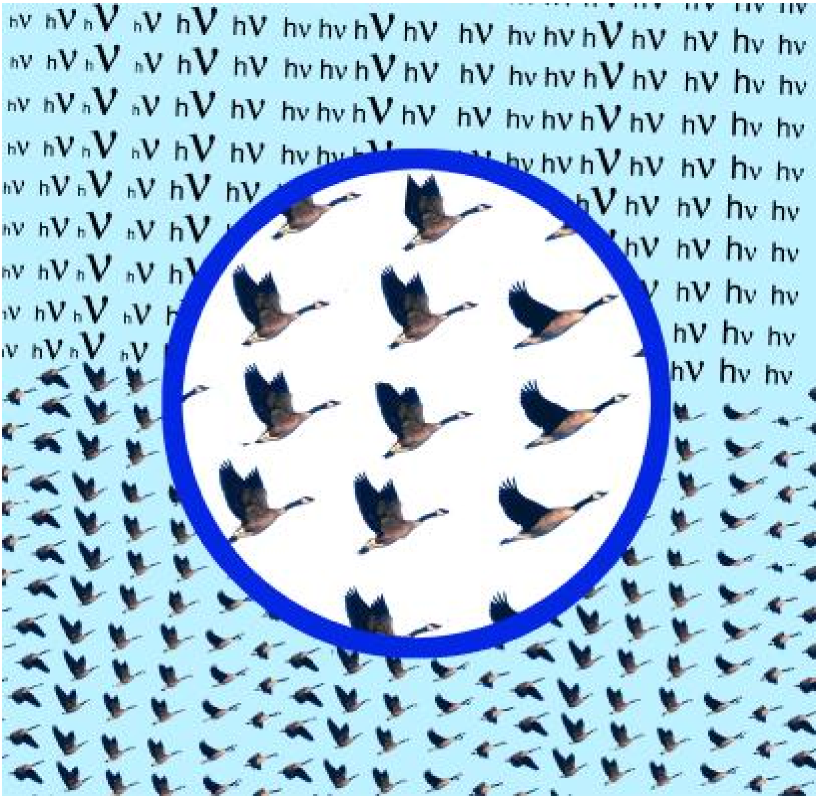
B.A. Sus', B.B. Sus', O.B. Kravchenko

THE UNUSUAL INTERPRETATION OF TRADITIONAL PHYSICS PROBLEMS



Kyiv-2012

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Scientific methodological edition
(the book for discussions)

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In educational–methodological edition of the textbook consideration is given to non-traditional interpretation of physics problems, administered in high, secondary school and on a college level. In particular, the existence of matter in the form of substance and field and its transition from one type to another in a form of movement, the issue of relativistic mass, dual nature of light as a form of movement, which represents the oscillations type mass-energy-mass-energy-..., the nature of the de Broglie waves and the nature of the uncertainty relation, consistent interpretation of quantum effects of diffraction and other problematic issues.

The manual can be used by college faculty and high school teachers to organize an independent work of students on the problematic issues of physics, on disputes and more.

Referees:
V.P. Sergienko – Professor of General and Experimental Physics in the Mikhail Dragomanov National Pedagogical University, doctor of pedagogical sciences, professor;
A.V. Franiv – Professor of Physics, National University "Lviv Polytechnic" Doctor of Physics and Mathematics, professor.

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Content

Introduction

Physics is the science about nature, and it is the most ancient of sciences. Therefore, it is a foundation of many other sciences. Physics gave a basis for technology development that spurred intensive development of the civilization. Electronics, radio electronics, materials science, mechanics, are sciences that consist the integral part of physics. In particular, engineering, physical chemistry, biophysics, medicine are the fields of science, directly related to the existence of living beings and in particular humans. Physics also provides the foundation for philosophy − the science about the beginning of our existence.

In terms of philosophy, there is infinite substance called the "matter" in the space of the universe. According to modern views, matter exists in continuous movement in space and time, and it appears in two ways − substances and fields. The usual characteristic of the matter as a substance is an availability of its mass. Mass is a measure of inertness of the body or the ability to save the state of motion. Such a mass in physics is called an inert mass. When interacting with other bodies, the body changes its form of movement, it is getting accelerated. However, the mass has another quality- it participates in the gravitational interactions of bodies. This mass is named gravitational. It is considered that inertial and gravitational mass are equivalent.

Another form of matter is the field. The concept of the field is also very well investigated in physics. We know of electric, magnetic, electromagnetic fields, the gravitational field and of the field of nuclear interaction. We have an ability to see light that is electromagnetic field also. The knowledge about electromagnetic field is also used for radio and television development. The electromagnetic field is also known as electromagnetic waves propagating in space with great speed.

Physics is a science directly studying substance and the field, as well as their motion and interaction. However, it is not limited to studying only the movement and interaction. If the matter appear in different kinds, it is logical to suppose that it can change from one type to another. It appears like one of the most fundamental problems of physics is complete understanding of the mutual transformation of both matter and fields. Many transformations of one type of matter to another are well known in physics. For example, nuclear fission of uranium mass fragments is less than the mass of the kernel that breaks. It is called mass defect. The part of the mass disappears. However, there is no absolute disappearance of either substances or fields in the universe. Obviously, nuclear fission of uranium mass does not disappear completely, but instead electromagnetic radiation, gamma-quanta appears. This is the example of transition of mass (or substance) to field. Since the electromagnetic field has energy, then we can talk about a change of mass into energy. As a result of nuclear fission of uranium in nuclear bombs enormous energy is released.

The change of mass into energy occurs in accordance with Einstein's formula $\Delta W = c^2 \times Dm$.

The reverse process, the transition of field into mass or substance, is also well known. As a result of the interaction of two gamma rays (field) two particles, electron and positron (matter) appear.

However, only individual manifestations of changes, field to substance or other way around, are studied. It is not addressed as a characteristic of matter as whole, as a form of movement.

We know the following types of body (substance) motion: rotational, translational, oscillatory (vibratory) and deformation. When the type of motion is changing, the energy is also changing from one kind to another. For example, during oscillatory movement the potential energy periodically changes to kinetic and other way around.

So it would be surprising if there was no another form of motion of matter, the transition of matter from one form to another as a continuous oscillating process, i.e. conversion from matter into the field and from the field into substance. The idea of pulsation of mass as a form of existence of matter was expressed by Mr. A. Einstein in the creation of the General Relativity Theory.

Matter fluctuates, generating gravitational waves and propagating with the speed of light. (Muller H. Relativist Theory. - M.: Nauka, 1966. − 462 pp.). There is every reason to believe that this type of motion is real, and this is discussed in this guide further. Nature has duality according to our present ideas and understanding. It appears in many natural phenomena, especially in micro world.

However, it is hard to comprehend duality of matter, and it is unresolved problem in science since the last century and up to now. Especially, it is true about electromagnetic fields. In particular, light as electromagnetic field, very clearly demonstrates the qualities of the wave (or field) and at the same time the qualities of particles(substance). Our traditional understanding is that the wave cannot be a particle at the same time or vice versa, the particle cannot be a wave. The wave is spread in the space, but the particle is localized in one point. Nevertheless, it is justified that the particle, moving with the great speed, exists and is called the de Broglie wave.

Electronic microscopes are well known devices, widely used in science, technology. They developed by using ideas of the de Broglie wave. De Broglie waves are a fundamental concept in quantum mechanics, which explains the huge success of the physical processes and different phenomena in a micro world.

Nevertheless, the problem remains unsolved for 100 years. Either 100 years ago or today, we cannot understand how the particle, localized in a small volume in space, can be at the same time the wave, which is spread in space. The same way as 100 years ago, physicists simply explain that it is a characteristic of the micro world. It doesn’t explain much. Logical and clear explanation should be found.

Otherwise, there is something wrong with our conceptions of physical phenomena and processes, and there is something wrong with the formation of concepts and terminology, which expresses these concepts. The problem of contradiction exists, and has to be properly addressed. The logical and non-contradictory explanation of dualism, in particular of dualism of light and electromagnetic waves, as well as the transformation of matter from one form to another is given in this book.

This manual can serve educators for classroom discussions and development of alternative approaches. It can also be useful to students for independent work in studying physics.

1. PROBLEMS OF RELATIVISTIC MOVEMENT OF THE PARTICLES

1.1 The definition of the problem

In the relativistic motion of bodies we understand the movement of bodies with high speeds, when the dependence of mass on velocity is significant. In science and especially in the educational literature there is no definitive understanding of the processes associated with relativistic motion. The formulations of scientific concepts and terminology that they represent are problematic. In this regard, it is necessary to consider these issues consistently, with due justification.

In school textbooks, the textbooks for high school, encyclopedic and scientific literature states it is stated that the body mass (particle mass) depends on the speed according to the known formula of relativity:

$$m = \frac{m_0}{\sqrt{1 - \frac{\upsilon^2}{c^2}}}, \qquad (1)$$

where m_0 is so called rest mass, or the mass in motionless coordinate system, and m is relativistic mass, defined in the coordinate system, which is uniformly moving with the velocity υ in relation to the motionless system [1-6].

Formula (1) is associated with the study of motion of electrons in a magnetic field and it is proven experimentally. This effect is used in the construction of accelerators of charged particles and is well established in academic literature. For the first time the dependence of mass on velocity was found and studied in the experiments of German physicist W. Kaufman in 1899-1906 and was confirmed by many physicists. Kaufman measured deviation of β-radium rays (fast electrons) in the magnetic and electric fields and found that the amount of

specific charge of an electron, i.e.in the ratio of its charge to mass, while increasing the mass, the speed of electrons decreases. Since the electron charge is not changed, it meant that the mass of the electron increases with increasing speed.
The question of mass dependence from the speed is not considered problematic for physicists working with particle accelerators. However, the issue of the dependence of the mass from the speed in our time is not straightforward and scientists treat this problem differently, and formula (1), which defines this relationship, denied. Such alternative views expressed in papers [7, 8].

There is also unambiguous relation in the sense of dependence between energy and body mass:

$$W = c^2 \cdot m, \qquad (2)$$

which is a fundamental conclusion of the theory of relativity. In the traditional theory of relativity under relativistic mass *m* the total mass understood, which includes the rest mass m_0 and gained mass due to increase in speed. Other scientists believe that in formulas (1) and (2) mass *m* − is just the rest mass (ie, m_0), and the energy *W* is rest energy ($W = W_0$). In [7, 8] the author purposefully explores this question and concludes that the concept of "relativistic mass" is archaic, and the term "rest mass" is even not needed , so instead the phrase "rest mass" (m_0) we should talk only about the mass *m,* which is independent of the motion of the system timer. By [7, 8] author explains that: *"The concept of mass, depending on speed, emerged in the early twentieth century as a result of "illegal" distribution of the Newton relation between momentum and velocity in velocities region, comparable with the speed of light in which it is unfair, and that "at the end of* *the twentieth century we have to say “good-bye “completely to the notion of mass depending on the speed.”*

It should be noted that the opinions, contained in two articles of big volume, are based mainly on the analysis of problems in the historical aspect with reference to the authorities. However, in these articles, unfortunately, there is lack of a consistent copyright analysis and physical reasoning of the problem, no comparison of findings with existing research data regarding the dependence of the specific charge on the particle velocity. There are no explanations of particle accelerators functioning in the spirit expressed in the articles of ideas.

Thus, there is a need to justify dependence or independence of body mass on the speed.

1.2. The question about correct recording of the formula for relativistic mass

We will show that in representation (1) there is an element of incorrectness incorporated, so you need something different for reading of this formula.

Suppose that the body is being monitored in several inertial coordinate systems, moving relative to the body at different speeds. For example, the body is in the plane, moving at speeds υ_1 relative to the Earth. Suppose that for an observer, also located in the same plane, the speed of the body $u_0 = 0$. For another observer, who is on Earth, the speed of the body will be υ_1. Another observer is riding on the train and is observing a body movement with the speed υ_2. From the perspective of observers, it appears that the body is moving at different speeds at the same time, so its mass, according to formula (1), has a different meaning. But mass is a measure of body's substance, and it can not depend on who is watching the body. We can therefore agree with the statement [7, 8], that mass does not depend on the coordinate system in which it is located.

Thus, there is reason to believe that the problem of ambiguity of interpretations regarding on whether there is or there is not any dependence of mass on speed, is largely methodological in nature. In particular, something is named wrong, so there is no clear understanding of the phenomenon. To eliminate the problem, we need to correct readings of formulas. **The fact is that if we want to consider the motion of the body in different coordinate systems, the body speed must be converted into one or another system, which means that its speed should really change.** This body must have the force applied on it for change in speed from 0 to υ, and the change of speed is due to acceleration. So in the formula (1) symbol υ really means not speed, but the change of speed: $\boldsymbol{\Delta}\upsilon = \upsilon - \upsilon_o = \upsilon - 0 = \upsilon$, and the corresponding change is $(\boldsymbol{\Delta}\upsilon)^2 = \upsilon^2$. Formula (1) is formally correct, but its correct recording should be like:

$$m = \frac{m_0}{\sqrt{1 - \frac{(\Delta\upsilon)^2}{c^2}}} . \qquad \textbf{(3)}$$

In this representation, depending on the speed of the mass, there is no contradiction, because it is about changing the speed of the body in the system, where its speed is equal to zero, to another system where the speed is equal υ. If for each of the observers velocity of the body is different, the difference in speeds, if it happens, is the same to all observers.

To change the speed of the body the work must be done, which means that its energy must be changed. And not only energy.

When we want
to consider the motion
of the body in different
coordinate systems,
then the body must be
transferred to a particular
system, which means
that its speed should
really be changed

Characteristic of the
motion is the
momentum ***K*.**
The body transferred has
the mass ***m*,**
the way of transferring
the body is characterized
by the speed $\boldsymbol{v}$:

$$\boldsymbol{K = mv}.$$

1.3. Movement as a property of matter

Let's look at the body movement in space and time more detail, based on our general understanding of the nature. Movement of the body (particle) is a movement of a substance in space and time. Characteristic of the substance (body or particle) is the mass ***m***. Characteristic of transfer is the speed υ. Thus, the characteristics of the movement are: something that is moving i.e. the mass ***m***, and the way how it is moving i.e. the speed *υ*. The characteristic, combining ***m*** and ***v*** is called the quantity of movement.

$$K = m \times \upsilon.$$

Please note, in the widely accepted terminology the quantity of movement is often called momentum. This term can hardly be considered successful, because momentum means push, kick, resulting in movement patterns change. If the body moves freely, there is no push, but the body has a certain amount of movement. Push (momentum) occurs when the body interacts with another body. If two bodies are moving with different velocities, then the push occurs at the moment of collision. The change of the quantity of movement at the time of the push is *dK.* Longer time of the push means greater change in the quantity of movement. So, it can be written:

$$dK = F\,dt. \qquad (4)$$

The change of the quantity of movement per unit of time is called the force, which influents the body:

$$F = dK/dt$$

In Newtonian mechanics it is considered that the mass is not changed in the process of movement (*m* = *constant*).
Then: $F = d(m\upsilon)/dt$

However, the work is performed and the energy of the body is changed as a result of the force applied. According to the relativist theory, there is a connection between the energy of the body and the mass.

$$W = c^2 m.$$

This means that the energy changes when the mass changes. Therefore, the force *F:*

$$F = \frac{dK}{dt} = \frac{d(m\upsilon)}{dt} = m\frac{d\upsilon}{dt} + \upsilon\frac{dm}{dt}.$$

Therefore, when the force applied, the mass and the velocity can change.
Thus, the force performs work:

$$dA = F\,dx = = \left(m\frac{d\upsilon}{dt} + \upsilon\frac{dm}{dt} \right)\cdot dx \qquad (5)$$

where *dx* is the displacement of the body under application of the force.

Apparently, the work of the force is applied to change of the velocity as well as the change in the mass of the body.

Please note that traditionally in the academic literature the unproved theory prevails: it is considered that the work, done by force that accelerates the body, is used only for increase of kinetic energy. It is not mentioned that the work of the force creates a change of the dynamic body mass [9, p. 30].

1.4. Work on the body displacement

Let's find the work on the body displacement, using (5). The body was displaced on the distance *x*.

$$A = \int dA = \int_{x_o}^{x} \left(m\frac{d\upsilon}{dt} + \upsilon\frac{dm}{dt} \right) dx =$$

$$= \int_{x_o}^{x} m\frac{d\upsilon}{dt} dx + \int_{x_o}^{x} \upsilon\frac{dm}{dt} dx \, .$$

Please note that $dx = \upsilon\, dt$. Let's replace variables:

$$A = \int_{\upsilon_o}^{\upsilon} m\frac{d\upsilon}{dt}(\upsilon \cdot dt) + \int_{m_o}^{m} \upsilon\frac{dm}{dt}(\upsilon \cdot dt) =$$

$$= \int_{\upsilon_o}^{\upsilon} m\upsilon \cdot d\upsilon + \int_{m_o}^{m} \upsilon^2 dm = m\frac{\upsilon^2}{2}\bigg|_{\upsilon_o}^{\upsilon} + \upsilon^2 m\Big|_{m_o}^{m} =$$

$$= \left(m\frac{\upsilon^2}{2} - \frac{m\upsilon_o^2}{2} \right) + \upsilon^2 \left(m - m_o \right) =$$

$$= m\left(\frac{\upsilon^2}{2} - \frac{\upsilon_o^2}{2} \right) + \upsilon^2 \left(m - m_o \right). \qquad (6)$$

So, the work on body displacement is:

$$A = m\frac{\Delta\left(\upsilon^2\right)}{2} + \upsilon^2 \left(\Delta m \right). \qquad (7)$$

Apparently, the relationship between mass and energy has universal nature.

As a result, the application of force changes kinetic energy and also body mass, Δm. This means that the work of the force used for not only for increasing of kinetic energy, but also for creation of a dynamic mass.

