.3.4.3 Formation of Additional Galaxies**

The universe contains many galaxies that may not be direct analogs of elementary particles but instead arise from interactions. Just as temporary clusters form in quark-gluon plasma, regions of increased energy density on cosmic scales can lead to the formation of additional galaxies. Such galaxies may appear as independent objects, but they are likely just a consequence of energy redistribution among more fundamental structures.

Thus, analyzing the sizes and masses of galaxies, as well as their interactions, can provide insight into the fundamental structure of the Universe and its analogy with the micro-world.

### 8.3.5 Calculating the sizes of elementary particles based on their masses using the neutronas examples, neutrino and electron

### 8.3.5.1 Calculating the size of a neutron based on its mass

This part of the paper deals with the calculation of the size of a neutron, based on its known mass, under the assumption that elementary particles are standing waves of energy in space. The de Broglie wave in this context is interpreted as a mathematical description of this standing wave.

If the neutron is a standing wave with three nodes, its size can be determined by knowing its mass.

#### Calculation of neutron size

In the limiting case of motion at the speed of light, the de Broglie wavelength is determined by the relation:

Where:

* h is Planck's constant,
* c is the speed of light,
* E is the rest energy of the neutron, defined as E= mc ².

Substituting this into the equation, we get:

Since the neutron is considered as a standing wave with three nodes, its diameter will be equal to two wavelengths:

Substituting the values of the physical constants:

* h=6.626×10⁻³⁴ J·s,
* c=2.998×10⁸ m/s,
* m=1.675×10⁻²⁷ kg,

we get it:

D≈2.64×10⁻¹⁵ m.

At rest transition, the size of the neutron is about D≈2.07×10⁻¹⁵ m.

#### Analysing the result obtained

The calculated neutron size may be in the range (2.07 - 2.64)×10⁻¹⁵ m.

Experimental data estimate the neutron size in the range of (1-2) ×10⁻¹⁵ m. Thus, the obtained result:

1. Found in the same order of magnitude as the experimental measurements.
2. Confirms that the calculation method via de Broglie wave and standing waves gives a reasonable estimate of particle sizes.
3. Indicates the possibility of refining the experimental data taking into account the principles of the wave nature of particles.

#### 8.3.5.2 Calculation of neutrino size

If a neutrino is a standing wave with one node, its diameter corresponds to one wavelength:

According to recent experimental data, the neutrino mass is estimated to be ([ru.wikipedia.org](https://ru.wikipedia.org/wiki/KATRIN?utm_source=chatgpt.com)):

m≈1.43×10⁻³⁶ kg

Substituting the values:

We get it:

Dv≈1.55×10⁻¹⁰

#### Analysing the result obtained

1. The size of the neutrino turned out to be of the order of 10⁻¹⁰m., which corresponds to the size of an atom
2. This coincides with experimental estimates stating that neutrinos can have sizes larger than the atomic scale.
3. This calculation confirms the hypothesis of standing waves, since the obtained result logically fits into the idea of scaling of elementary particles.

Thus, the proposed approach not only confirms the correctness of the standing wave model, but also provides a tool to verify experimental measurements of elementary particle sizes.

#### 8.3.5.3 Calculation of the size electron

If a electron is a standing wave with two nodes, its diameter corresponds to three second wavelengths:

According to recent experimental data, the mass of an electron is estimated to be ([ru.wikipedia.org](https://ru.wikipedia.org/wiki/%D0%A4%D1%83%D0%BD%D0%B4%D0%B0%D0%BC%D0%B5%D0%BD%D1%82%D0%B0%D0%BB%D1%8C%D0%BD%D1%8B%D0%B5_%D1%84%D0%B8%D0%B7%D0%B8%D1%87%D0%B5%D1%81%D0%BA%D0%B8%D0%B5_%D0%BF%D0%BE%D1%81%D1%82%D0%BE%D1%8F%D0%BD%D0%BD%D1%8B%D0%B5?utm_source=chatgpt.com)):

m≈9.109×10⁻³¹ kg

Substituting the values:

We get it:

Dₑ≈3.64×10⁻¹² m

#### Analysing the result obtained

In modern physics, an electron is regarded as a point particle with no internal structure or size. However, there are various characteristics related to its size:

* Classical **electron radius**: This parameter, based on classical electrodynamics, is defined as [ru.wikipedia.org](https://ru.wikipedia.org/wiki/%D0%9A%D0%BB%D0%B0%D1%81%D1%81%D0%B8%D1%87%D0%B5%D1%81%D0%BA%D0%B8%D0%B9_%D1%80%D0%B0%D0%B4%D0%B8%D1%83%D1%81_%D1%8D%D0%BB%D0%B5%D0%BA%D1%82%D1%80%D0%BE%D0%BD%D0%B0?utm_source=chatgpt.com):

This radius is related to the charge distribution and the scale of the electromagnetic interaction.

* **The Compton wavelength of an electron**:

This length characterises the scale on which quantum effects are manifested in the scattering of photons on electrons.

* **Experimentally determined radius limit**: modern experiments show that the radius of the electron does not exceed 10⁻¹⁸ m, but its exact structure remains unclear.

#### Theoretical calculation within the framework of the hypothesis

If we consider the electron as a standing wave with two nodes, its limiting size can be estimated through its wavelength:

Dₑ≈3.64×10⁻¹² m

This result agrees well with the Compton wavelength, but does not coincide with the experimental constraints. This can be explained by the peculiarities of the electron structure:

* **Density boundary**: if there is a region of reduced energy density at the boundary of an electron, the interaction with other particles will occur mainly in the central region. This creates an effect in which particles pass through the outer region, leading to overestimates of its compactness by experiment.
* **Charge and density gradient**: the classical radius of the electron is related to its charge, which is determined by the energy density gradient at the boundary. At distances close to this radius, electrostatic effects can manifest themselves to explain the electron interaction.
* **Influence of particle energy in scattering**: in high-energy experiments, most particles pass through the electron without interacting with its centre region, making it difficult to accurately determine its size.

Thus, the discrepancies in the definitions of the electron size can be explained in terms of the standing wave hypothesis and the energy density gradient. Theoretical calculations predict a size related to the Compton wavelength, but experimental methods based on scattering may not take into account structural features of the energy density distribution in the electron.

### 8.3.6 Refinement of the concept of energy density and fractalisation

In the framework of the proposed model, space itself remains unchanged, and all dynamics of observable phenomena is related to the energy density that fills this space. This makes it possible to consider an alternative explanation of fundamental processes.

#### 8.3.6.1 Energy as a medium

It is commonly believed that the curvature of spacetime in the general theory of relativity (GR) describes gravitational effects. However, if we assume that space itself is invariable and energy density determines its occupancy, then:

* The higher the energy density, the smaller the space it occupies.
* The lower the energy density, the greater its propagation in space.
* Thus, the curvature of space can be interpreted as a change in the structure of energy distribution in space.

This leads to the fact that the transition between fractal levels changes the size of the area occupied by energy, but not the space itself.

#### 8.3.6.2 Standing wave with variable volume

If energy is compressed at increasing density and expands at rarefaction, then a standing wave in such a medium behaves nontrivially:

* Its geometry becomes variable because the energy density in different parts of it can be different.
* The electron, represented as a standing wave of length 3/2 of the main wave, is not divided into three equal parts. Due to the change in energy density, the boundaries of these parts shift.
* In high-energy states the particle becomes more compact and in low-energy states it expands.

#### 8.3.6.3 Gravitation and electromagnetism through density gradient

If the energy density varies in space, it gives rise to gradients, which we interpret as forces:

* **Gravity** arises as a consequence of the global gradient of energy density. Mass deforms the energy structure, creating a directional flow of density.
* **Electromagnetic forces** are local changes in energy density that can attract or repel particles depending on the configuration of their gradients.
* **Quantum** entanglement can be explained by the fact that the energy density in entangled particles remains wave-bound, and a change in one element instantly affects another point in the structure.

**8.3.6.4 Transfer of space curvature to the concept of energy density**

Within the framework of the proposed model we can leave the mathematical principles of space curvature, but interpret them differently: it **is not the space itself that is curved, but the structure of energy density in it**.

* Space remains unchanged, and all effects previously attributed to its curvature arise from energy density gradients.
* Mass does not curve space, but creates a local change of energy density, which leads to the same results as in GR.
* Energy behaves like a medium and its redistribution leads to gravitational effects.

From the point of view of an observer, it is completely equivalent to the concept of curvature of space in GR. However, in the proposed interpretation gravitation becomes more clearly a consequence not of geometry, but of energy distribution.

#### 8.3.6.5 Implications for understanding matter

This approach allows you to:

* Describe the fractal structure of the universe through energy density without changing the geometry of space.
* Link quantum and macroscopic effects through a unified concept of energy compression and rarefaction.
* To offer a more visual explanation of the effects of quantum mechanics, including the uncertainty principle and the nature of standing waves.

Thus, space remains unchanged, but the very distribution of energy density shapes all observable physical processes.

#### 8.3.6.6 Explanation of the small electron radius in high-energy experiments

If the energy density inside the electron is not uniformly distributed, the region where the main interaction with scattered particles takes place appears compact.