In traditional explanation relativistic mass is the sum of the rest mass (when the body doesn't move) and the dynamic mass (acquired as a result of acceleration of the body).

> The work of the force
> on the body
> displacement is used for
> increase
> of kinetic energy
> and also for
> a change of the body
> mass

1.5. The relationship between mass and energy

Let's pay attention to the formula reading:

$$W = c^2 \cdot m. \qquad (2')$$

(See formula (2)). There are different interpretations of it. Yes, there is an explanation [7, 8] that in the formula (2 ') mass m is the rest mass ($m = m_o$), and energy *W* is the rest energy (*W* = *Wo)*. There is widely known that this formula expresses the equivalence of mass and energy in the traditional interpretation. Obviously, there is certain methodical incorrectness, so it is important to come up with the same understanding basis.

In physics the concept of defect mass is widely known, which enables more thoughtful reading of the formula (2 '). In division of heavy uranium nucleus, the kernel mass is equal to the mass of fragments, which the nucleus breaks on. However, gamma-radiation appears that has energy. Therefore, the mass disappears, but the energy appears in accordance with the formula (2 '). Therefore, it's interexchange of mass and energy that should be reflected in the formula. Logically, formula (2) should be recorded as:

$$\Delta W = c^2 \cdot \Delta m. \qquad (7)$$

It means that when the body mass is changed, there is the corresponding change of energy as well. And vice versa, when the energy is changed, there is a change in body mass. Therefore, the conclusion about the existence of another form of motion is made, it is mass-energy interexchange. This form of movement is not new however; it is described in physics as partial cases. Currently, it is not described as a fundamental physical phenomenon indicating that matter not only exists in two types, substances and fields, but also changes from one type to another. More, such mutual conversions should exist as a continuous process.

When energy changes,
the body weight changes too,
and vise versa.
Mass-energy interexchange
is the continuous process

1.6. Speed of light

Relativistic motion of bodies is connected with the speed of light. Speed of light is a constant and is a part of the formulas (1) and (2) for mass and energy:

$$m = \frac{m_0}{\sqrt{1 - \frac{\upsilon^2}{c^2}}},$$

$$W = c^2 \cdot m.$$

Since light has dual nature, it is the waves and particles (photons) at the same time, then the logical question arises: what is the speed of light ? Is this the speed matter (mass) displacement, or phase velocity of electromagnetic waves ? If c is phase velocity; how is it related to the speed of the body, which represents the substance movement ? If c is velocity of a particle (photon), then how the phase is related to the photon movement ?

These issues are problematic and they should be answered. Acceptable explanation of dual nature of the light should be found.

What is the speed of light
Is this a phase velocity?
Is this a speed of mass
displacement?

Speed of light has
dual nature.
It is the velocity
of mass displacement,
and the velocity of fixed
phase of the
oscillating particle

All my life
I will think about
What is light

Albert Einstein

2. So, what is light?

The question about the nature of light became actual 100 years ago, however is not resolved yet. It is known that light has dual nature: the waves and particles at the same time. The quality of light as a wave is proven by distinguished qualities of diffraction and interference. However, the experiment of Bote about one way photon spreading, photo effect and light pressure confirm corpuscular light qualities.

Corpuscular qualities very well are proven by Bote experiment. [10.–P.38]. When thin metal film *Φ* is bombarded by X-rays of not too high intensity, and with frequency ν_1, photons with energy $h\nu_2$ (Fig. 2.1) are extracted as a result of fluorescence.

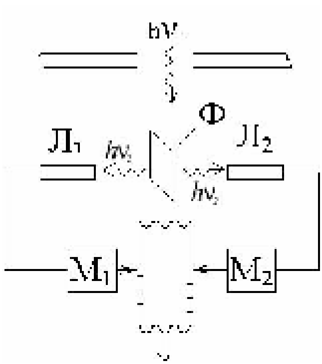

Fig. 2.1

These quanta of secondary X-flashing are counted by meters L_1 and L_2 with the help of recording devices M_1 and M_2 at the outer sides of metal film *Φ*. Devices M_1 i M_2 work not simultaneously, as it would be expected in case of wave spreading, but chaotically and independently from each other. It appears that the atom irradiates photon as a particle with momentum $\vec{p}$ that moves in certain direction.

Therefore a single act of atom radiation cannot be qualified as a wave that spreads in all directions. Nevertheless, the point source of light and spherical surface are defined in all wide known textbooks without any explainable limitations, when phenomena of diffraction is explained. [11,12,13].

The problem is that the qualities of light as a particle and wave at the same time are very contradictory. The particle is focused in one point in space, but wave is spread widely. It is hard to imagine how these opposite qualities can be present simultaneously. More, the matter has mass, and it proves that matter is substance and has corpuscular nature. Available scientific literature vaguely explains mass of the photon, and often presents to the reader very contradictory explanations. Some authors believe that photon doesn't have any mass, and others consider that photon doesn't have rest mass, but has relativist mass.

Traditionally it is considered that photon has mass, and therefore it is particle. However, so-called relativist mass is connected with movement, but rest mass is equal zero.[10. – C. 40; 14. – C. 373]. Other authors object any kind of mass of photon [7, 8]. Therefore, **photon cannot be considered as a particle in such a point of view.** Obviously, there are problems with terminology, which create confusion in educational process. It is important to get clear about what we name a particle (body).

On the other hand, light is the waves that spread with maximally possible speed $c = 3 \cdot 10^8$ м/s. It needs to be considered that any kind of waves spread in substance. However, Michelson experiments proved there is no substance (ether) exists for spreading light waves. The definition of a photon as a particle and a wave at the same time is not understandable. It is often used the expression "photon of a certain frequency". However, the nature and the mechanism of photon oscillation have never been explained. The thought about "**quivering**" behavior of particles was published, though.

There is also a problem understanding the energy transfer by light. It is known, when the wave spreads, the energy is transferred also, while mass is not transferrable. On the other hand, if photon is a particle that moves in space, it should transfer mass. There is another major problem not explained in physics well, and not having definite answer. What exactly is a speed of light? If the light is a wave, then we are talking about a phase speed. Considering photon it should be a speed of mass transfer. Overall, when the topic about light is studied in particular, or about electromagnetic waves in general, many problems of scientific or educational character should be addressed.

2.1. Light as a flow of oscillating particles

Obviously, light is a special case of oscillations, when the speed of particles (photons) movement and phase speed of the wave is the same. Traditionally, such a kind of oscillations is not explained in scientific and educational literature. However, it should logically exist, and it does. This is not only a flow of particles, but also a flow of particles that oscillate.

An example can be oscillations of the wings of the bird’s flock that flies in one direction. Here the velocity of the bird (mass) transfer and phase fluctuations are the same. Among the swarms it is possible to distinguish the surface, where the birds fluttering in one phase, simultaneously raise and lower their wings. It forms a wave surface in accordance with the principle of Huygens. It can be identified a lot of such wave surfaces. (Fig. 2.2).

Light is a stream
of oscillating
particles

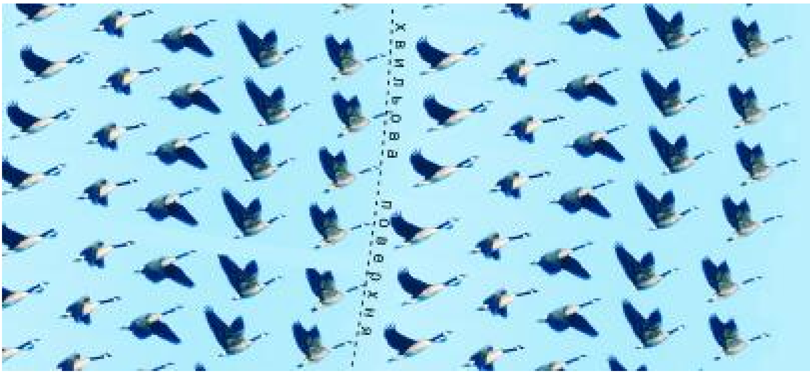

Fig. 2.2

Thus, the light should be seen as a stream of particles called photons. Photons are specific particles, each of which is in the vibration state.

In the fig. 2.3 the point source of light that emits photons in all directions is schematically shown. Photons fluctuate with different phases, but it is possible to choose among them those that oscillate in one phase.

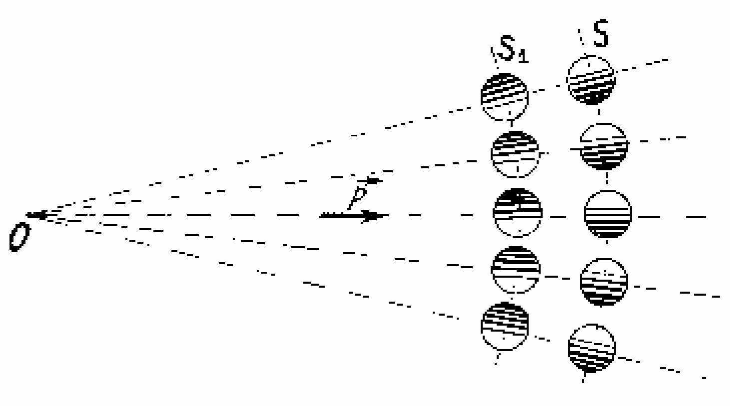

Fig. 2.3

Photons, which fluctuate in the same phase, form the wave surface *S*, which corresponds to the principle of Huygens. In the case of point source, the wave surface is spherical.

Thus light is a stream of special particles.

However, light is also electromagnetic wave.

2.2. Light is electromagnetic wave

The conclusion that light is electromagnetic wave was created by Maxwell on the basis of his theory of electromagnetic waves. Since this conclusion is extremely important and applicable to the solution of the problem, the elements of the Maxwell theory should be considered.

The basics for the system of Maxwell equations consists a theorem on the circulation of magnetic field (the law of full current) and the law of electromagnetic induction:

$$\oint_{l} \vec{H} d\vec{l} = \int_{S} \frac{d\vec{D}}{dt} d\vec{s} + \int_{S} \vec{j} d\vec{s}, \qquad (17)$$

$$\oint_{l} \vec{E} d\vec{l} = -\frac{d}{dt}\left(\int_{S} \vec{B} d\vec{s}\right),$$

where $\vec{D} = \varepsilon\varepsilon_0 \vec{E}$ – electric displacement vector,

a $\vec{B} = \mu\mu_0 \vec{H}$ – vector of magnetic induction.

These equations link the values of the electric field $\vec{E}$ and magnetic field $\vec{H}$ along some contour l with the values $\frac{dB}{dt}$ i $\frac{dD}{dt}$ at the points of the surface covered by contour (Fig. 2.4). For example, change in the the process of time of the vector $\vec{B}$, which penetrates the surface S, covered by a leading circuit, is accompanied by the appearance of electromotive force of induction. Conversely, a change in time of the electric field goes along with the appearance of the magnetic field.

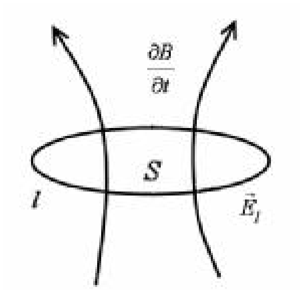

Fig. 2.4

2.3. Maxwell's equations in differential form

Maxwell's equations (17) recorded by the components of vectors. In differential form, they have the following format [11. – S. 295]:

$$\frac{dH_z}{dy}-\frac{dH_y}{dz}=\frac{dD_x}{dt}+j_x, \qquad \frac{dE_z}{dy}-\frac{dE_y}{dz}=-\frac{dB_x}{dt},$$

$$\frac{dH_x}{dz}-\frac{dH_z}{dx}=\frac{dD_y}{dt}+j_y, \qquad \frac{dE_x}{dz}-\frac{dE_z}{dx}=-\frac{dB_y}{dt},$$

$$\frac{dH_y}{dx}-\frac{dH_x}{dy}=\frac{dD_z}{dt}+j_z, \qquad \frac{dE_y}{dx}-\frac{dE_x}{dy}=-\frac{dB_z}{dt},$$

$$\frac{dD_x}{dx}+\frac{dD_y}{dy}+\frac{dD_z}{dz}=\rho, \qquad \frac{dB_x}{dx}+\frac{dB_y}{dy}+\frac{dB_z}{dz}=0.$$

If the subsatance is non-conducting ($j_x = j_y = j_z = 0$), the charge density is ρ = 0, and if considered that $\vec{E}$ i $\vec{H}$ depend only on one coordinate *x* and time *t*, Maxwell's equations will take the form:

$$0=\frac{dD_x}{dt},\qquad 0=-\frac{dB_x}{dt},$$
$$-\frac{dH_z}{dx}=\frac{dD_y}{dt},\qquad -\frac{dE_z}{dx}=-\frac{dB_y}{dt},$$
$$\frac{dH_y}{dx}=\frac{dD_z}{dt},\qquad \frac{dE_y}{dx}=-\frac{dB_z}{dt}, \tag{1}$$
$$\frac{dD_x}{dx}=0,\qquad \frac{dB_x}{dx}=0.$$

Let's allocate from the system of equations (1) a single component, such as E_y:

$$-\frac{dH_z}{dx}=\frac{dD_y}{dt},\quad \frac{dE_y}{dx}=-\frac{dB_z}{dt}. \tag{2}$$

Considering that $D_y=ee_0E_y$, a $B_z=mm_0H_z$ in equation (2) lets note:

$$-\frac{dH_z}{dx}=ee_0\frac{dE_y}{dt},\quad \frac{dE_y}{dx}=-mm_0\frac{dH_z}{dt}. \tag{3}$$

Lets exclude the magnetic field from a system of equations (3), and differentiate the first equation by t, and second one – by x:

$$\frac{d^2H_z}{dxdt}=-\varepsilon\varepsilon_0\frac{d^2E_y}{dt^2},\quad \frac{d^2E_y}{dx^2}=-mm_0\frac{d^2H_z}{dxdt}. \tag{4}$$

After multiplying left and right sides (4), we will get:

$$\frac{d^2E_y}{dx^2}=\varepsilon\varepsilon_0\mu\mu_0\frac{d^2E_y}{dt^2}. \tag{5}$$

Similarly, if E_y is excluded from (3):

$$\frac{d^2 H_z}{dx^2} = ee_0 mm_0 \frac{d^2 H_z}{dt^2}. \tag{6}$$

The equations (5) and (6) are the wave equations in differential form, or so-called wave equations that have the following general form:

$$\frac{d^2 S}{dx^2} = \frac{1}{u^2} \frac{d^2 S}{dt^2}. \tag{7}$$

Comparing (7) to equations (5) and (6), it is easy to see that:

$$\varepsilon \varepsilon_0 \mu \mu_0 = \frac{1}{\upsilon^2},$$

So the wave velocity would be:

$$\upsilon = \frac{1}{\sqrt{\varepsilon \varepsilon_0 \mu \mu_0}} = \frac{1}{\sqrt{\varepsilon_0 \mu_0} \sqrt{\varepsilon \mu}}. \tag{8}$$

In vacuum: $\upsilon \cong 3 \cdot 10^8 \frac{м}{c} = c.$

Solutions of wave equations (5) and (6) are the harmonic functions:

$$E_y = E_{oy} cos(\omega t - kx + \psi_1), \tag{9}$$

$$H_z = H_{oz} cos(\omega t - kx + \psi_2). \tag{10}$$

These functions are the plane wave propagating in x-direction.

Thus, based on Maxwell's equations, we come to the conclusion that electrical and magnetic waves should be mutually related and should be described as electromagnetic waves.

Let’s investigate the nature and properties of these waves.

2.4. The main properties of electromagnetic waves

Let us write again the Maxwell equation (3) from which we have received the wave equations (9) and (10):

$$-\frac{dH_z}{dx} = \varepsilon\varepsilon_0 \frac{dE_y}{dt},$$
$$\frac{dE_y}{dx} = -\mu\mu_0 \frac{dH_z}{dt}.$$

As we can see, this system of equations contains H_z and E_y, that are mutually perpendicular components of electric and magnetic fields.The component of electric field E_y, varying in time, is associated with changing magnetic field H_z , and varying in time magnetic field H_z is associated with electric field E_y. Similarly it is clear that the same is true for other components (E_x, E_z, H_x, H_y).

Thus, we come to an important conclusion: **mutually dependent electric and magnetic fields, when varying in time, become mutually perpendicular:**

$$\vec{H} \perp \vec{E} \qquad (11)$$

Let’s find the phases of oscillations *E* and *H*.

Let’s write the formulas for H_z and E_y the following way: (see. (9) and (10):

$$E_y = E_{0y} cos\left(\omega t - kx + \psi_1\right),$$
$$H_z = H_{0z} cos\left(\omega t - kx + \psi_2\right),$$

And use them for equation (3):

$$-\frac{dH_z}{dx} = ee_0 \frac{dE_y}{dt},$$
$$\frac{dE_y}{dx} = -mm_0 \frac{dH_z}{dt}.$$

Differentiating accordingly, we will get:

$$\begin{gathered} -H_{0z} \cdot k \cdot sin(\omega t - kx + \psi_2) = \\ = -\varepsilon\varepsilon_0 E_{0y} \omega sin(\omega t - kx + \psi_1), \\ E_{0y} \cdot k \cdot sin(\omega t - kx + \psi_1) = \\ = \mu\mu_0 H_{0z} \omega sin(\omega t - kx + \psi_2). \end{gathered} \qquad (12)$$

Left and right side of the equation may be equal when the arguments in the sine functions are the same, which is possible only if phases are equal:

$$\psi_1 = \psi_2 \qquad (13)$$

Therefore, the oscillations of vectors $\vec{E}$ and $\vec{H}$ have the same phases.

The electric and magnetic fields in electromagnetic wave change in one phase

The coefficients of left and right sides of equations (12) must be equal too:

$$-H_{0z}\cdot k = -\varepsilon\varepsilon_0 E_{0y}\omega, \qquad (14)$$

$$E_{0y}\cdot k = \mu\mu_0 H_{0z}\omega. \qquad (15)$$

Let's divide the equation (14) on the equation (15):

$$\frac{H_{0z}}{E_{0y}} = \frac{\varepsilon\varepsilon_0}{\mu\mu_0}\cdot\frac{E_{0y}}{H_{0z}}. \qquad (16)$$

Hence we obtain the relation for the amplitudes E_{0y} and H_{0z}:

$$\mu\mu_0 H_{0z}^2 = \varepsilon\varepsilon_0 E_{0y}^2,$$

$$\boxed{\sqrt{\mu\mu_0}H_{0z} = \sqrt{\varepsilon\varepsilon_0}E_{0y}.} \qquad (17)$$

Therefore, vectors $\vec{E}$ and $\vec{H}$ are mutually related and constitute a single electromagnetic wave. We can construct an image of this wave for a specific time point (Fig. 2.5).

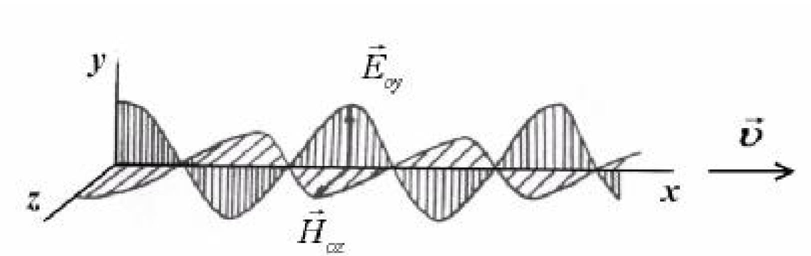

Fig 2.5

For further consideration it is important to note that the vectors $\vec{E}$ **i** $\vec{H}$ **oscillate with the same phase.**

The electric and magnetic fields have the energy. As within the electromagnetic wave $\vec{E}$ and $\vec{H}$ change in space and time, it is clear that wave energy also changes. However, if the energy is changed, then it should in turn into something.

Oscillations of intensity of electric and magnetic fields means oscillation of energy of electromagnetic wave

If the energy of electromagnetic field is changing, what is it transferred into?

2.5. Which of the photon oscillations occur?

In terms of corpuscular approach, as shown in (2.1), electromagnetic wave is a stream of photons, particles that oscillate, but solution of Maxwell's equations implies that electric ($\vec{E}$) and magnetic ($\vec{B}$) fields oscillate. But the presence of such oscillations has no physical justification for the electric and magnetic fields have energy, which also oscillates. The problem is that, as already mentioned, oscillations of vectors $\vec{E}$ **and** $\vec{B}$ **occurs with the same phase,** because the energy of the electric field cannot move into the energy of magnetic field or vice versa, as is the case in the oscillatory circuit. In oscillatory circuit the difference between phases of $\vec{E}$ and $\vec{B}$ is π/2. In connection with this the question arises, what energy of the electric and magnetic fields in electromagnetic waves is converted into, when change $\vec{E}$ and $\vec{B}$ occurs? The explanation may be one: in the electromagnetic waves there are oscillations of energy occur in accordance with the equation (2):

$$W = c^2 \cdot m.$$

This means that the change of energy in electromagnetic waves is accompanied by changes in mass of photon:

$$\Delta W = c^2 \cdot \Delta m.$$

Note that the mass of photon *m* here only dynamic, because the rest mass of photon is equal to zero.

Changing of energy
in electromagnetic waves is
accompanied by
change in mass of photon:

$$\Delta W = c^2 \cdot \Delta m$$

Thus, electromagnetic waves, including light, are a stream of particles-photons, in which there is oscillation:

$$\Delta W \rightarrow \Delta \boldsymbol{m} \rightarrow \Delta W \rightarrow \Delta \boldsymbol{m} \rightarrow \ldots \qquad (17)$$

With this consideration it is clear that when light spreads, photons as particles transfer mass, and therefore the speed of light is the speed of moving mass. From another point of view the mass that is transferred, is in the oscillation state, hence constant velocity phase is also the diffusion speed of photons. Thus, the speed of light represents the velocity of photons as particles, as well as the velocity of constant phase distribution in oscillatory processes. Even though by nature these velocities are different, they have the same values.

Considering the light (and other electromagnetic waves) as a stream of particles (photons) that are in the oscillation state of type: $\Delta W \rightarrow \Delta \boldsymbol{m} \rightarrow \Delta W \rightarrow \Delta \boldsymbol{m} \rightarrow \ldots$, it is necessary to consider in the same way all other known phenomena and effects - Fizeau and Michelson's experiments on discovery of ether as a medium for light propagation, Doppler effect, interference and diffraction phenomena, and explanation why the speed of light is a constant and is independent of motion coordinate system, in which it is defined.

Light is the stream of particles, photons, in which there is oscillation type:
$\Delta W \rightarrow \Delta \boldsymbol{m} \rightarrow \Delta W \rightarrow \Delta \boldsymbol{m} \rightarrow \ldots$

3. What is photon as a particle?

We examined the movement of "orplinary" body, and "ordinary" particles, which move in space. The force can be applied to the body and change its speed. When the body is accelerating, its mass is increasing from the rest mass m_0 to the relativistic mass m:

$$m = \frac{m_0}{\sqrt{1 - \frac{\Delta \upsilon^2}{c^2}}} . \qquad (1)$$

Relativistic mass is the total body mass, the sum of the rest mass m_0 and the dynamic mass Δm, acquired during acceleration:

$$m = m_0 + \Delta m.$$

It is logical to suppose that the body may have different rest masses, and the rest mass in the limit can be in value equal zero: $m_0 = 0$. For such body mass can be only dynamic, i.e. variable:

$$m = m_0 + \Delta m = 0 + \Delta m = \Delta m.$$

Such a particle that has only dynamical mass is the photon. For photon, formula (1) means that it moves with the velocity $\upsilon = \Delta\upsilon = c$. But then the denominator of expression tends to zero and the mass m must be an infinitely large, which means the loss of physical sense. However, the formula is meaningful if the rest mass of photon $m_0 = 0$, because under such conditions uncertainty appears, at which the mass of photon has a specific meaning:

$$m = \Delta m = \frac{0}{0} .$$

Thus, for photon $m_0 = 0$, and it only has a dynamic mass $\mathbf{\Delta}\boldsymbol{m}$, which is variable, and thus there is a following type of the oscillatory process:

$$\Delta W \rightarrow \Delta \boldsymbol{m} \rightarrow \Delta W \rightarrow \Delta \boldsymbol{m} \rightarrow \ldots$$

So a photon is a special particle that is in the oscillatory state, and moving with great speed, which is a constant.

Photon is a special particle
that is in the oscillatory state,
and moving with
the constant speed

3.1. Why is speed of light constant?

Photon appears when energy changes, including the transition of an electron in an atom from a higher energy level to a lower: $\Delta W = h\nu$.

It is impossible to modify motion of the photon, or accelerate it because the inertial mass photon rest mass is equal to zero. Photon is moving with great speed with which a constant value *c*. Stability and speed is crucial, because it defines features of photon. To change the speed of the photon as a particle, the force should be applied. For example, electrons are accelerated with application of the electric force in cathode-ray tubes, or in a cyclotron. Because electron has a charge, it can accelerate in the electric field. Photon, however, is neutral and cannot be accelerated with electric force. Therefore, the definition of photon speed in any moving system gives the same result: the speed of photon is a constant value.

With a dynamic mass Δm, and moving with the constant speed $\vec{c}$, photon has a certain amount of movement, which is traditionally called momentum $\vec{p}$. Since the photon mass is variable, then the quantity of movement $\vec{p}$ (momentum) is also variable: $\Delta p = \Delta m \cdot \vec{c}$.

3.2. Momentum maintenance in the distribution of electromagnetic waves

Light has dual nature, wave and quantum [12]. In terms of the quantum theory, light is a stream of particles /photons, which have mass and moving with a speed $c \cong 300000$ *кm/s*, therefore they have momentum (quantity of movement) $\vec{p} = m\vec{c}$. Due to the momentum of photons, light exerts pressure on matter, on which it falls, that is one confirmation of corpuscular properties of light.

However, light also has wave properties, is an electromagnetic wave and is the fluctuation vectors of electric $\vec{E}$ and magnetic $\vec{H}$ fields that occur with the same phase and spread with the speed of light $\vec{c}$:

$$E = E_m \cos(w t - kx + y),$$
$$H = H_m \cos(w t - kx + y).$$

Inside the photon, which is a special particle in ccordance with the formula $\Delta W = \Delta m c^2$, oscillations occur when mass is getting transformed into energy fields and vice versa:

$$\Delta W \rightarrow \Delta m \rightarrow \Delta W \rightarrow \Delta m \rightarrow \ldots$$

Having dynamic mass Δm and moving at the speed of $\vec{c}$, photon has a certain amount of movement, which is traditionally called momentum $\vec{p}$. Since the photon mass is variable, and then momentum or quantity of movement is variable also: $\Delta p = \Delta m \cdot \vec{c}$. Therefore it is necessary to talk about conservation of momentum. Obviously, the law of conservation of momentum in these conditions is provided because mechanical momentum of photon $m\vec{c}$ at the change of mass is converted into electromagnetic momentum (and vice versa).

The fact that in addition to mechanical impulse (momentum), there is electromagnetic impulse was known since Thomson's research, who assigned momentum to electromagnetic field. He believed that the electromagnetic momentum is as real as the mechanical momentum that caused by the presence of mass: "It's important to remember that this quantity of movement in any respect is no different from ordinary mechanical momentum and can be added or taken away from the movement of bodies that move" (J. Thomson. Matter and electricity. M.: HYZ, 1928. – P. 21).

Electromagnetic momentum is manifested by the interaction of light with matter, which is also causing the pressure of light. Under the influence of the electric vector component waves (photons), electrons in substance are displaced in the direction perpendicular to the beam. It causes the appearance of electron velocity, which is directed perpendicular to the magnetic component of the wave (photon), and of the Lorentz force acting in the direction of the beam, and the last one causes pressure and light.

Therefore it is logical to assume that when electromagnetic waves propagate, mutual transformation of the movement associated with mass and electromagnetic momentum occurs, which determines the overall momentum conservation.

Speaking of light propagation in space is important to determine the mechanism of this dissemination.

4. ENVIRONMENT FOR SPREADING LIGHT

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In our time we use to talk about light as the propagation of electromagnetic waves. The problem of clarifying the mechanism of light propagation was more urgent than a hundred years ago. It was important experimental confirmation (or denial) the existence of ether as a medium for propagation of light waves in XIX century. It was thought that if the light spreads within the Earth atmosphere, the environment around it, sustainable for wave propagation should be aired. This was possible in two cases: either the Earth moves through still ether, or ether is a part of the Earth atmosphere, and the Earth moves together with it.

Experiments were developed to identify ether winds, including experiments of Fizeau and Michelson. The Fizeau experiment suggested that there was a partial seizure of ether by Earth, but Michelson experiment concluded that there was no ether wind, which meant either that ether captured Earth in full, or it was no ether at all. Considering the other experimental data, including the aberration of light, it was concluded that there is no ether at all. These studies were experimental groundwork for Einstein's special theory of relativity, and the main conclusion is that space and time are mutually connected and form a single form of existence of matter. Traditionally, Fizeau and Michelson's experiments are discussed in the literature on the theory of relativity, and included practically in all textbooks for high school. Since the mechanism of propagation of electromagnetic waves in the framework of traditional notions is unknown, it is interesting to look at Fizeau and Michelson's experiments in terms of ideas about light as the special particles, which inherent their own internal fluctuations (see 2.1. – P. 26).

4.1. Problems of traditional interpretation of the Fizeau experiments regarding consumption of ether by moving body

In 1851 Fizeau experiment was developed, which was based on the idea that ether, through which light was spread, was consumed by moving bodies [16. – P. 395-399].

In experiment of Fizeau, the light beam from the light source S was divided on two parallel beams 1 and 2 by the semi-transparent mirror *P* (Fig. 4.1). Mirrors M_1, M_2, M_3 helped to assure that beams *1* and *2* travel the same distance. The interference of the beams occurred after the beams reached the telescope *T*. Two tubes, where water circulated with the speed *u*, were placed on the way of beams *1* and *2*. The ray *1* was propagating along the current, while the ray *2* was propagating against the current of water.

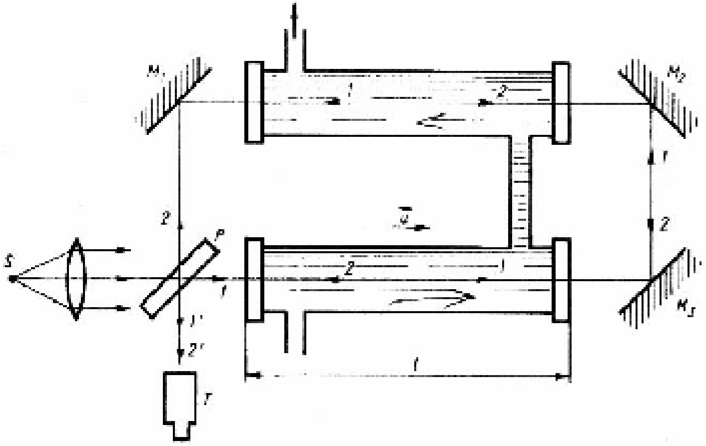

Fig. 4.1

A study showed that the movement of water in the system leaded to a shift of interference fringes in telescope *T*, The effect of environment influence on the speed of light in it was confirmed. It appeared meant that Fizeau experiment should have confirmed the existence of ether in which light waves spread.

4.2. Michelson experiment regarding capture of ether by moving body

The idea of the experiment, allowing in principle the possibility of direct detection of the Earth movement through ether, was expressed by Maxwell in 1878. In 1881 the experiment was developed by Michelson. The accuracy of it was provided by the sensitive interferometer (Fig. 4.2).

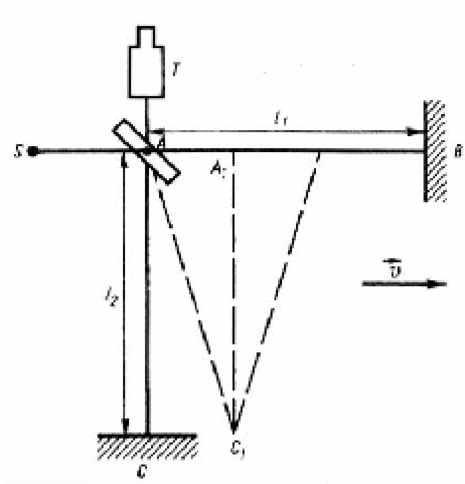

Fig. 4.2

A beam of light from source *S* is divided into two beams by semitransparent mirror *A*. One of them propagates in the direction *AB*, is getting reflected from a mirror and enters the telescope *T*. Since the two beams are coherent, then the interference pattern is observed in the telescope *T*. If the Earth didn't move in relation to ether, and shoulders were equal, then the maximum of the interference pattern would have been observed in the center.

Interferometer is oriented the way that one of the shoulders, such as *AB,* is oriented in the direction of Earth's orbit, and another one *AC* is perpendicular to it. Then the intervals *t1* and *t2*, which light spends when passing back and forth the same distances *AB* and *AC*, are different. Indeed, when considering that the ether is still, and interferometer is moving together with the Earth through the ether, the light along the length *AB* should propagate longer, since the point *B* is moving all the time away. This means that the distance *l* will be greater: $\tau_1 = \frac{l}{c-v}$. Conversely, in the reverse distribution of light from point *B* to point *A*, which is moving towards the light, the distance *BA* = *l* will be shorter: $\tau_2 = \frac{l}{c+v}$. до *A*

Total time of passing by light the distance from *A* to *B* and from *B* to *A*:

$$t_1 = \tau_1 + \tau_2 = \frac{l}{c-v} + \frac{l}{c+v} = \frac{2l}{c}\frac{1}{1-\frac{v^2}{c^2}}.$$

Under such conditions the perpendicular beams in an interferometer with his shoulders turning 90° should give a difference of motion and displacement of the interference pattern. However, the shift of interference pattern is not the case**,** although the sensitivity of the device guarantees the possibility of its detection. This meant that the speed of light is independent of the coordinate system in which it moves and in which the speed of light is measured.

Lack of interference pattern changes could be explained by complete consumption of ether by Earth. Then the distribution of light in ether wouldn't be dependent on the movement of the Earth. The similar situation could occur if, for example, considering the sound propagation in air in a closed moving car, when the speed of propagating sound is the same in the direction of the car movement as well as in the direction perpendicular to it. However, it is possible to agree with the idea of complete capturing of ether if it did not conflict with other experiments, including the phenomenon of light aberration that is observed when the beam from a star, captured by a telescope, should be slightly tilted in the direction of the Earth.

This means that light propagates in the air, which does not move with it, nor is consumed by the Earth. Thus, one experiment proved a complete capturing of ether by the Earth, and the other − the absence of any capturing. Agreement between these experiments could only be the absence of the very ether itself. That is, if the ether doesn't exist, it is equally possible to believe that it is fully captured by the Earth and at the same time is not captured at all. However, this scheme does not agree with Fizeau experiment, which confirmed the partial capture of ether It turned out that there is no ether, but it is partly captured! Nonsense! All this required explanation.

This task performed Einstein theory of relativity, according to which a reduction of sizes of bodies occurs in the moving coordinate system. According to Michelson's experiment, interferometer arm length becomes shorter in the direction of travel, and it explains the absence of interference pattern shifts when turning interferometer.

However, the theory of relativity does not reveal the mechanism of propagation of light waves without any substance. This is not included in its functions. Also it did not explain the Fizeau experiment on partial consumption of ether by moving substance (water).

Physical phenomena occur no matter how we describe them. There are various ways of description, but their findings should not contradict each other.