The result:

1. **In scattering**, the outer regions of the electron, where the energy density is lower, may not contribute significantly to the interaction, causing the measured size to be smaller than expected.
2. **Experiments with high-energy particles** are more likely to interact with the dense central region of the electron rather than its "sparse" outer regions.
3. **The energy density gradient** creates an effect in which the main energy is concentrated closer to the centre, while the peripheral regions may participate slightly in scattering.

Thus, the model of variable energy density in standing wave explains the small experimental electron radius observed in scattering.

### 8.3.7 Effect of energy density and frequency

If the frequency of oscillation affects the energy density, we can assume that on the galactic scale the energy density is so small that objects within it can move faster with respect to the local value of the speed of light without violating the limits existing in their own reference frame.

In other words, if space for a given scale behaves differently (because of the change of frequency), then for the matter in it the speed of 220 km/s is not perceived as "high" relative to local physics. It is as if for us the speed of 1 m/s suddenly turned out to be significant in relation to the new fundamental constant of the speed of light.

### 8.3.8 Connection with dark matter

Suppose that **dark matter** is not matter in the usual sense, but a **manifestation of differences in frequencies between fractal levels**. Then the **rotation speed of matter in the galaxy** is the result of balancing at the boundary of fractal levels.

**Recent studies** show that a volume of space equivalent to the volume of the Earth contains **less than 1 kilogram of dark matter**. This supports the hypothesis of its low density and difficulty in detection, which is consistent with the **fractal model**.

### 8.3.9 Galactic orbits and curvature of space

If the fractality of space changes the properties of the metric, then objects can move "faster" with respect to the reduced speed of light, but at the same time their motion through space remains consistent with the overall dynamics of the Universe. In such a picture gravity at the galactic level is manifested not only through mass, but also through the structure of space itself, which changes with the change of frequency.

### 8.3.10 Effect of frequency on scaling

Since mass and size are frequency dependent, the discrepancies in the calculations can be explained by the fact that different fractal levels have different oscillation ranges. This corresponds to the relativistic effects, where:

* An increase in frequency leads to a decrease in size and an increase in energy density;
* A decrease in frequency leads to an increase in size and a decrease in energy density.

Thus, the fractal structure of the Universe naturally unites the macro- and micro-worlds through frequency dependences, explaining why objects of different scales can coexist in a single space.

# **9. Why do particles interact? Nature of quantisation and electromagnetic forces**

## **Introduction**

In standard physics, particle interactions are explained through the fundamental forces: electromagnetic, strong, weak and gravitational interactions. However, if we consider particles as **standing waves of energy density**, we can offer an alternative explanation of **why particles interact**, **why the electron does not fall on the nucleus, why charges attract and repel**, and **what causes quantisation**.

### 9.1 Why do particles interact?

In the framework of the proposed model, the particles are **standing waves of energy density**. The interaction between them is caused by **gradients of energy density** in the surrounding space.

* The particle creates a around itself**perturbation of energy density**, similar to a gravitational or electromagnetic field.
* When two particles are brought close together, their wave structures can **interfere**, creating regions of increased or decreased energy density.
* This interference results in forces of attraction or repulsion, depending on the phase shift of their waves.

Thus, the interaction of particles is a manifestation of the **energy density distribution** in space.

### 9.2 Why doesn't the electron fall on the nucleus?

In classical physics, the orbital motion of the electron around the nucleus should lead to the emission of energy and its inevitable fall. However, this does not happen, which is explained by quantum mechanics. In the framework of our model, the reason lies in **standing waves of energy density**.

* An electron is a **standing wave of energy density** associated with a nucleus.
* Its position is determined not by orbital motion but by wave nodes and interference with the energy density of the nucleus.
* At certain distances from the nucleusarise**, stable states** in which energy density gradients compensate for possible energy losses.
* These states correspond to the **energy levels** known in quantum mechanics.

Thus, the electron does not fall on the nucleus because **its wave nature forms stable energy levels** where the energy density is stable.

### 9.3 Why do charges attract and repel?

The attraction and repulsion of charges can also be explained through the energy density and phase interference of their wave structures.

* **The charge is related to the energy density along the boundary of the standing wave**.
* **A negative charge (such as an electron)** occurs if there is a region of at the boundary of particle**reduced energy density the**.
* **A positive charge (such as a proton)** occurs if there is a region of at the boundary of particle**higher energy density the**.
* **Charges of the same name repel** because their wave structures increase the change in energy density in space, which creates a repulsion effect.
* **Dissimilar charges are attracted** because their wave structures complement each other, reduce the change of energy density in space, which leads to the pulling effect.

This explains the electromagnetic forces **without the need to introduce virtual particles**, but through fundamental changes in energy density.

In addition, this explanation clarifies why **protons can form nuclear bonds while electrons cannot**. Since the proton has a region of lower energy density at the boundary, it is able to unite with other protons through neutrons, which stabilise their interaction in the nucleus. The electron, on the other hand, having a higher energy density at the boundary, is not capable of such bonds.

### 9.4 What is the reason for quantisation?

Quantisation within this model naturally follows from the **structure of standing waves of energy density**.

* For each particle there are only **certain stable wave states** corresponding to the nodes and bunches of standing waves.
* These states determine the **energy levels** and the possible values of momentum and spin.
* The scaling of the energy density causes **different levels of fractality to repeat the same patterns**, which explains the universality of quantum effects.

Thus, **quantisation is not an artificial restriction, but a natural consequence of formation of stable standing waves of energy density**.

# **10. Standing waves of energy density and nature of fundamental forces**

## **Introduction**

In modern physics, the fundamental forces (gravitational, electromagnetic, strong and weak) are described through fields and carriers of interactions. However, if we consider particles as **standing waves of energy density**, an alternative explanation of the nature of fields and interactions can be proposed. This chapter examines how **energy density determines the properties of fields and fundamental forces**.

### 10.1 What is a field in terms of energy density?

From the point of view of this theory, **the field is a gradient of energy density in space**. Any particle is a **localised standing wave of energy density** creating density changes around itself. These changes define the interaction field.

* A gravitational field is a **gradient of energy density throughout space** caused by mass objects.
* The electromagnetic field is **localised changes in energy density associated with standing waves of charges**.
* Strong and weak interactions **are special forms of energy density changes acting on small scales due to peculiarities of particle structure**.

Thus, the field is not a separate entity, but a manifestation of the **non-uniform distribution of energy density in space**.

### 10.2 Why do interactions between particles occur through fields?

If particles are standing waves of energy density, they can **interact through changes in energy density in the surrounding space**. Such interaction occurs by several mechanisms:

1. **Wave superposition** - the wave structures of particles overlap, creating regions of increasing and decreasing energy density.
2. **Density gradient** - the motion of particles is caused by the desire to equalise the energy density.
3. **Resonance states** - if the energy density of two particles are matched, they can form stable states (e.g. atomic levels or nuclear bonds).

Thus, interaction through fields is a natural consequence of the fact that particles **are localised changes in energy density**.

### 10.3 Why are the fundamental forces so different?

The fundamental forces differ in range and intensity, but in the framework of the proposed model they are all manifestations of **one phenomenon - redistribution of energy density**.

* **Gravity** is a consequence of the **global energy density gradient** and acts on any mass.
* **Electromagnetic forces** are related to the **local redistribution of energy density at the standing wave boundary** and can be both attractive and repulsive.
* **The strong interaction** arises from **the compression of the energy density within particles**, making it extremely powerful at small distances.
* **Weak interactions** are associated with changes in the energy density structure within particles, as manifested in nuclear decays.

Thus, the differences between the fundamental forces are due to the **scale and peculiarities of energy density redistribution**.

### 10.4 Why do strong and weak interactions act only at small distances?

### 10.4.1 Strong interaction

The strong interaction occurs within the atomic nucleus and holds protons and neutrons together. Within this model:

* Interactions between nucleons occur through **very high energy density gradients**.
* External energy density gradients interfere with long-range action, causing the force to weaken exponentially with distance.
* Nucleons are held in the nucleus because the energy density inside it is higher than in the surrounding space.

### 10.4.2 Weak interaction

The weak interaction is responsible for the decay of particles and changes in their structure. Within this theory:

* It is related to **local fluctuations of the energy density inside the particles**.
* Such fluctuations can lead to changes in the state of particles and their disintegration.
* Due to the very local nature of the energy density, the weak interaction only acts at short distances.

Thus, strong and weak interactions are limited to small distances because they are due to **local changes in energy density that do not propagate far away**.

# **11. Standing waves of energy density and the nature of mass**

## **Introduction**

Mass is a fundamental characteristic of matter, but its origin remains one of the key questions in physics. In the Standard Model, the mass of particles is explained by the mechanismHiggs , but this chapter considers an alternative approach: **mass as a manifestation of energy density in standing waves**. We explain why mass is proportional to energy, how inertia is related to energy density, and why particles have different masses.

### 11.1 How do standing waves of energy density explain mass?

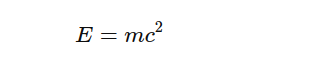
In the framework of the proposed model particles are **standing waves of energy density** which possess steady states. The mass in this case is determined by **a local gradient of energy density**:

* The greater the energy density inside a standing wave, the **greater its mass**.
* Mass is a measure of resistance to change in energy density, which corresponds to the **inertial properties of matter**.
* Different particles have different masses because their **standing wave structure is** different and hence their energy density is different.