For example, we listen to radio show in the theater. Others see it on TV, but without sound. The idea of what actually happens in the theater and the audience and viewers should not be in contradiction. To find agreement between the Michelson-Morley experiment and other experiments, the idea of ether as a medium for propagation of electromagnetic waves had to be abandoned. H. Lorenz and J. Fitzgerald hypothesized that the bodies (in this case, devices), moving in ether, experience linear reduction in size in the direction of movement. This idea formed the basis of special theory of relativity, developed by Einstein.

The equations for the change of length and time are developed the way to explain the compensation for the difference in motion, formed in the Michelson experiment. Thus, Michelson's research denied capture of ether that in view of other experiments made it possible to conclude that there is no ether. As examined by us quantum theory, light is a stream of particles-photons (see 2.1, Fig. 21), then their propagation does not require a particular environment, but independent motion of photons resembles to the model of motionless ether in Michelson experiment. Moreover, our proposed oscillation quantum theory of light is quite consistent with the conclusions of Michelson experiment about absence of ether as an environment for the propagating of light waves. The research findings are explained by the theory of relativity.

However, Michelson's experiment was in conflict with the research of the Fizeau [16], which detected the partial capture of ether by moving substance. Therefore, it is important to find explanations for such differences.

4.3. The discrepancy between the experiments Fizeau and Michelson

The discrepancy between the experiments Fizeau and Michelson is explained by quantum theory of light oscillation (2. - P. 24), where light is not an oscillation of environment (air, vacuum), but the flow of photons, particles that have specific. Therefore, photons are particles, which on the one hand have to their own, inherent (internal) fluctuations mass and momentum, and on another, photons are particles that have phase that characterizes their oscillatory state. Important that a mutual transformation of energy into mass and vice versa in accordance with the law $\Delta W = \Delta m c^2$ occurs inside of photon along with inner fluctuations of energy.

The representation of light as fluctuating particles in Michelson experiment does not explain the absence of differences in phase changes compared with the case of waves, propagating in a medium that moves. Indeed, the internal fluctuations of photon when it moves at speed c are quite similar to fluctuations of light waves, propagating in hypothetical ether, captured by Earth. However, in Michelson's experiment the expected shift of interference pattern didn’t occur, so as expected phase difference of rays, which explains the independence of light speed from the Earth movement. As already mentioned, this fact is explained by reducing distances in the moving coordinate system that follows from the theory of relativity.

At the same time in the Fizeau experiment the phase difference was observed, when rays were passing through streams of water, moving in opposite directions, despite the fact that the speed of moving water is much smaller than the speed of the Earth.

Contradiction between Michelson and Fizeau experiments from which follows the partial capture of ether in moving substance in the theory of mass-oscillatory nature of light, is explained as following:

Light in vacuum propagates with the speed $\vec{c}$. This is somewhat different from free distribution of photons in vacuum because it carries the consequences of the interaction of photons with matter, absorption of photons by the atom and the subsequent radiation**.** In a substance as we know, velocity is lower than in vacuum. To explain this, the mechanism of light propagation in substance should be considered. Obviously, it is somewhat different from the free flow of photons in a vacuum, since photons interact with substance, so as absorption of photons by the atom and the subsequent radiation occurs. Therefore the speed of light in substance can be considered as a process of relay subsequent radiation of photons when the atom absorbs a quantum of energy, moves a certain distance and after a while re-radiates. Next atom absorbs the radiation of previous atom and re-radiates again. This process causes the relay wave propagation in the environment. Thus, the delay in radiation due to relay emission of light propagation in the environment is the reason that the speed of light in the environment is smaller than in vacuum.

Relay nature of the radiation turns out differently in the wave propagating movement along and against movement of water in the Fizeau experiment. During the time of relay re-radiation an atom moves some distance in the direction of light in one case, along the light propagation, whereas otherwise it goes against the light propagation. This difference in spreading the light causes a phase difference in the Fizeau experiment, which was interpreted as the effect of partial captivation of ether by water that moves.

Thus, the interpretation of Fizeau experiments should be connected not with ether like some ideal environment due to oscillations, by which light is spread, but with features of natural light and character of its distribution in the substance. Relay-rate nature of the absorption and re-radiation leads to the phase difference between rays that extend along the movement and against movement of water that leads to displacement of the interference pattern compared with the case where water is motionless. So, there is no need to attribute the results of the experiment of Fizeau to arguments on which the theory of relativity was built.

Interpretation of Fizeau experiment should be explained by the nature of light and the nature of its distribution in substance

5. Independence of the speed of light from the motion of coordinate system in which it propagates

Constancy of the speed of light in vacuum is confirmed by many experiments with high accuracy. It is one of the postulates of relativity theory: in any system of coordinates that are moving uniformly relative to one another, the speed of light is a constant and doesn't depend on the speed of the system of classic bodies without "dynamic" mass. This means that in different inertial coordinate systems the movement of photons as particles, fundamentally different from the classical motion of bodies, which in addition to "dynamic" mass m have "rest" mass m_0.

The lack of rest mass does not allow accelerating photon and changing its speed. There is no such system, where the speed of light is equal to zero. We will show this in the finding of speed of the classic body versus finding the speed of light (photon).

We know that speed of the body depends on the motion of the coordinate system in which the body is, and can change depending on the system. So, the fact that the speed of light (photon) is a constant gives reason to believe that there is a fundamental difference between the speed of movement of the body and the speed of light (photon) in the inertial coordinate system. To detect this difference we will look at the experiments on the determination of the speed of the classic body and the speed of light in coordinate systems that move uniformly relative to one another. These systems can be, for example, Earth and Sun.

5.1. The difference between the speed of the body and the speed of light

Let's determine the velocity of the body in two cases – in the direction of the Earth movement around the Sun and in perpendicular direction.

Let there be a bullet that flies out of a shotgun. Measurements will be done for example, using the device P_1 made from two disks that rotate on one axis with constant angular velocity (Fig. 5.1). Obviously, the velocity is proportional to the angle φ between holes, slain by a bullet in the discs.

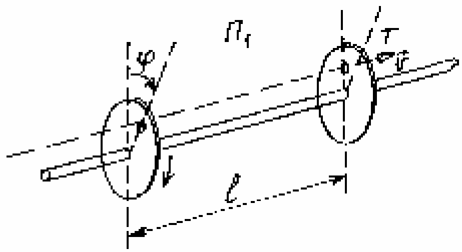

Fig. 5.1

If the device P_1 for measuring the bullet velocity measures velocity in the coordinate system associated with the Earth, it doesn't move, in relation to Earth. In this case, the bullet velocity before the shot, relative to the Earth, is zero, and measured by the device P_1 velocity after the shot is $\vec{u}_T$, and it doesn't depend on the direction.

When the device P_1 for measuring velocity is in coordinate system, lined up to the Sun (C), then measured bullet velocity before the shot equals the speed of the Earth relative to the Sun is $\vec{u}_0$, and after the shot it will be $\vec{u}_1 = \vec{u}_T + \vec{u}_0$ (Fig. 5.2). In the perpendicular direction to the

Earth the bullet velocity after the shot is equal to the geometric sum of $\vec{u}_T$ relative to the gun and speed of the Earth $\vec{u}_0$ along the orbit: $\vec{u}_1 = \vec{u}_T + \vec{u}_0$.

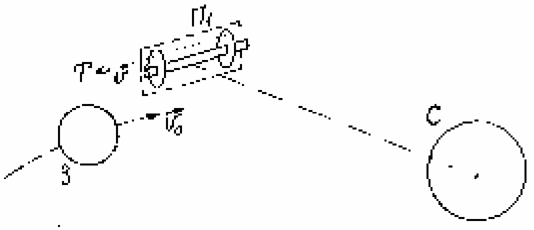

Fig.5.2

Thus, the velocity of the body depends on which coordinate system is chosen for the movement measuring, and is determined as a result of the geometric velocity addition. Obviously, in this case we are dealing with inert body weight, i.e. mass, which changes its speed by the action of external forces (or other bodies).

Now let’s measure the speed of light, for example, by Michelson method, using the device with a mirror-prism (Figure 5.3).

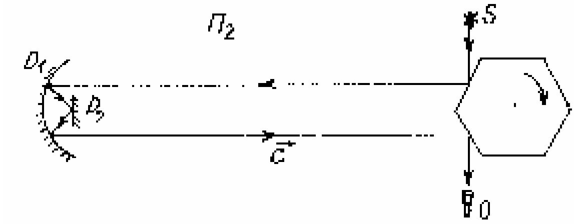

Fig. 5.3

The ray from the light source S is reflected from prism, propagates the distance to the mirror D_1, is getting reflected, and comes to the prism again. At a certain position of the prism the ray can be seen as the reflected beam through the telescope *O*. When rotating the prism, the beam disappears, but at a certain frequency, when the prism rotates to the certain angle that makes reflection of the beam possible, it can be seen again. Knowing the angular velocity of rotation of the prism, we can determine the speed of light. The result we know: the speed of light is the same regardless of how the device is oriented relative to the Earth – parallel or perpendicular to its motion in orbit. It is no matter in which coordinate system the device for measuring the speed of light will be located. For example, despite the fact that the Earth is moving at a speed $\vec{u}_0$ related to the device P_2, which is associated with the sun, measured value of the speed of light is constant (Figure 5. 4).

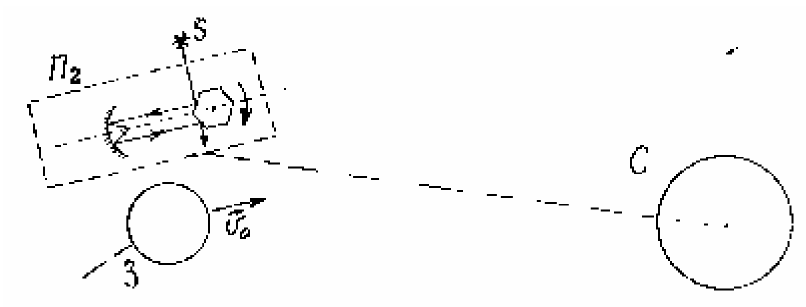

Fig. 5.4

Thus, the results of measuring the speed of light (electromagnetic field) are fundamentally different from the case of the bullet (body and substance) that must be explained. Note that neither a classical wave nor quantum theory is certainly revealing the mechanism of propagation of light as electromagnetic waves as aluminiferous medium. Initially it was believed that light travels as oscillations of the ether. However, Michelson experiment to detect "ether wind" speed of light showed independence from the direction of its propagation in the Earth's motion in orbit.To explain the results of this experiment the Einstein theory of relativity was set up, which denies the existence of ether.

We will adhere to this conclusion and consider the light in terms of corpuscular approach, i.e. as a stream of photons, particles of light. Moreover, according to the model representations of the quantum theory of oscillating, consider photons as specific particles, such as inheriting internal oscillation process (2.1. - P. 26).

Thus, in accordance with the theory of relativity emitted photon moves with **constant speed regardless of the coordinate system** in which this movement is considered. If we define the speed of a photon, it will be (as opposed to experiment with a bullet the same for any of coordinate systems, moving at different speeds either relative to Earth, or one another, or the Sun. The peculiarity of this behavior of a photon is determined by its nature.

If a bullet is the form of matter, which we actually call matter, the photon is an object of another type of matter, called a field. The principal difference between a ball and photons that the ball in the coordinate system, associated with the Earth has a lot of rest mass. This rest mass is an expression of the inertial properties of the body. Because in the system of coordinates associated with the Sun, the ball has a speed even before shooting, determined by the movement in relation to the Sun along with Earth, so it has kinetic energy. Same characteristics are very different for photons. Speed of a photon within the Earth doesn’t depend on its movement.**The Earth does not convey to any photon the energy, associated with its movement**. Since the rest mass of a photon is equal to zero and in the very beginning it is impossible, because there is no way to act on a photon. A photon has mass, but the so-called relativistic, more "dynamic" weight (3. – P. 42). Movement of the Earth can be transmitted to the body that has an inert mass, which can be identified with rest mass. Inert mass can accelerate or slow down. It is impossible to speed up or slow down the dynamic mass. This mass is in the oscillating state in accordance with a ratio $DW = c^2 \Delta m$. We can conclude that this formula reflects the relationship between two states of matter, field and substance, and related to them various forms of movement.

It is important to note another feature of rectilinear movement comparison of substance particles and photons as the substance particles. When observing the movement of the substance particle, we are dealing with the mass and determine the speed of its movement in space. When distributing the same general waves and light waves in particular, we are not talking about moving mass (rest mass) in the direction of wave propagation (when the wave is propagating, the mass is not transferred), but about a movement of a certain phase during the oscillating process. Therefore, formal direct comparison and the formal analogy cannot be considered reasonable.

5.2. Doppler Effect in terms of quantum theory of light oscillating

Lack of substance for the propagation of electromagnetic waves as well as a unique mechanism of their proliferation as a stream of particles that are in the oscillatory state, require an explanation from this perspective for traditionally known concepts, effects and phenomena, in particular s Doppler effect, the phenomenon of diffraction of de Broglie waves and the idea of quantum mechanics.

It is known that during the propagation of waves in the substance, the Doppler Effect should be considered. It describes the change of the frequency of oscillations depending on the speed of the driving source or receiver when they move in substance. Doppler Effect is also observed in the propagation of electromagnetic waves, including light. The oscillation frequency of the light depends on the relative velocity of source and receiver, moving in substance [11. – P. 468]. Because light has a dual nature, wave and corpuscular and electromagnetic wave's propagation mechanism is unknown, there is a specific explanation in this case of the nature of the Doppler Effect.

In the classic case the wave propagation (e.g. Acoustic) occurs in the environment, so changing the oscillation frequency depends on the source motion or receiver motion, relative to the environment. Indeed, suppose that two stationary sources D_1 and D_2 simultaneously emit signals with equal frequency, which are distributed in the environment towards motionless receivers P_1 and P_2 . Let the second signal start radiating when the first signals from both sources have reached position *1* (Fig. 5.5). The second signal is also emitted simultaneously by two sources, but the source D_2 moves with speed *v*, so its signal will be emitted from position *2'*, which is closer to the first signal than the source D_1, which is not moving. Accordingly, the distance l_1 between two adjacent signals from the source D_1 will be greater than the distance l_2 when the source moves. Thus, the signals from the source D_2 will be received by the receiver with greater frequency than the signals from the source D_1, although they are emitted in the same time.

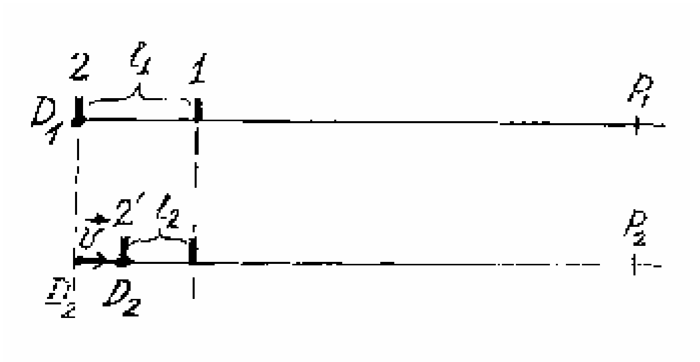

Fig. 5.5

If the distance increases when the source moves in opposite direction, compared with the motionless state of the source, the signal is sent all the time from a greater distance to the receiver and reaches receiver later. This is interpreted as a lowering frequency.

The similar situation occurs when the receiver is moving relative to the environment. In this case the signal reaches the receiver faster if the receiver is moving toward the source (which is perceived as increasing the frequency), and delayed when the receiver is moving away from the source (lowering frequency).

According to modern concepts, light is not seen as oscillations of a medium (ether, vacuum). Lack of ether is brought by Michelson experiments. Therefore, to explain light propagation it is required a different interpretation of the Doppler Effect, which is defined only by relative motion of source and receiver without the transfer substance for propagation of waves (here we don't consider the propagation of light in water, glass etc., because there is a slightly different mechanism of propagation of light in substance).

Let's consider the explanation of the Doppler Effect for light on the basis of quantum theory of light oscillating (2. – P. 23). According to this theory, light is regarded as a stream of photons, specific particles in oscillating state. Photon has inner oscillations, such as: weight energy–mass–energy–mass… Photon fluctuations, occurring inside cause correspondent equivalent type of energy conversions. Thus, the photons propagate in space with the speed of light and oscillating inside. Therefore, they have peculiar phase, which characterizes the oscillation. Thus, the light wave propagation should be considered as a stream of photons and can be characterized by the movement of only one particle, i.e. a single photon.

Consider two identical sources D_1 and D_2, which emit photons simultaneously. Source D_1 and receiver P are not moving relative to each other, while the source D_2 is moving at a speed *v* relative to the receiver. Source (atom) emits a photon as a particle that oscillates. Photon emission process takes some time. Propagating in space, the photon oscillates. The process of absorption of a photon by the receiver (atom) also takes some time and the receiver receives the changes in the state of a photon with a certain frequency.

Fig. 5.6 schematically shows the formation of two photons, which are radiated simultaneously by motionless source of radiation D_1 (Fig. 5.6 a) and the source D_2 (Fig. 5.6 b), which moves in the direction of the receiver. Let in the moment, when the process of radiation ends for photon *1*, it reaches position 1. Since the source moves at a speed υ then at the end of radiation of the photon *2,* it will reach the location of atom *2*. The distance between the beginning and end of the road of the photon, which is one oscillation ("wavelength"), will be shorter if the source is not moving. Receiver will indicate an increase in frequency.