Thus, mass is not an entity in its own right, but a manifestation of the energy density within the standing wave.

### 11.2 Why is mass proportional to energy?

From the special theory of relativity we know that energy and mass are related by the equation:



In our model, this relation follows naturally from the standing wave structure:

* The energy of a particle is determined by its **energy density and frequency of oscillation**.
* Mass arises as a parameter characterising **the local energy density in a standing wave**.
* The speed of light at this scale sets the limiting speed of energy transfer within the system.

Thus, **mass is proportional to energy because the energy density determines the properties of the standing wave that makes up the particle**.

### 11.3 Why does inertia depend on mass?

Inertia is resistance to changes in the state of motion. Within the framework of this model, inertia occurs for the following reasons:

* The higher the energy density in a standing wave, the **more difficult it is to change its structure**.
* Any change in the state of a particle requires a redistribution of the energy density in space.
* This redistribution obeys **wave processes**, which are constrained by the law of conservation of energy.

Hence, **inertia is proportional to mass**, since more massive particles have higher energy density and require more energy to change their state.

### 11.4 Why do particles have different masses?

The mass of different particles depends on the **structure of their standing wave**:

* Different oscillation frequencies result in different energy densities.
* The more nodes in the standing wave, the higher the energy concentration and the **larger the mass of the particle**.
* The mass scaling occurs according to fractal energy density levels, which may explain similar particle structures at different scales.

Thus, the masses of particles are different because **their wave structure is formed by different energy density conditions**.

### 11.5 Is the necessaryHiggs mechanism ?

In the standard model the mass of particles is explained by their interaction with the fieldHiggs . However, in the framework of our theory the **mass naturally arises as a consequence of the energy density in standing waves**. This leads to the following conclusions:

1. **The Higgs field can be interpreted as a manifestation of energy density at a certain fractal level**. In this case it is not a separate mechanism, but only reflects the existence of the energy density gradient.
2. **If mass is determined by the standing wave structure, then the mechanism is Higgs unnecessary**, since particles acquire mass simply by having an energy density at a given point in space.

Thus, the Higgs field may be **unnecessary** in the fundamental understanding of mass. It can be a convenient mathematical tool, but the mass itself is determined by the **energy density structure** without the necessity to postulate an additional field.

# **12. Speed of Light, Fractality and Expansion of the Universe**

## **Introduction**

The speed of light is considered a fundamental constant of physics, but why does it remain unchanged in different frames of reference? Within the framework of our theory, in which space is characterised by **energy density and standing waves**, the speed of light is a **local characteristic of energy density**. This explains not only its constancy, but also phenomena such as **redshift**.

### 12.1 Why is the speed of light a local constant?

In classical physics, the speed of light is considered to be a universal quantity, but within the framework of the proposed model:

* The speed of light determined by the is**local energy density.**
* It remains unchanged for observers within a given energy density level.
* This is analogous to how the speed of sound depends on the density of a medium, but remains constant within that medium.

Thus, the speed of light is a **local characteristic of the energy density of space**.

### 12.2 Why do we see redshift, why do we observe the expansion of the Universe?

Redshift is traditionally explained by the Doppler effect or the stretching of space, but within the framework of our theory it may be a consequence of **changes in energy density and gravitational effects**:

* The frequency of light depends on the **density of the surrounding space**.
* When passing through regions with different energy densities, not only the speed of light changes, but also its frequency, which leads to a shift in the spectrum.
* **Gravitational disturbances bend the trajectory of light, causing it to move along a curve, which creates a centripetal force**.
* **This force does the work of causing the photon to lose energy**.
* Since frequency is responsible for the energy density, this results in **a shift to the red region of the spectrum**.

Thus, the **redshift and expansion of the Universe** can be considered as a **consequence of the expenditure of light energy to overcome gravitational perturbations and changes in the density of the medium**.

### 12.3 Why is the speed of light important to the structure of the universe?

The speed of light plays a key role in shaping the structure of the universe:

* **It limits the maximum transmission rate of interactions**.
* **It defines the energy density and the boundaries of possible levels of fractality**.
* **Gravitational effects**, which depend on energy density, **affect the propagation of light, creating the observed effects of cosmology**.

Thus, the speed of light is not just a constant, but a **key parameter governing the energy density and structure of the Universe**.

# **13. Gravitational time dilation and energy density**

## **Introduction**

Gravitational time dilation is traditionally explained within the framework of the General Theory of Relativity (GTR) through the curvature of spacetime. However, if we consider space not as a geometrical structure but as a distribution of **energy density**, an alternative explanation of this effect can be proposed. This chapter considers whether the concept of time dilation is really necessary or whether it can be replaced by a change in the velocity of electromagnetic wave propagation in a medium with different energy density.

### 13.1 Gravitational time dilation or change in the speed of processes?

In GR the gravitational time dilation is explained by the fact that near massive objects space-time is curved and the clocks go slower. However in the framework of the proposed model:

* **Time as an independent physical entity does not change**.
* Near massive objects, the energy density is higher, which **slows down the speed of propagation of electromagnetic oscillations**.
* All physical processes, including the operation of atomic clocks, are slower, not because of a change in time, but because of a change in environmental conditions.

Thus, **gravitational time dilation can be replaced by a change in the rate of electromagnetic processes in a medium with high energy density**.

### 13.2 Is curvature of space necessary?

GR uses the mathematical concept of curvature to describe gravitation. However, in the framework of our model:

* Space itself remains unchanged, only the changes **energy density**.
* The curvature of object trajectories can be explained not geometrically, but through **energy density gradients**.
* Gravitational forces are not a consequence of curvature, but a result of the tendency of objects to move towards the lowest energy density.

Thus, it is possible to replace the concept of **curvature of space by a change in energy density** without violating the known laws of physics.

### 13.3 Why can energy density replace curvature?

* All observed gravitational effects can be expressed through the energy density and its gradients.
* GR uses the energy-momentum tensor, which already describes the energy density, but through a geometrical interpretation.
* In the framework of the proposed approach, there is no need for curvature of space, since the motion of objects and time dilation are fully explained by energy density.

So **the curvature of space is a mathematical tool and the real physical quantity is energy density**.

### 13.4 Can Einstein's equations be replaced by energy density equations?

Einstein's equations describe the dependence of the curvature of space on the distribution of energy and momentum. However, if we replace curvature by energy density, we can obtain an alternative approach:

* The gravitational field can be expressed as a gradient of energy density.
* The motion of objects is determined by changes in energy density, not geometry.
* In the framework of quantum gravity this approach can be more convenient, since quantum fields are already described through the energy density.

Thus, Einstein's equations can be rewritten in terms of **changes in energy density**, which simplifies the understanding of gravitation and its relation to quantum mechanics.

# **14. Spooky interaction and Heisenberg uncertainty via energy density**

## **Introduction**

Quantum mechanics describes many phenomena that seem counterintuitive to classical intuition. Some of the most puzzling are **quantum entanglement (spooky interaction) and Heisenberg's uncertainty principle**. In the framework of our theory, where **energy density determines the structure of particles and interactions**, these effects can be more clearly explained. The plays a special role in this process **rotation of the energy density inside the particle**.

### 14.1 How do you explain the spooky interaction?

Quantum entanglement (spooky interaction, to quote Einstein) implies that two particles can instantaneously affect each other at any distance. In standard physics this seems like a paradox, but if we consider particles as **standing waves of energy density with internal rotation**, an alternative explanation can be proposed:

* Entangled particles are a **single standing wave distributed in space**.
* The rotation of the energy density within the particle creates a **centripetal force** that moves the energy to a point where the **concept of distance becomes meaningless**.
* Thus, changes in the state of one particle are instantly reflected on another because they are a **single rotating wave formation**.

This explains why the spooky interaction does not require information to be transmitted at superluminal speed - it is a consequence of **a uniform distribution of energy density and its rotation**.

### 14.2 Energy density rotation and its role

* Neutral particles (e.g. **neutron and neutrino**) have an **odd number of standing wave nodes**, which causes the **energy density inside the particle to rotate**.
* Spiral galaxies have a similar process - their structure reflects the **rotational distribution of energy density**.
* Photons can also rotate due to the **mismatch between the centre of mass and the geometric centre of the wave structure.**, which explains polarisation
* The rotation of the energy density creates **localised changes in density gradient** the, resulting in instantaneous transmission of changes in the entangled particle system.

Thus, the spooky interaction can be seen as the **effect of moving energy into a region where distance becomes meaningless due to the rotational compression of the energy density**.

### 14.3 How can the Heisenberg uncertainty be explained?

The Heisenberg uncertainty principle states that it is impossible to measure the momentum and coordinate of a particle simultaneously accurately. In the framework of our model this effect can be explained as follows:

* A particle is produced by the propagation of an electromagnetic wave, which is an **energy density wave structure travelling through a sphere.**
* The generated wave in space is related to the wave on the sphere through the **number π**, which is irrational.
* If we know exactly the boundary of the sphere, it is impossible to calculate its centre accurately even mathematically.
* If the centre is known, it is impossible to calculate the length of the sphere accurately, even mathematically.
* The mass of a particle is formed due to the spherical structure, and it is the **geometry of the wave process that creates the fundamental uncertainty**.