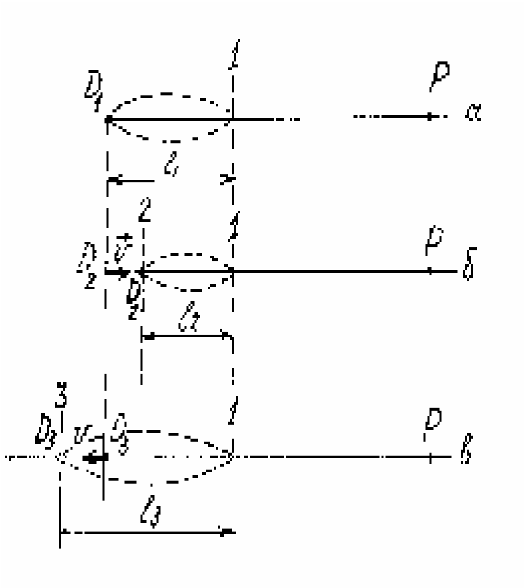

Fig. 5.6

If the source *D* moves away from the receiver, the end of a photon formation corresponds to the position *3*, i.e. it takes place on a larger gap path. The receiver would process it as lower frequency oscillations (Fig. 5.6 c). Similarly the process of change in frequency occurs when the receiver is moving toward the source. If the receiver is moving toward the photon, the distance it runs in the process of absorption of a photon will be smaller, which is perceived as increasing frequency. Conversely, in the distance between the photon and the receiver is extended, it is equivalent to decreasing frequency.
Thus, the Doppler Effect for light has a specific explanation as compared to wave propagation in the environment. It is a manifestation of the interaction of the receiver or the light source moving relative to one another, with photon as a particle, which carries light. Photon is an oscillatory system.

"So far nobody has been able to make
satisfactory determination of the difference
between the diffraction and interference.
The only point is in the habit, but the
substantial physical difference between
these two phenomena does not exist"

R.Feynman

Diffraction is a type of interference, when coherent sources are the sharp edges of obstacles

6. PHENOMENON OF DIFFRACTION, EXPLAINED THROUGH CONSIDERATION OF OSCILLATORY NATURE OF PHOTONS

In studying the phenomenon of diffraction of electromagnetic waves in general, there is some uncertainty in understanding the physical nature of this phenomenon, especially in high school. Thus, experience shows that students mainly formulate the phenomenon of diffraction as an "entering by rays the geometric shadow region due to bending of the ray around sharp inhomogeneity." This definition is only partially and superficially reflects the physical essence of the phenomenon of diffraction. For the diffraction pattern as a result of diffraction occurs not only in the shadows (point K_1 in Fig. 6.1), but also in the direct rays illuminated region (point K) and even in the opposite direction of propagation of rays (point K_2). This is easily seen if the light is directed on a slit, and the picture of the diffraction maxima on the screens of E_1 and E_2 at the points P_1 and P_2 appears (Fig. 6.1).

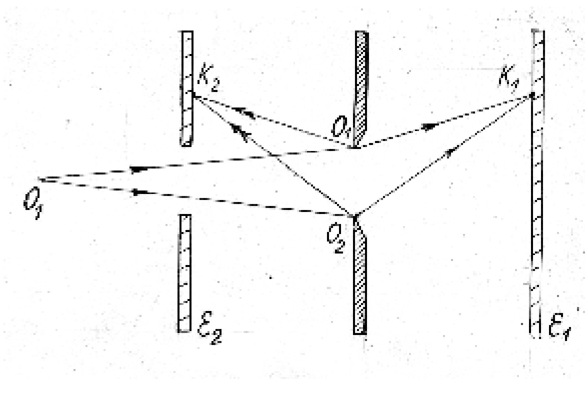

Fig. 6.1

If the diffraction picture on the screen $\mathcal{E}_1$ corresponds to a certain extent of the above definition of diffraction, the diffraction pattern of $\mathcal{E}_2$ on the screen requires additional clarification. Thus, the explanations of diffraction require clarification of the physical nature of this phenomenon and use of the appropriate terminology.

6. 1. Diffraction as one of the types of interference

The phenomenon of interference is the occurrence of an interference pattern of maximums and minimums as a result of interaction of coherent beams. Diffraction is also a case of interference. In particular, this idea appears in [24. − *P*. 61], but the description of phenomena and abstract features of diffraction are not revealed. Featuring of the diffraction as the interference is only explains getting the coherent light sources. In diffraction picture the coherent sources are sharp edges of the obstacle, which reradiate light rays more precisely i.e. reradiate photons (Fig. 6.1). When light reaches the barrier, the electrons come to the vibrational motion, and the light is reradiated by the sharp edges of the obstacles, and it can get in the shadow region, creating an interference pattern.

In Fig. 6.2 there is the diffraction disk exhibited. Quanta, emitted by the certain point source O and distributed as particles (photons) that oscillate, are getting to the edges of the disc D. Excited electrons at the edges of the disk oscillate with the same phase, but reradiated photons come to the points of the screen K, and M with different phases, resulting in the observation of diffraction pattern with maxima and minima.

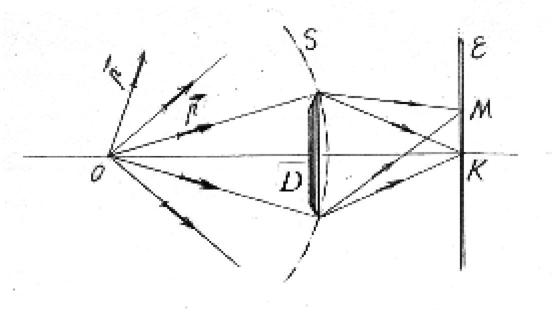

Fig. 6.2

In the case of diffraction grating radiating elements (oscillators) are the sharp edges of scratches (strokes) on a transparent plate.

It is important to stress that **it is the sharp edges of obstacles reradiate light, not transparent gaps (gap) between them**, as it has traditionally been considered [11. − P. 372].

6.2. Calculations of the diffraction picture based on the wave approach

In terms of the wave theory of light, in accordance with the principle of Huygens, each element of the wave surface is a source of new waves. Thus, the light source is considered replaced by the wave surface, which is lit. This wave surface is divided into Fresnel zones, which take into account the phase difference of rays through different lengths of their ways to the point of observation *K* (Fig. 6.3).

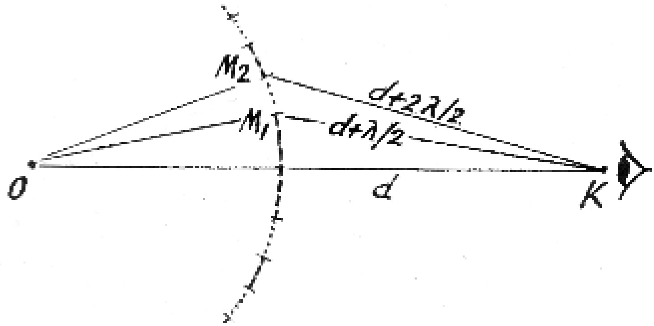

Fig. 6.3

As a result, at the point *K* there is interference of rays from all elements of the wave surface. According to the calculation of the diffraction pattern, each Fresnel zone is divided into infinitesimal elements and the result of radiation of all the elements for all zones at the point of observation is found.

Thus, the feature of Huygens-Fresnel principle is that **the light source is replaced by the wave surface, which is lit**. It should be noted that the revised method of calculating the diffraction pattern is formal, since the light is seen as some abstract wave process in which quantum properties of light are not considered.

This approach is valid for waves, which propagate in the environment, but this principle is unacceptable to light with dual nature; to light, which is a wave and particle simultaneously, but for which the environment for propagation is missing.

\

6.3. Diffraction of light from the quantum ideas point of view

Consideration of diffraction on the basis of quantum approach should only complement the description of diffraction phenomena. However, consideration of the quantum properties of light leads to disagreement with the fundamental wave theory of light and even with the traditional interpretation of diffraction. In terms of quantum representations, light is a stream of photons, the special particles, which are oscillating with frequency and phase (see 2.1. − P. 26). Photon as a particle has momentum, and because there is a law of conservation of momentum, it must be taken into account when considering the phenomenon of diffraction. However, the existence of photon momentum contradicts the principle of Huygens on the wave propagation. According to Huygens principle each element of the wave surface is a source of new waves.

However, the photon, reaching the element of the wave surface *dS* (Fig. 6.4), under the law of conservation of momentum cannot change the direction of their movement and cannot get to point *K*. This observation contradicts the principle of Huygens.

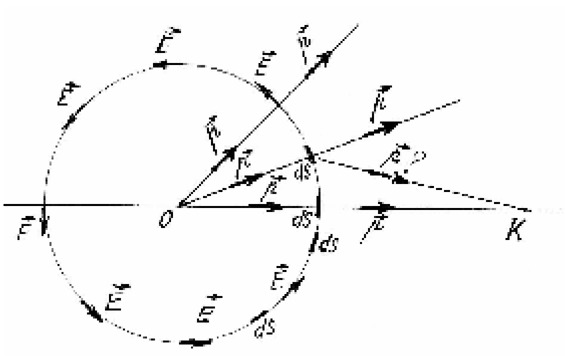

Fig. 6.4

It turns out that in terms of the quantum approach to light Huygens principle has no real physical sense, and therefore calculations and explanation of diffraction effects are of abstract character. As a result, the wave and quantum approaches, which describe the same phenomena, show contradictory results. However, findings on physical phenomena do not depend on the method of description. Therefore, it is necessary to seek an explanation that would not lead to contradictory results. In this regard, pay attention to the fact that the diffraction pattern is observed with the following important conditions: **the edges of obstacles must be sharp!** This is crucial, because the sharp edges of obstacles determine the presence of a diffraction phenomenon.

For example, if the wave surface is covered by zone plates (in Fig. 6.5 opaque parts of the wave surface), the photon will pass through the open area of *M −L,* without changing the direction of motion. This photon will not get to the point of observation *K*. However, if a photon hits the edge of zone plate (at the point *M* or *L*), it will interact with the obstacle and reradiating by obstacle in any direction, including the direction of *K*, will occur.

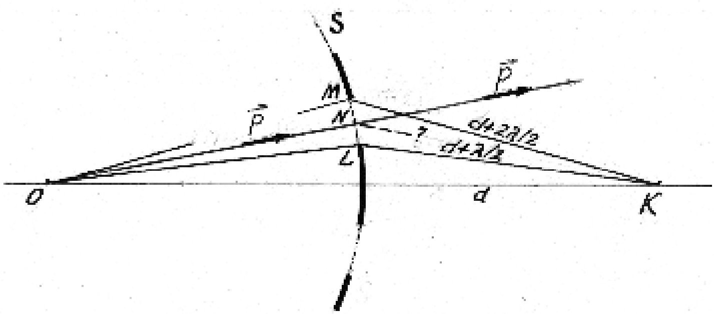

Fig. 6.5

Thus, **the edges of obstacles in the points *M* and *L* are coherent sources, which create an interference pattern, and at the point *K*** some intensity value (maximum or minimum) can be observed. Sharpness of the obstacles edges is crucial, since only under these conditions the sources can be considered "point" sources, and the interference (diffraction) pattern is contrast enough.

Note that in diffraction experiments the radiating elements, i.e., coherent sources are not open parts of the wave surface $M - L$, but the edges of the zone plate (points M and L), where the light is reradiated.

During diffraction radiating elements (coherent sources) are not the open zones of the wave surface, but the edges of obstacles

6.4. Diffraction on an aperture in terms of quantum approach

To confirm the identity of the concepts of interference and diffraction we conducted an experiment on observation of diffraction on aperture. A beam of helium-neon laser was directed on a narrow slit, and a clear interference pattern with many maxima and minima (Fig. 6.6) occurred on a screen.

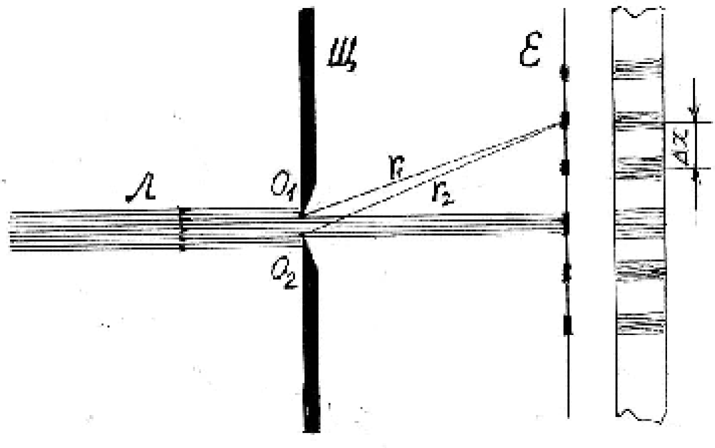

Fig. 6.6

Fig. 6.7 shows photos of the real diffraction pattern, which has a bright central part as a result of direct light beam, and the sides: a periodic structure of maxima and minima of diffraction (interference) pattern.

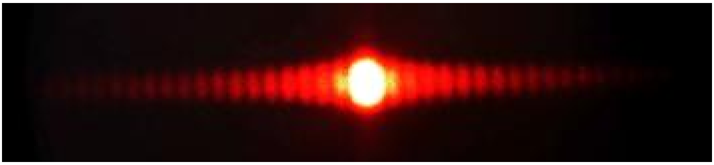

Fig. 6.7

Measuring the width of the interference fringes Δx (distance between two maxima), the distance between the slit and the screen *l*, and the slit width ***d*** helped to calculate the wavelength of the light beam by the formula for the interference of two coherent sources:

$$\lambda = \frac{d}{l} \cdot \Delta x \cdot \quad (1)$$

Note that in this case we believe that the coherent sources are the slit edges, so the gap width ***d*** is the distance between the coherent sources.

In the experiment with slit width ***d*** = 0,28 *mm*, the distance from slit to screen *l* = 100 cm in the interval ***h*** = 10,0 *cm* it is observed 36 maxima (i.e. the distance between two neighboring maxima Δx = 2.8 *mm*). Calculated by the formula (1) wavelength λ = 0,66 *mkm*, that within the measurement error $\Delta \lambda$ = 0,04 *mkm* coincides with the wavelength of the helium-neon laser (λ = 0,63 *mkm*).

Considering light from a position of oscillating quantum theory as a special stream of particles - photons, which are in oscillating condition, we receive certain results, explaining the phenomena of interference and diffraction of light in agreement with both classic and quantum theories. It appears that diffraction is just a kind of interference when sharp edges of the obstacles become coherent sources, reradiating light. In the case of diffraction grating coherent sources are the edges of "carved strokes", which create diffraction grating, but not transparent spaces between them.

6.5. Calculation of the interference pattern of the diffraction grating, based on the concepts of quantum theory of light

Let's evaluate the nature of the diffraction pattern, created by the diffraction grating: a periodic structure of many narrow slits. **Traditional calculations, such as in the case of one slit, are based on the principle of Huygens-Fresnel,** i.e. on the notion that radiation is coming from the open areas of surface wave in case of the diffraction grating [11. −P. 392, 16. − P. 269]. Since such a model contradicts quantum theory of light (see 2. − P. 24), diffraction on diffraction grating (D), as in the case of one slit, should be considered as **interference from a large number (*N*) coherent sources**, such as **acute edges of opaque gaps** in a periodic grating structure (Fig. 6.8).

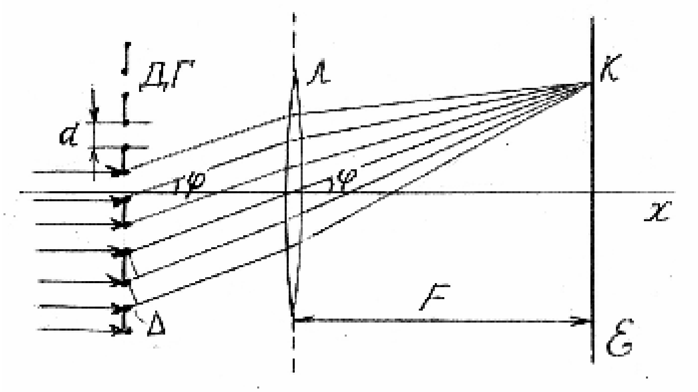

Fig. 6.8

Let's parallel beams reach diffraction grating (*D*), so it's edges would become coherent light sources, which oscillate in the same phase and radiate electromagnetic waves, but under different angles. (Fig. 6.8).

Let's parallel beams propagate in certain direction φ, and be gathered on a screen by lens *L*, then amplitude of oscillation on a screen and in a point *K* is determined by the sum:

$$E = E^* cos(\omega t) + E^* cos(\omega t+\varphi) + \\ + E^* cos(\omega t+2\varphi) + \ldots + E^* cos(\omega t+N\varphi), \qquad (1)$$

where E^* is the amplitude of oscillations from one single source. Importantly, there is a phase difference ψ between oscillations that come from nearby sources to the point *K*, due to the rays' path differenceΔ:

$$\psi = \kappa \Delta = \frac{2\pi}{\lambda}\Delta. \qquad (2)$$

where $\kappa = \dfrac{2\pi}{\lambda}$ is a wave number.

To determine the sum *E* we will use the geometric method of adding oscillations [11. − P. 378: 12. − P. 158; 17. – P. 61]. We will represent every oscillation as a vector

$\vec{OK}, \vec{KL}, \ldots$ orientation of which determines the phase of oscillations at the point *K* (fig. 6.9).

Composite vectors form a polygon with *N* sides, whose vertices lie on a circle with a radius *r*, and have a center in a point *Q*. It can be seen from geometrical drawing that *OQK* is the same as ψ, so it is equal to the phase difference in oscillations in electromagnetic waves that come from two nearby sources.