Thus, the Heisenberg uncertainty is not just a mathematical constraint, but a **consequence of the spherical wave structure of particles and the properties of the π number**.

### 14.4 Relation of entanglement, rotation and uncertainty

If particles are standing waves of energy density with spin, entanglement and the uncertainty principle may be related:

* Entangled particles are a **single wave structure with rotational components** in which the uncertainty of coordinate and momentum is propagated to the whole system.
* The rotation of the energy density leads to centripetal effects in which the distance between entangled particles becomes meaningless.
* Measuring one of the particles changes the entire wave, thereby instantly changing the state of the second particle.

# **15. Measurements in the context of energy density theory**

## **Introduction**

Measurement plays a key role in physics, defining the boundaries of our understanding of reality. In the standard interpretation of quantum mechanics, the measurement process is associated with the collapse of the wave function, which leads to many paradoxes. However, in the framework of **energy density theory**, in which particles are considered as standing waves of energy density, measurement acquires a new physical explanation related to the **structure of space, rotation and geometry constraints**.

### 15.1 Measurement limitations and energy density geometry

Measurement is not possible without the interaction of the system with the environment. Within the framework of our model this is related to:

* **Spherical energy density structure**: the particles are standing waves, and their boundaries and centre are related through the π number.
* **Uncertainty of the boundary and centre**: since the number π is irrational, it is impossible to precisely determine both the boundary of the particle and its centre at the same time.
* **The relationship between wave and spatial dimensions**: any attempt to fix coordinates or momentum upsets the balance of energy density, changing the system itself.

Thus, the measurement limitations are not just a statistical consequence, but a result of **fundamental properties of energy density**.

### 15.2 Measurement process and interaction with energy density

In traditional quantum mechanics, measurement leads to the collapse of the wave function. In the framework of the energy density theory this can be explained differently:

* **A measurement is a redistribution of energy density**: when a system interacts with an instrument, the local energy density changes.
* **Changing the wave structure**: the measurement captures one of the possible configurations of energy density, changing the system.
* **Inability to measure coordinate and momentum simultaneously**: due to the spherical nature of wave structures, measuring one characteristic changes the other.

Measurement is a process involving the redistribution of energy density, not the abstract collapse of a wave function.

### 15.3 How does energy density affect measurement accuracy?

If the particles are standing waves of energy density, the accuracy of the measurements is limited by several factors:

* **Frequency of energy density fluctuations**: higher energy density creates sharper gradients, reducing uncertainty.
* **Gravitational field**: changes in energy density in space can alter the trajectories of measured particles, creating additional distortions.
* **Influence of energy density rotation**: particles with intrinsic rotation create dynamical position uncertainty.

Thus, measurement in physics is the process of interacting with a **dynamic system of energy density** rather than static determination of parameters.

# **16. Space, time and mass: three fundamental quantities**

## **Introduction**

In physics it is common to consider many fundamental quantities such as length, mass, time, electric charge and others. However, within the framework of **energy density theory**, three key fundamental quantities can be identified - **space, time and mass**, each of which is responsible for a different aspect of reality. This chapter explains why these three characteristics are the basic ones, and why the other parameters can be derived from them.

### 16.1 Space as the basis of structure

Space determines the **coordinates of objects** and their relative position. Within the framework of our theory, space can be represented as a **wave medium with different energy density**:

* Space defines the boundaries of the possible arrangement of particles.
* **Standing waves of energy density** are formed in it, defining the structure of matter.
* The change in energy density in space creates gravitational effects.

Thus, space is not just a background, but an **active environment** in which energy redistribution takes place.

### 16.2 Time as a characteristic of dynamics

Time is traditionally considered as an independent quantity, but within the framework of energy density theory it can be related to the frequency of energy density fluctuations:

* **The frequency of wave processes** determines the local speed of the processes flow.
* Time can be viewed as a parameter that depends on energy density but does not vary by itself.
* Time is not a changeable entity, but a **characteristic of the rate of interactions in a medium with a certain energy density**.

Thus, within the framework of this theory there **is no need for time warp**, and its manifestations are explained by changes in the properties of the medium.

### 16.3 Mass as a measure of energy density

Mass in classical physics is defined through inertia and gravitational interaction. In the framework of our model, mass is a **local compactification of energy in a standing wave**:

* Mass arises due to the **concentration of energy density** in a certain area.
* The higher the energy density, the greater the mass of the object.
* Mass is the source of gravity because it creates a gradient of energy density in the surrounding space.

Thus, mass is a **consequence of the wave structure of energy density**, not a separate property of matter.

### 16.4 Other parameters as derivatives

If space, time and mass are fundamental quantities, then other physical parameters can be expressed through them:

* **Velocity** is the ratio of coordinates to time.
* **Impulse** is the product of mass times velocity.
* **Electric charge** can be associated with energy density gradients at standing wave boundaries.

Thus, other quantities can be viewed as derivatives of **space, time, and mass**.

## **Conclusion**

This paper considers a new concept that explains fundamental physical processes through the **energy density, frequency and fractal structure of the Universe**. Within the framework of this model it was possible to link such phenomena as quantum uncertainty, gravitation, electromagnetism and the structure of matter, without the need to introduce additional entities such as spacetime curvature.

### The key achievements of this paper are:

1. **The fractal relationship between scales of matter has been revealed**- from elementary particles to galaxies. Calculations of the Milky Way radius and mass based on neutron parameters and coefficient fractalisation gave values close to the observed ones.
2. **A new interpretation of the de Broglie wave is proposed** as a mathematical description of standing waves forming elementary particles. This made it possible to theoretically determine the dimensions of the neutron and neutrino based on their mass. The calculations showed that:
   * The neutron size (~2.64 × 10⁻¹⁵ m) is consistent with experimental data.
   * The size of the neutrino (~1.55 × 10⁻¹⁰ m) has been found to be comparable to the atomic scale, as confirmed by recent studies.
3. **Methods of measuring sizes and masses at different scale levels have been clarified.** If standing waves determine the structure of matter, then the existing methods for estimating the sizes of particles and astrophysical objects may require correction taking into account their wave nature.
4. **It is shown that dark matter can be a consequence of a smooth gradient of energy density**. In this model dark matter is not a separate substance, but is a distributed energy creating gravitational effects.
5. **An alternative explanation of the accelerated expansion of the Universe is proposed.** The gravitational influence of rarefied energy at large distances can cause an additional redshift of photons, which is perceived as an effect of accelerated expansion of galaxies.
6. **The possibility of using the fractal approach to predict physical parameters was confirmed.** Scaling of sizes and masses from neutron to galaxy confirmed the applicability of the model at different levels of matter organisation.

Thus, this paper offers a **new perspective on the nature of matter, gravity and the structure of the Universe**, unifying quantum mechanics and astrophysics through the principle of fractality.

**Future steps include**:

1. **Further development of the model**, including its application to more complex physical systems.
2. **Developing new predictions** that can be tested by observations and experiments.
3. **To popularize the theory** among the scientific community and a wide audience.

Thus, this paper does not simply propose a new hypothesis, but forms the basis for further study of the laws of nature through the principles of energy density and fractal structure.

## **PS:)**

Albert Einstein created a very beautiful and coherent theory. It really describes everything very well. It is absolutely correct, so it cannot be refuted. It has only one drawback - it is difficult to understand and to describe. But it's absolutely correct.

The Michelson-Morley experiment (1887) was the decisive factor at that time. The wave nature of elementary particles had not yet been discovered. At that time, the wave theory of light existed, but the corpuscular-wave dualism had not yet been formulated. The very fact that light can behave as a particle began to be discussed later, in the early 20th century.

Einstein, developing the special theory of relativity (1905), took as a basis the negative result of the Michelson-Morley experiment; his approach was to reject the ether concept rather than to consider the wave nature of matter. At that time it was accepted that light was an electromagnetic wave (according to Maxwell), but in a sense it was considered a separate nature from matter.

The reason why Einstein did not view everything as waves is that at that time there was neither experience nor mathematical apparatus to support this view. Corpuscular-wave dualism only began to take shape after 1924, when Louis de Broglie hypothesised the wave properties of matter. And quantum mechanics, which explained it, did not develop until the 1920s and 1930s.

Einstein was later sceptical about the interpretation of quantum mechanics, but his original 1905 paper on the photoelectric effect suggested that light could behave as a particle (photon). That is, in a sense, he himself laid the foundation for the future wave description of matter, but within the framework of STO he solved another problem - the elimination of the ether and the revision of the concept of space and time.

Had ideas about the wave nature of particles already existed at his time, perhaps he would have considered them in the context of his theory. But in 1905 such ideas simply did not exist.

I deeply respect Einstein and his contributions to science. He did the right thing for his time. Experiments showed that the speed of light remains constant, and he had no choice but to introduce the concept of curvature of space. However, Einstein himself emphasised that it is in an absolute vacuum that the speed of light is constant.

At this stage, it is not possible to determine definitively which of the constants - the Planck constant or the reduced Planck constant - should act as the fractalisation coefficient. The available experimental data are still not precise enough to make an unambiguous choice. Therefore, this question remains open and requires further study.