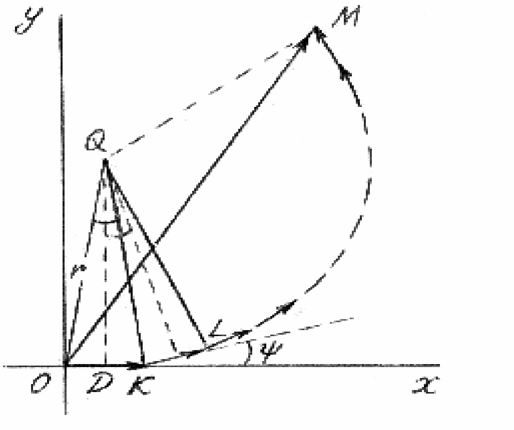

Рис. 6.9

Because $DK = OK / 2 = r \cdot sin(\psi/2),$ (3)

then $OK = 2r \cdot sin(\psi/2).$ (4)

For the large angle *OQM* summary vector $\vec{OM}$ has length:

$$OM = 2r \cdot sin(N \cdot \psi/2)\ . \qquad (5)$$

Let's divide equation (5) by equation (4), then we will receive a formula for the length of summary vector $\vec{OM}$, which is equal to the amplitude of oscillations:

$$OM = OK \frac{sin(\frac{N\psi}{2})}{sin(\frac{\psi}{2})}. \qquad (6)$$

The intensity is proportional to the square of the amplitude

$$I = (OM)^2 = (OK)^2 \frac{\sin^2(\frac{N\psi}{2})}{\sin^2(\frac{\psi}{2})} . \qquad (7)$$

Let's denote: $(OM)^2 = I$, $(OK)^2 = I^*$.
Then

$$I = I^* \frac{\sin^2(\frac{N\psi}{2})}{\sin^2(\frac{\psi}{2})} , \qquad (8)$$

According to (8), when $N = 1$, then $I = I^*$ and is the intensity of oscillations in the point K coming from one oscillating source (Fig. 8.8). The phase difference ψ is due to the path difference Δ between nearby rays (2):

$$\psi = \kappa\,\Delta = \frac{2\pi}{\lambda}\Delta. \qquad (9)$$

According to fig. 6.8 $\Delta = d\sin\varphi$, where d is the distance between nearby oscillators . Then (9) can be written as:

$$\psi = \frac{2\pi}{\lambda} d\sin\varphi \cdot \qquad (10)$$

Then formula for the intensity (8) will look like:

$$I = I^* \frac{\sin^2(\frac{N\cdot\psi}{2})}{\sin^2(\frac{\psi}{2})} =$$

$$= I^* \frac{sin^2(\frac{N}{2}\frac{2\pi}{\lambda} d\, sin\varphi)}{sin^2(\frac{1}{2}\frac{2\pi}{\lambda} d\, sin\varphi)} =$$

$$= I^* \frac{sin^2(N\frac{\pi}{\lambda} d\, sin\varphi)}{sin^2(\frac{\pi}{\lambda} d\, sin\varphi)}. \qquad (11)$$

Apparently, the intensity of diffracted rays depends on the number of oscillators N and the direction φ in which diffraction pattern is observed.

Note that formula (11) is obtained for the intensity of light, emitted by the periodic structure of point sources, and it completely coincides with the formula for the diffraction grating, based on the Huygens-Fresnel principle, when it is believed that radiation of secondary waves is coming from each element of the open part of the wave surface between the edges of obstacles [11. − P. 392; 16. − P. 269]. However, one should pay attention to the incorrectness of reasoning and calculations performed on the basis of Huygens-Fresnel principle, because the abstract element of the wave surface cannot be a source of photons emitted in different directions, because the photon has momentum and it cannot change its direction of motion to get to the point *K* (Fig. 8.4). This means that element of the wave surface can be a source of secondary waves, where *K* is the point of observation of re-radiation.

Thus, diffraction is a type of interference, a unique case of coherent sources of light, which are the sharp edges of obstacles. The phenomenon of diffraction is clearly explained entirely in terms of interference, and its traditional examination, based on Huygens ‘ Principle cannot be considered valid methodologically, because it contradicts the quantum theory of light.

7. DESCRIPTION OF DIFFRACTIONAL EFFECTS BASED ON QUANTUM THEORY OF LIGHT

7.1. The method of graphic adding of amplitudes in the diffraction of light in terms of the quantum theory of light

To explain the diffraction phenomena we will use the method of Fresnel zones, which consists in replacing the light source by surface wave and its breakdown into zones the way, so that the light from each neighboring areas comes to the point of observation in opposite phase (Fig. 7.1). To calculate the amplitude at the point of observation *K* we will use easy and obvious way to represent fluctuations by vectors, the length of which is characterized by the amplitude and orientation − phase fluctuations [12. − P. 158]. The surface of a Fresnel zone (zone M_0M_1 on the picture) is divided into elements *1, 2, 3 ...*, each of which is presented in a point observation *K* by the elementary vector *1¢, 2¢, 3¢* .

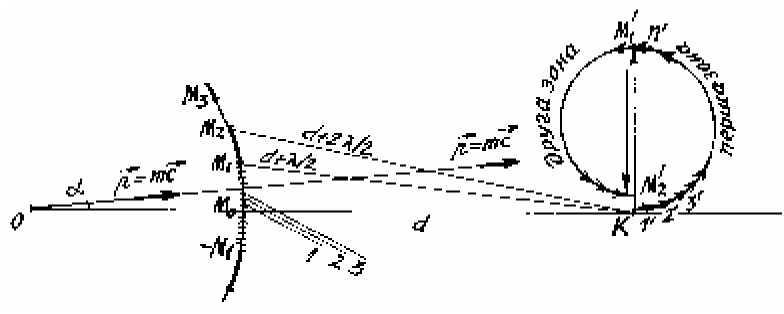

Fig. 7.1.

The last element of zone M_0M_1 is characterized by vector n', which is in conformity with the division into zones, oriented opposite to the first vector *1′*. Therefore, the whole zone is characterized by vector $\vec{KM_1'}$

However, as shown in 6.3 (p. 72, Fig. 6.3), based on quantum ideas for light wave surface is an abstract and really cannot replace a point source, because photons, which are distributed at a certain angle to the direction of *OK*, keep their momentum $\vec{p}$ and cannot get to the point of observation *K* (Fig. 6.4) from different points of the surface wave. Therefore, addition of vectors *1′, 2′, 3′*... etc. is devoid of any meaning. The physical content belongs only to the first vector (*1′*), because it points to the point *K*, and the last vector *n′*, which characterizes reradiating from the **edge M_1 of the band ring** M_1M_2 that covers the second zone (in Fig. 7.1 in bold) and at the edge of which in point M_1 diffraction is observed. Only these two vectors characterize the first zone M_0M_1 and create a diffraction pattern at point *K*. It should be borne in mind that the beam *O*-M_0-*K* is a direct beam from the source *O*, while the beam *O* -M_1-*K* the diffracted beam, i.e. reradiated from the edge M_1 of the ring zone (Fig. 7.1). Therefore, the amplitude of oscillations coming from the point must be represented by a vector *1′′* which is much longer, than the amplitude of oscillations of light diffracted from a point M_1 (vector *n′′*). Fig. 7.2 qualitatively represents these two vectors.

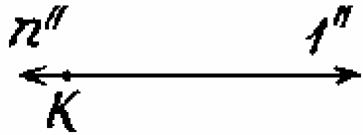

Fig. 7. 2.

Vectors 1¢¢ and n¢¢ have opposite direction, and therefore are subtracted, so the amplitude in the point *K* will be somewhat smaller than in the case of direct light (Let's note that the vector 1¢¢ characterizes the amplitude of the direct light from the source).

If the zone plate is used also to cover other paired zones, for example M_2M_3 etc., it makes sense to consider diffraction from their edges, which will slightly increase or decrease the amplitude of oscillation at the point *K*, and which will be determined mainly by vector *1″* (Fig. 7.2). The vector *1″* characterizes direct light from the source *O*.

Thus, the graphical method of adding amplitudes based on the method of Fresnel zones and used for the description of light diffraction, is inconsistent with the consideration of diffraction in terms of the quantum theory of light, since the creation of diffraction pattern involved does not represent any point of the wave surface, and only edges of obstacles are the only potential sources of light reradiating. This method makes it impossible to calculate the diffraction pattern the way, so that the wave and quantum approaches to the description of the phenomenon of diffraction could give the same result.

Failure of the method of the graphic addition of amplitudes reflects the inconsistency of the idea of zoned plates.

7.2. Zone plates in terms of quantum theory of light

Traditionally, the explanation of wave diffraction is based on the principle of Huygens regarding the wave propagation, whereby every point of the wave surface is the center of new waves. However, such a consideration arise fundamental inconsistencies and conflicting conclusions. It can be seen when considering the phenomenon of diffraction zone plates.

The idea of zoned plates is based on the principle of Huygens-Fresnel, by which point light source *O* is replaced by the wave surface S [14. − 205], each element of which reradiates light that travels in all directions, and it comes to some point in space *K* with the corresponding phases of oscillation, which determines the intensity of light at the point *K* (Fig. 6.4).

If we break the wave surface on zones by the Fresnel method and make a plate from the system of segmented rings that correspond to even or odd zones, we can cover the areas from which radiate light is in the opposite phase, which should give a much greater intensity than at the open front of the wave. In Fig. 7.3 bold lines mark ring zone plates, which cover the odd Fresnel zones.

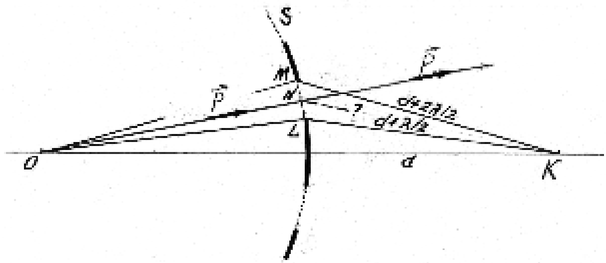

Fig. 7.3

In this case the zone plate (so-called amplitude zone plate) should act as a lens [12. – P.156]. The academic literature argues that zone plates allow several times amplify the intensity of light coming from a point source [11. −P. 380, 16. − P. 274].

However, such findings, in our opinion, cannot be considered conclusive, because they, like the method of Fresnel zones itself, are based solely on the wave nature of light and are abstract. Indeed, since the principle of Huygens-Fresnel assumes that each point of the surface wave is the center of new wave, this means that the light from each such a point, for example *N* (Fig. 7.3), comes to the point *K*. However, from the quantum point of view it is impossible, because the photon is a quantum of light, for which there is a law of conservation of momentum $\vec{p}$. Since the photon from the light source *O* in the direction of *N* extends rectilinearly, it keeps the same direction, while passing the point *N*, because its momentum doesn't change, therefore it cannot get to the point *K*. Thus, neither even nor odd Fresnel zones cannot be those elements of the wave surface, which emit light toward the point *K*. However, at the edges of the zone plate (points *L*, *M* in Fig. 7.3) photon momentum direction can be changed. Exactly these points could reradiate light and then it can already get to the point *K*.

Note that according to the following considerations, the light is not emitted by open areas, but is getting reradiated by the edges of zone rings. However, because these are diffracted rays, their intensity is small, compared to the intensity of the direct rays, coming from the light source *O*. Therefore, these considerations cannot be considered regarding any increase in light intensity by zone plates compared with the intensity of the open wave front, i.e., compared with direct illumination of the point *K*. More, we cannot talk about the increase of intensity of light because the light rays, coming from adjacent edges of each two neighboring segmented zone rings (points *L* andi *M*) reach the point *K* in opposite phases.

All this also applies to the phase zone plate, which is designed not only to eliminate the influence of zones, reradiating light in opposite phases, but also change the phase of light waves to the opposite phase and thus achieve even greater amplification of light.

An optical device that is called "zone plate" can be realized as a diffraction grating. Unlike the "hypothetical" zone plate, in which radiation comes from the open parts of the wave surface, in fact, reradiating takes place only on the edges of each zone plate. Therefore, calculation of areas should be done the way, considering the light from the edges of the plate coming to the point of observation *K* in the same phase.

In Fig. 7.4 bold lines depict the rings of Fresnel zones, from the edges of which the light comes to the point *K* in the phase.

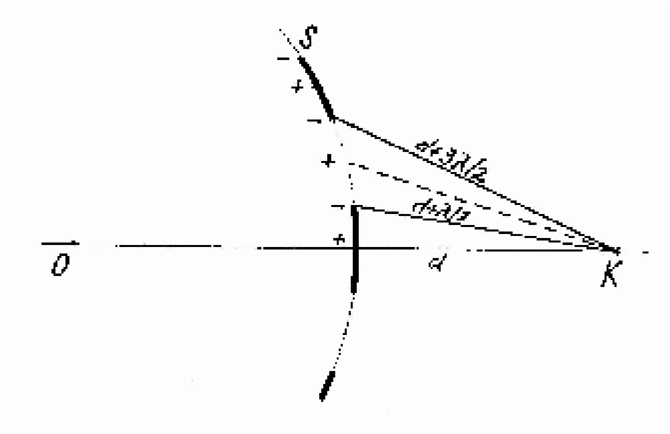

Fig. 7.4

Thus, the property of zoned plates to amplify light in terms of the quantum nature of light, in our opinion, is not justified. Modern technologies make it possible to manufacture sophisticated zone plates, but we do not know at least laboratory samples of optical devices that would give intensity enhancement in a few times. Existing examples of the zone plates, in our opinion, is nothing like options of more or less successful diffraction gratings.

7.3. Experimental confirmation of interpretation of quantum phenomenon of diffraction

In order to confirm the truth of expressed reasoning, it is enough to develop the experiment, where the central (odd) zoned area M_0M_1 is covered by a zone ring, and a direct beam doesn't fall at point *K*, but even zones (e.g. the second zone M_1M_2 in Fig. 7.5) are open.

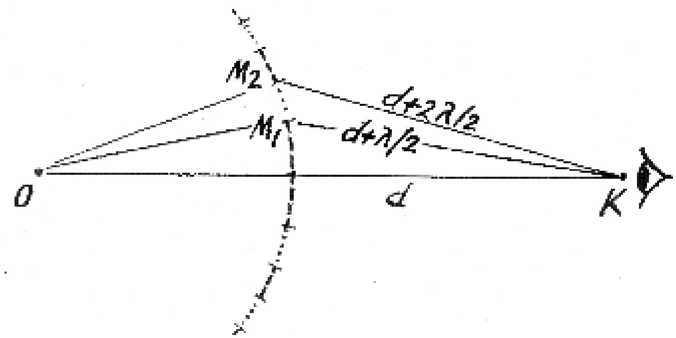

Fig. 7.5

Then according to the principle of Huygens all points of the open zone M_1M_2 must be the sources of "the new waves", and in the point *K* luminosity of this zone must be observed. On the spiral in Fig. 7.1 the influence of the zone M_1M_2 at the point *K* is characterized by a vector M_1M_2, which in size compared with the vector $\vec{KM_1'}$. This means that while observing the picture from the point *K* (Fig. 7.5) we would see a bright glow of the open second zone, intensity of which is compared with the direct beam.

However, based on quantum ideas, glow in the open second zone (and others) is impossible because photons, radiated from the surface of the open zone, according to the law of conservation of momentum $\vec{p} = m\vec{c}$, cannot reach the point *K* (Fig. 7.3). We can only observe the rays diffracted from the edges M_1 and M_2 of zone rings. But at first, these rays are diffracted (i.e. reradiated at the edges), therefore their intensity is low. And secondly, they are in accordance with the breakdown of the wave surface by zones at the point *K*, so they produce oscillations in opposite phases and should be mutually cancelled.

However, according to the wave theory of diffraction, the open zone should radiate light, while in terms of quantum theory, when light is represented as a stream of photons, the particles which are in the oscillatory state, luminosity of the open area should not occur. Therefore, we can conclude that building a spiral of vectors that represent elements of the Fresnel zones, is meaningless.

For solutions to the highlighted contradictions we had to develop the experiment to detect the luminance of the separately selected Fresnel zone.

7. 4. Does Fresnel zone radiate light ?

The laser beam *L* is directed on the narrow slit W_1, which is used as a point source of light (Fig. 7.6).

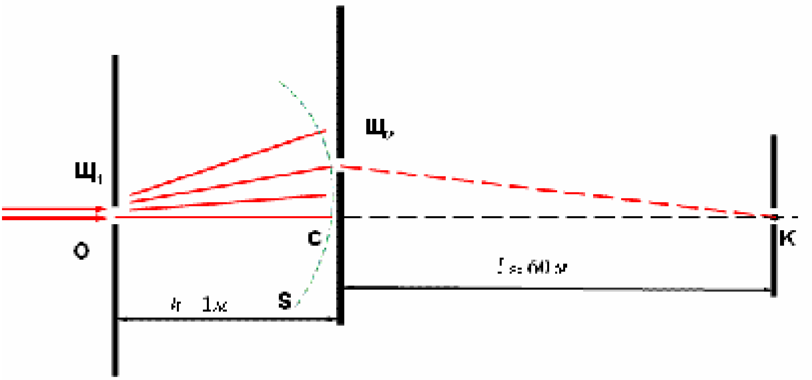

Fig. 7.6

Wave surface *S* was conditionally broken into Fresnel zones. In accordance with the set parameters, the width of Fresnel zone was ≈1 mm. Moving a narrow slit W_2 (which was narrower than the width of the Fresnel zone) with a barrier *B*, which covered the direct beam *OK* at different points of the wave surface, didn't reveal the glow of these points as sources of new waves. Only the placement of the slit W_2 in the point C gave the opportunity to observe the direct beam from the slit W_1.

Thus, **the experimental results are consistent not with the wave, but with the quantum approach when conside-ring the diffraction of light.**

7.5. Diffraction on rectilinear edge of the plane in terms of the quantum approach

The very similar situation is observed while explaining the diffraction on rectilinear edge of the plane *B* (Fig. 7.7).

In some point on a screen *K*¢ there are coming direct rays from point *O*, as well as diffracted, i.e. reradiated light on the plane edge in the point *L*. Depending on the path difference between the direct ray *OK*¢ and diffracted *LK*¢ there will be interference result observed in a point *K*¢ .

It is possible to observe only diffracted light in the point *L*, on the left from the point *K*. (Photon path O-M_2-K, for example, is impossible, based on momentum conservation law), which gives only low intensity I_1 . Moving the point *K*¢ вправо to the right will create a periodic change of intensity around I_0 , which is observed in the open wave front.

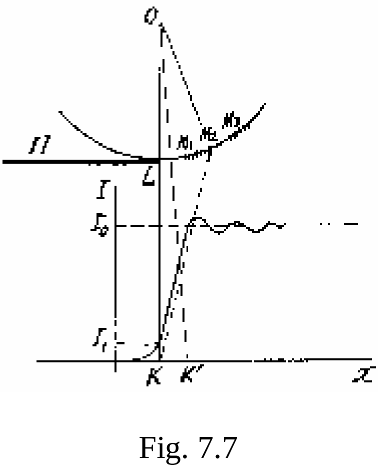

Fig. 7.7

Thus, the vector representing the amplitude of oscillations (Cornu spiral), formed by elements of even and odd zones, as in the case of Fresnel zones in spherical wave surface, is an abstraction and has no physical meaning.

7.6. Problems with tasks on diffraction

When considering the phenomenon of diffraction, dual nature of light is manifested. Traditionally, diffraction is explained on the basis of Huygens-Fresnel principle, which is an expression of wave approach. Therefore, there is a need to coordinate all the conclusions of corpuscular approach, because a physical phenomenon does not depend on our way of its description. However, comparison of the wave and corpuscular ideas leads to fundamental contradictions that require analysis and explanation. Such problems arise when studying the phenomenon of diffraction in high school, particularly in solving problems.

Let's consider a typical problem from the most famous collections of problems for higher education.

16.28. Light from monochromatic source (λ = 600 *nm*) falls normally on the diaphragm with a round opening. The diameter of the opening is 6 mm. There is a screen behind the diaphragm on a distance *3 m*. How many Fresnel zones fit into the aperture of the diaphragm ?

1) What will be the center of diffraction pattern on the screen: dark or light ? [18].

24-1. There is a diaphragm with the round opening between the point source of light (λ = *0,50* microns) and screen. Its radius is r_0 = *1,0 mm*. The distances from diaphragm to the source and to the screen accordingly are *R* = *1,00* and r_0 = 2,00 *m*.

How the luminosity in the center of the screen is going to change, if the diaphragm removed ? [19].

Example 8. (P. 293) [20]**.** The parallel beam of light falls normally on a round opening with a radius of *1.0 mm* in opaque screen. The light wavelength is 0.5 microns. The screen is placed on the path of rays that have passed through the opening. Determine the maximum distance from the aperture to the screen where the dark spot is still observed in the center of diffraction pattern ?

31-3. A parallel beam of light (λ = *0.5* micron) normally falls on a round opening with diameter $d = 4\ mm$. Observation point is at a distance $R_0 = 1\ m$ from the opening.

How many Fresnel zones fit in the opening ? Dark or light spot will occur if the screen is placed at the point of observation ? [20].

5.100. Monochromatic plane wave with intensity *Io* falls normally on the screen with a round opening. What is the intensity of light *I* behind the screen at the point, for which the opening size is equal to the first Fresnel zone ? What if it's the inner half of the first zone ? [21].

Presented here and in other textbooks, problems, which are constructed on the basis of wave concepts of light, do not take into account the quantum properties of light. Thus, the very content of the problems inherits impropriety, denying them the right solution. Incorrectness is fundamental, because according to the principle of Huygens-Fresnel wave surface at every point is a source of new waves of light. This cannot be realized because the motion of a photon as a particle is subjected to the law of conservation of momentum. Photon, having momentum $\vec{p}$ cannot change direction and get, for example, from the wave surface element *dS* to the point *K* (Fig.7.8).

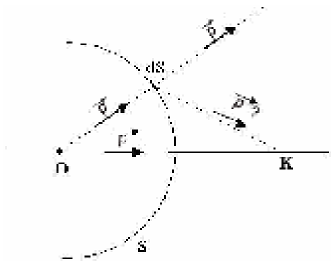

Fig. 7.8

However it is considered that in all our problems each element of the Fresnel zones can radiate light, extended in various directions, and in particular, to the point of observation *K*. It is impossible to agree with that, because it contradicts the law of conservation of momentum. Because of the law of conservation of momentum, photon cannot move in the direction of *K* from some abstract point *N* of the wave surface *S* (Fig.7.9).

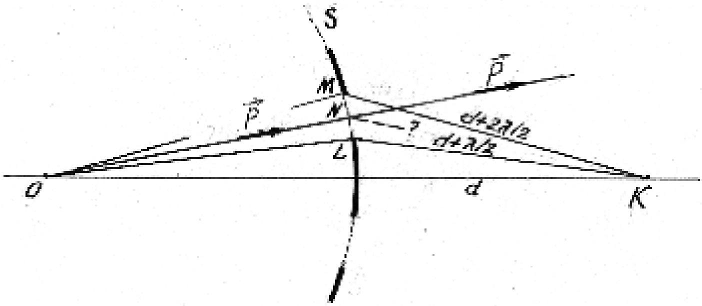

Fig. 7.9

When solving diffraction problems, another significant fact must be considered: it is necessary to distinguish between direct and diffracted rays. Assuming that the odd zones are covered by opaque rings (in Fig. 7.9 they are marked in bold), the **direct light** does not fall to a point *K*. Then the rays **diffracted at the sharp edges** of *M* and *L* rings, may spread to the point *K*, or in different directions and create on screen e the interference pattern.

If the central area is open, the interpretation of diffraction must be somewhat different (Fig. 7.10).

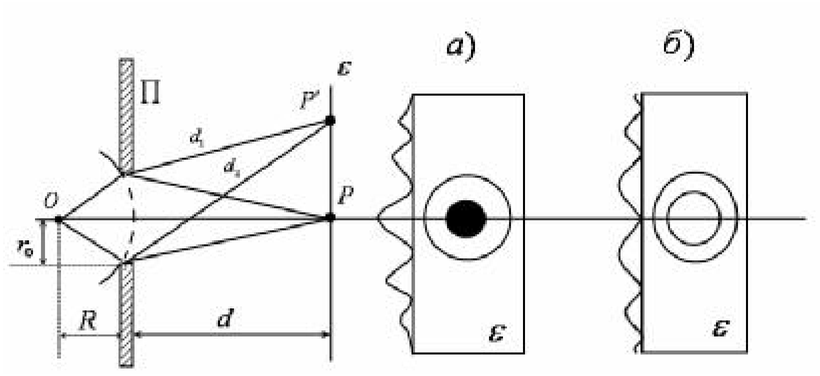

Fig. 7.10

.

In this case there is **a direct light** falling on a screen, a ray *OP*, as well as **the diffracted light** beam from the edge of obstacle. Of course, in this case the diffraction pattern on the screen appears, and at the center, at the point *P*, there will be a maximum of (*a*) or minimum of (*b*) interference picture, which depends on the path difference of direct and diffracted beams. However, **the difference in luminance between the maximum and minimum will be negligible** because the intensity of the diffracted beam is very small compared with the direct beam and noticing the difference under the conditions of direct illumination is hardly possible. Therefore, the question in the problem 16.28 [18] which diffraction pattern will be observed in the center of the screen , dark or light, cannot be considered valid because the center of diffraction pattern will always be bright, though somewhat more or less.

Similar comments apply equally to other tasks.

Let's analyze given in the book [19] solution of the problem 24.1 on diffraction of light on a round opening. The explanation states that the result of diffraction at the edges of the screen there is a diffraction pattern on the screen, light and dark rings. There is a light or dark spot in the center, depending on the number of Fresnel zones, which are embedded on the surface of the wave front within the opening. This conclusion cannot be considered valid, because, firstly, the center of the screen is illuminated by direct rays, as well as diffracted rays from the edges of the opening, which only slightly change its luminosity. Secondly, it’s not taken into account that light is a stream of particles (photons). In this case, the calculations show that 3 Fresnel zones are embedded in the opening. Photons from the second and third zones cannot get to the center of the screen because of the law of conservation of momentum (see Fig. 7.11). This means that the center of the screen will be illuminated only by the photons of the central zone and from the edges of the opening.

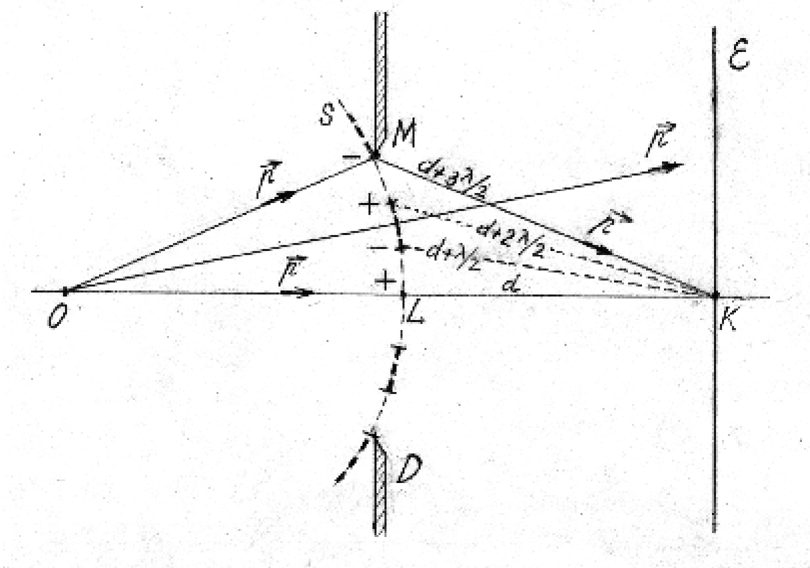

Fig. 7.11

However, the oscillations of these photons, according to the construction of zones, occur in opposite phase. So this should give weakening of the illumination of the screen. In solution, though, it is concluded that according to the principle of Huygens two areas compensate each other, so the third zone in the center will produce the light spot. Apparently, wave and quantum approaches give quite opposite results.

Let's analyze given in the book [20] solution of the problem 8 regarding of diffraction of parallel rays. It is asked, whether in the center of the screen there will be observed a dark spot. First, the center of the screen will always be illuminated by direct rays and dark spots will not occur, but only a little more or less light due to imposition of strong direct beam and low diffracted beams coming from the edge of the opening (Fig. 7.10). Secondly, according to the wave approach dark stain should occur when the opening contains two Fresnel zones. However, according to the quantum approach only photons of the first (central) zone and photons diffracted from the edge of the opening can get to the center. By given condition the end of the opening coincides with the edge of the second Fresnel zone, which means that the central and the diffracted rays from the edge of the opening are in phase and should give light amplification on the screen. Thus, the results of the problems solutions are quite opposite in wave and quantum approaches.

In previously described problems considering the wave approach, it implies that when the screen is moved away from the diaphragm opening, the number of Fresnel zones increases and according to its movement, alternate light and dark illumination of zones will take turns. According to the quantum approach, the center of the screen should be illuminated by direct rays, and the change of diffraction pattern on the background of this illumination cannot be noticeable. The research was conducted for the purpose of experimental verification of these contradictory findings.

7.7. **Experimental verification of Fresnel zones**

The light was directed from the point source *O* to the opening of the narrow slit (width *1 mm*) made in a barrier *D*, which was located on the distance *1 m* from the source (Fig. 7.12).

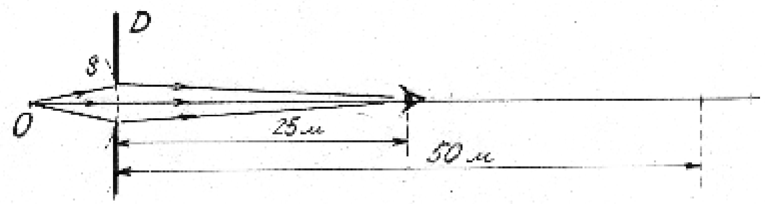

Fig. 7.12

The diffraction beams were observed behind the slit , which according to the wave representations, should have produced diffraction minima and maxima at the different distances from the slit. Thus, estimated at *25 m* distance, when 2 Fresnel zones are visible at the observation point, the dark spot should have been observed, and at the distance of *50 m* − light. However, while getting further from the slit, the intensity decreases very slowly and periodic changes in intensity were not observed. These experimental findings confirm the incorrectness of the principle of Huygens-Fresnel, while explaining diffraction, as well as the necessity of considering the corpuscular nature of light.

Read it. Though it seems
that it is written by crazy.
It’s written seriously.

Albert Einstein

De Broglie wave
is a particle that moves
and still is in oscillating motion,
type
energy–mass–energy–mass ...

"The motion of the electron and of any other particle
with the spin 1/2 and a nonzero rest mass
is very complex.
This movement cannot be described by
conventional notions of classical mechanics.
If, however, the scientific rigidity is abandoned,
and we try to give a very
approximate visual model,
we can say that being in motion,
the particle performs complex random "vibration"
along with ordinary displacement.
O.S. Davydov. Atoms. The nucleus. Particles.
– Kiev: "Naukova Dumka". In 1973. – S. 18.

8. De Broglie waves from the perspective of oscillatory motion

In photons, elementary particles of light, dual nature of matter is inherited. Indeed, a quantum of light has energy

$$W = h\nu . \qquad (1\ )$$

On other hand,

$$W = mc^2. \qquad (2\ )$$

Equalizing (1) and (2), we will receive:

$$h\nu = mc^2. \qquad (\ 3\ )$$

Since frequency is $\nu = \frac{c}{\lambda}$, then (3) will be written:

$$h \cdot \frac{c}{\lambda} = mc^2,$$

and

$$\lambda = \frac{h}{mc} . \qquad (4\ )$$

As we see formula (4) contains the length of wave λ as characteristic of wave properties, so as mass *m*, which expresses corpuscular properties of light.

Once similar to light theory, de Broglie advanced the hypothesis of wave properties not only of light but also any particle moving with speed u. The length of de Broglie wave is

$$\lambda_Д = \frac{h}{m\upsilon} . \qquad (5)$$

The hypothesis of de Broglie wave seems incredible, but as it is known, very soon it found full confirmation. It was an opportunity to explain the discrete electron orbits of the atom: an electron in an atom behaves like a wave and orbit must fit a number of de Broglie waves, equal an integer. Based on the ideas of de Broglie waves, electron microscopes are constructed. However, in terms of classical concepts duality of nature of micro particles generates contradiction that traditional physics could not explain. There were questions: Why moving particle can be regarded as a wave process? Since the wave process is described by harmonic functions and defined by phase (ωt), it is unclear how the phase can characterize particles, uniformly moving with some speed u? How in particle, moving uniformly at a rate u, the oscillating process is manifested?

Doubtless, these questions make it possible to formulate the theory of oscillating motion of matter (see 2.5. − P. 38).

If the particle is accelerated, it has the power to perform the work, which, in accordance with (1.4. − P. 19), is used for the increase in kinetic energy and the growth of dynamic mass. **With the growth of dynamic mass** the oscillating mechanism of the process type:

$$\Delta W \rightarrow \Delta \boldsymbol{m} \rightarrow \Delta W \rightarrow \Delta \boldsymbol{m} \rightarrow \ldots$$

is developed.

Such particle with the pulsating mass is a de Broglie wave. Thus, accelerated micro particle transfers to the oscillating condition where there is a pulsation of mass, so that is not just a moving particle, but specific particle, which by moving forward, is oscillating as well. Such particle with the pulsating mass is a de Broglie wave.

The occurrence of de Broglie waves can be demonstrated by the movement of an electron in an atom of hydrogen.

8.1. Electron in an atom of hydrogen as a de Broglie wave

Let's consider the motion of the electron in the simplest atom, hydrogen atom. In the unexcited state the electron is located on the first circular orbit with a radius $r_1 = 0{,}526 \cdot 10^{-10}$ *m,* and according to the Bohr's theory it has full energy W_1 = – 13,53 *eB* (Fig. 8.1). For the separation of an electron from the atom, i.e. for ionization of the atom, the energy is required:

$$\Delta W = W_\infty - W_1 = 13{,}53 \ \ eB \ .$$

$n = \infty$ ____________________________ $W_\infty = 0$

_ _

_ _

_ _

$n = 3$ ____________________________ $W_3 = -1{,}5 \ eB$

$n = 2$ ____________________________ $W_2 = -3{,}38 \ eB$

$n = 1$ ____________________________ $W_1 = -13{,}53 \ eB$

Fig. 8.1

Let's consider the reverse process, the formation of a hydrogen atom.

Let the electron be at a great distance, so that it can be considered free (Fig. 8.2).

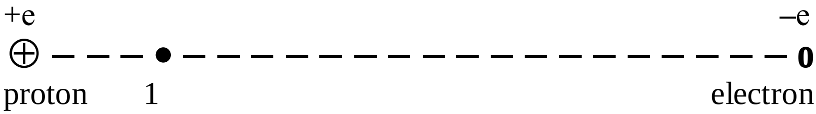

Fig. 8.2

Due to the Coulomb interaction an electron is moving with acceleration in the direction of proton, located at the point 1 at a distance r_1, of the first orbit of electron in atom. The potential, created by proton in point 1 is:

$$\varphi_1 = \frac{q}{4\pi\varepsilon_0 r_1} = \frac{1{,}60\cdot 10^{-19}}{4\cdot 3{,}14\cdot 8{,}85\cdot 10^{-12}\cdot 0{,}53\cdot 10^{-10}} = 27{,}36\ B$$

.

Going under the influence of electric field, the electron kinetic energy becomes equal to the work of the field:

$$W_k = e\cdot\Delta\varphi = e\varphi_1 =$$
$$= 1{,}60\cdot 10^{-19}\cdot 27{,}36\ Дж = 27{,}36\ eB.$$

Electron in an atom of hydrogen must be in orbit at point 1, i.e. it must reach the distance r_1 (the distance to the first orbit of electron in atom) and have kinetic energy $W_k = 27{,}36\ eB\cdot$

According to Bohr's theory, the electron on the first orbit has a speed:

$$\upsilon_1 = \frac{e^2}{4\pi\varepsilon_0 \mathbf{h}} = 2{,}193\cdot 10^6\ м/c$$

and related kinetic energy:

$$W_{K1}\frac{m\upsilon_1 r}{r} = 13{,}69\ eB\cdot$$

By traditional notions, the calculated value of kinetic energy is two times more than it is in an atom of hydrogen. This discrepancy is explained by the fact that the electron, accelerating in a field of the proton reaches the distance of the radius of the orbit and emits a photon. In the energy diagram this corresponds to electron transition from level W_∞ on level W_1:

$$h\nu = \Delta W = W_\infty - W_1 = 13.53\ eB\cdot$$

Thus, the energy balance is likely kept, but in the above estimates the essential fact is not taken into account. The fact is that according to the theory of relativity when electron energy increases because of acceleration, its weight increases also:

$$m_1 = \frac{m_0}{\sqrt{1-\frac{\upsilon^2}{c^2}}} = \frac{9{,}11\cdot 10^{-3}}{\sqrt{1-\frac{\left(2{,}193\cdot 10^6\right)}{\left(3\cdot 10^8\right)^2}}} = 9{,}109776\cdot 10^{-31}\text{кг}.$$

The increase in mass (dynamical mass) is the

$$\Delta m = m_1 - m_0 =$$

$$= \left(9{,}109776 - 9{,}109534\right)\cdot 10^{-31} =$$

$$= 0{,}00024\cdot 10^{-31}\ \text{кг}.$$

It may be hypothesized that this growth of dynamic weight is caused by the wave process in motion of an electron in an orbit, where a change in mass causes corresponding changes in energy and vice versa:

$$\Delta m \to \Delta W \to \Delta m \to \Delta W \to \ldots$$

Interestingly, the equivalent change in energy when changing the dynamic mass in the process of electron acceleration is:

$$\Delta W = c^2 \Delta m =$$

$$= \left(3 \cdot 10^8\right)^2 \cdot 0{,}00024 \cdot 10^{-31} \text{Дж} = 13{,}5 \text{ eB}.$$

Under such conditions the electron, moving along its orbit, is in the oscillating state, and such an orbit is realized, on which an integer number of oscillations occurs for moving electron. With this interpretation, de Broglie waves obtain quite real physical meaning instead of virtual interpretation.

Thus, we conclude that **the motion of an electron orbiting an atom is realized in the form of motion type**:

energy–**mass**–energy–**mass** ...

which can be interpreted as de Broglie wave.

The motion of an electron orbiting an atom is realized in the form of motion type *energy*–**mass**–*energy*–**mass** ...

9. QUANTUM-MECHANICAL PHENOMENA IN TERMS OF OSCILLATORY MOTION OF MATTER

We considered the de Broglie wave like onward motion of micro particles as a wave process. The formula for the de Broglie wavelength besides the wave length λ_D, as the wave parameter, includes also corpuscular parameter, mass of the particle:

$$\lambda_D = \frac{h}{m\upsilon}. \tag{9.1}$$

However, the question of dual nature of micro particles that it is a particle and wave at the same time is difficult to understand, because such an interpretation contains a contradiction: particle is localized, but wave is spatial phenomenon, and it is impossible to comprehend. In addition, the wave process is characterized by phase, and what is a phase in waves of de Broglie is unclear. However, it should be noted that the de Broglie hypothesis became convincing reality. Based on this hypothesis, there is advanced science such as quantum mechanics developed, which describes with great accuracy the movement of electrons in atoms.

Contradiction of dual nature of micro particles is eliminated, if the motion of micro particles is seen in terms of quantum-oscillating nature of matter (2.5. – P. 38). The prototype of de Broglie wave is a photon as a particle, which is in a continuous process of oscillation energy transfer of equivalent electric and magnetic fields in the mass and vice versa, mass into energy of photon. Moreover, the entire mass of the photon is dynamic (relativistic) mass because a photon has no rest mass.

Fig. 9.1 shows the changes of the electric *E* and magnetic *H* fields of electromagnetic waves, (figure a) and corresponding changes (qualitative representation) of mass *m* (chart b).

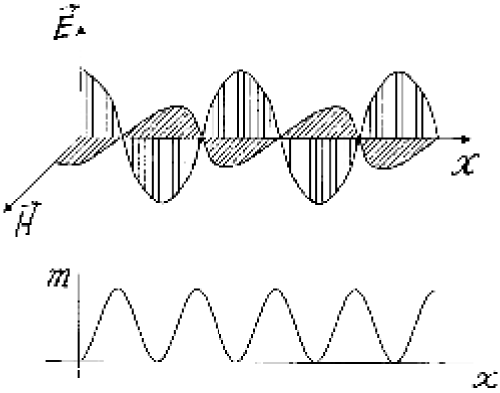

Fig. 9.1

The electric and magnetic fields have energy, because with decreasing *E* and *H* the energy of these fields decreases too, and to fulfill the law of conservation of energy reduction in energy must be accompanied by an equivalent increase in mass. Similar changes occur with increasing *E* and *H*.

By analogy to the light "de Broglie wave" can also be viewed as motion of a particle that is in the oscillating state, and this process is a periodic transfer of the mass into the energy of the particle, and vice versa. However, it is important to note that when in the case of the photon, its entire mass changes, the transformation takes place here only with a dynamic component of mass (Fig. 9.2), i.e. in equivalent mass $D\ m = m - m_o$, which appears when velocity increases:

$$m = \frac{m_o}{\sqrt{1 - \frac{\Delta \upsilon^2}{c^2}}}.$$

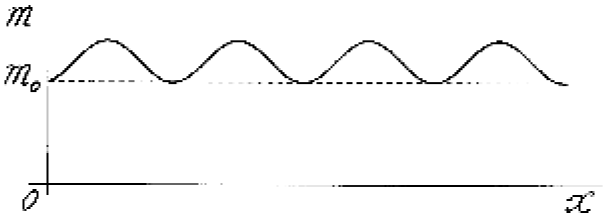

Fig. 9.2

9.1. Schrödinger equation in terms of oscillating motion

Oscillatory process begins when micro particles accelerate during their speed increase, so as their mass increases. Further, changes in the mass have oscillating nature; and this process of oscillatory motion of a particle is described by the wave equation. This is the Schrödinger equation. The solution of the Schrödinger equation makes it possible to find some wave function ψ, square of module of which determines the probability of finding the particle in any place or condition. Logically, the probability to find the particle must be greater where the particle mass in the oscillation process is greater.

In terms of "wave properties" of micro particles Heisenberg uncertainty relation can be interpreted, which is an important principle of quantum mechanics.

9.2. Heisenberg uncertainty relation as a result of oscillating motion

Uncertainty relation implies the impossibility of simultaneous precise knowledge of the coordinates of the particle and its momentum, that means the existence of uncertainty Δx and Δp_x :

$$\Delta p_x \Delta x \ ^{3} \ \hbar.$$

This uncertainty appears from the state of the micro particle itself.

Since the micro particle is in the oscillating condition, in which its mass continuously changing, momentum of the particle also is changing accordingly. The momentum of a particle is described by a rest mass m_o, and a dynamic component *D m*. Assuming that the change in momentum occurs as the harmonic function, the qualitative dependence ***p (t)*** has the form presented in Fig. 9.3.

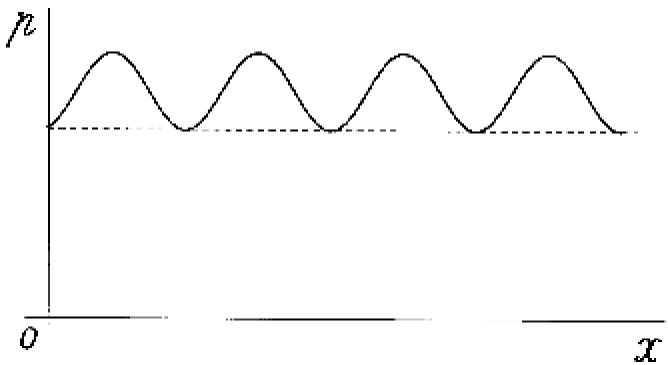

Fig. 9.3

In this case we consider the uncertainty of the momentum component p_x . However, the momentum of the particle is oriented at random and we do not know its orientation, therefore we will assume that uncertainty bΔp_x is equal momentum value p :

$$\Delta p_x = p. \tag{2}$$

Uncertainty of the **position** of a particle also has completely distinct physical character. Indeed, since during the particle motion oscillation of mass occurs (i.e. mass is determined by the presence of the particle, i.e. its substance presence), this variable mass is spread along the length of the "wave." In other words, the uncertainty coordinates, where the mass is located, equal to the de Broglie wavelength (Fig. 9.4).

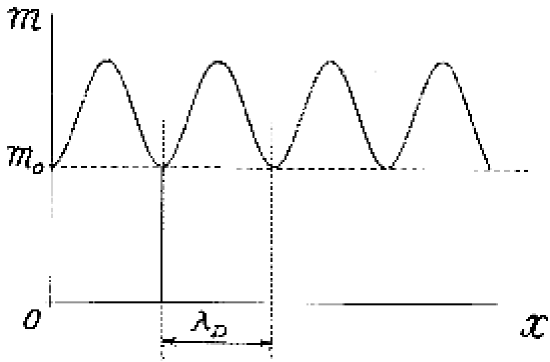

Fig. 9.4

Therefore, we can assume:

$$\Delta x = \lambda_D. \tag{3}$$

When we multiply left and right parts (2) and (3):

$$\Delta p \cdot \Delta x = p \cdot \lambda_D. \qquad (4)$$

Since De Broglie wavelength is:

$$\lambda_D = \frac{h}{p},$$

then (4) will look like:

$$\Delta p \cdot \Delta x = h. \qquad (5)$$

Thus, based on conventional physical representations in the quantum-oscillating theory of matter let’s conclude that the simultaneous precise knowledge of position and momentum of micro particles is limited by value (5).

Values of uncertainties have become a topic of philosophical debate and have different interpretations. One of these interpretations is that particles are present in each of specific coordinates and momenta, but we have no way to know them. Uncertainty relations sort of "prohibit" that we get to know them, i.e. setting the limit of knowledge.

According to another interpretation, the content ratio of uncertainties is not that they limit the opportunity to get to know accurately the coordinates and momenta (or other size), but that these micro particles simply do not have simultaneous exact values of higher mentioned characteristics.

Heisenberg himself in 1927 concluded that quantum mechanics represents the law of causality as insolvent, which requires prediction of the condition for any future state of the particle, based on accurate knowledge of the system at any given time. This is quite possible in classical mechanics, but impossible in quantum mechanics, because it is impossible to know initial values of p_x and x.

Consideration of this issue in terms of oscillating quantum theory of matter makes it possible to get closer to understanding the physical processes, which occur with the particle in the micro world and where the other forms of motion of matter are apparent, which implicitly are described by the quantum mechanics.

Thus, quantum mechanics describes the motion of micro particles, considering it as a wave process, and therefore there are contradictions and difficulties in understanding the physical content of this important principle, which the Heisenberg uncertainty relation is. In terms of the quantum-oscillating nature of matter, Heisenberg uncertainty relation makes concrete physical sense: precise determination of the coordinates of micro particles in terms of quantum mechanics is impossible because it is associated with dynamic (relativistic) component of the mass of the particle, which is in the oscillatory state, and this mass is scattered in time and space. That is, under these conditions the exact coordinates of the particles simply cannot be determined.

"What is gravity ?
Newton didn’t try to guess.
However, there is no mechanism
since that time was discovered”

R. Feynman

10. Rationale for the gravitation mechanism

Oscillatory state of matter also provides an opportunity to explain the gravitational interaction between bodies.

Between physical bodies two kinds of interactions exist: attraction and repulsion. Mutual attraction of the bodies is called gravity. Formally, gravity is described by Newton's law of universal gravitation, which formulates the notion of body weight, if its mass is extremely small compare to another body mass, in the gravitational field of which it is located. However, we do not know anything about the mechanism of gravitational interaction of bodies, although there were many theoretical attempts to describe the nature of gravity, including the general theory of relativity. Moreover, these explanations are based on abstract notions of" space distortions", gravitational field, gravitational waves, gravitons, etc. When creating a general theory of relativity, A. Einstein expressed the idea of pulsation of mass as a form of existence of matter: "*matter fluctuates, generating gravitational waves that spread with the speed of light"* [22]. There is every reason to believe that this form of motion is justified. However, numerous expensive experiments to detect carriers of experimental gravitational interaction have failed so far [23]. So, let’s make an attempt to identify the mechanism of interaction, which causes gravity, based on general physical concepts. Gravity refers to the type of weak interaction, but we actually feel it very much. Gravity affects every substance in any form and occurs where there is mass. Even photons, flying near large masses, are subject to the influence of gravity, which distort the trajectory of movement.

In physics we know two types of interaction between bodies: **through the medium of substance and as a result of exchange of particles by bodies.** Other ways of interaction are not established. Therefore, let’s consider more mechanisms and outcomes for such interactions.

In physics we know
two types
of interaction
between bodies:
through the environment
and as a result
of the exchange
of particles of the bodies

10.1. The interaction of bodies through the environment

Let there be two boats on the water. If one of them starts shaking, then this movement is transmitted through water (environment) to the second boat and it will shake also. What about the Earth and the Sun? Of course, we can assume the existence of "ether" or "vacuum", which promotes attraction of bodies in space. However, we do not have confirmation of any medium (ether) to explain gravity, so we will not practice building hypotheses on assumptions that have no experimental evidence, or invent ways of interaction through the hypothetical environment. Therefore, let’s consider another option of interaction, through the exchange of particles-gravitons.

10.2. The interaction of bodies through the exchange of particles

Exchange bodies conventional particles that have mass and momentum, can only lead to their repulsion. For example, let there be a boat with the cannonball in it, staying on the water (Fig.10.1).

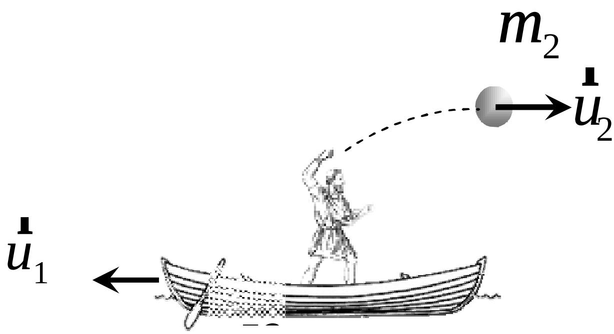

Fig. 10.1

The mass of the boat is m_1 , it's velocity is $\upsilon = 0$, the mass of the cannonball is m_2 . The quantity of motion (momentum) of the boat with the cannonball is:

$$K = (m_1 + m_2)\cdot\upsilon = (m_1 + m_2)\cdot 0 = 0.$$

If the cannonball is thrown away from the boat to the right at a speed υ_2 , то then the boat will start moving opposite way, i.e. to the left. The boat's velocity can be found from the momentum conservation law: $m_1\upsilon_x + m_2\upsilon_2 = K = 0,$ where $\upsilon_x = -(m_2/m_1)\upsilon_2$. So, the vector of the boat's velocity has opposite direction compare to the cannonball.

If two similar cannonballs are thrown simultaneously in opposite directions, the boat will be still in place. (Fig. 10.2).

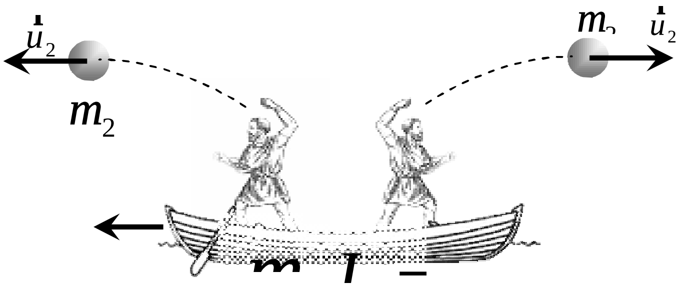

Fig. 10.2

Let's consider the case, when the cannonball falls into the boat from the outside. (Fig.10.3)

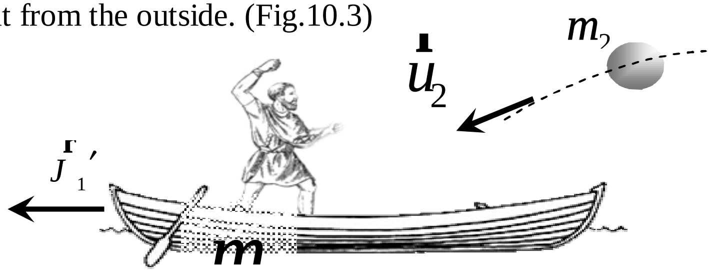

Fig. 10.3

The speed of the boat before the interaction is $\upsilon_1 = 0$, the speed of the cannonball is υ_2 . The quantity of motion before the interaction is $K = m_1 \cdot 0 + m_2 \cdot \upsilon_2 = m_2 \cdot \upsilon_2$, after interaction: $K' = (m_1 + m_2) \cdot \upsilon'_x$. Summary momentum before and after the motion doesn't change, i.e. $K = K'$. Then $m_2 \cdot \upsilon_2 = (m_1 + m_2) \cdot \upsilon'_x$ and the speed of the boat after interaction is:

$$\upsilon'_x = \frac{m_2}{m_1 + m_2} \upsilon_2 .$$

So, after interaction the boat will move in the direction of the cannonball, i.e. to the left.

Let's now consider simultaneous exchange by cannonballs, which were launched from two boats toward each other. Getting the cannonball from the other boat, as we have already discussed, will cause movement in the direction of the cannonball, which gets boats away from each other. Hitting another boat by the cannonball also leads to the boat moving in opposite direction (Fig. 10.4).

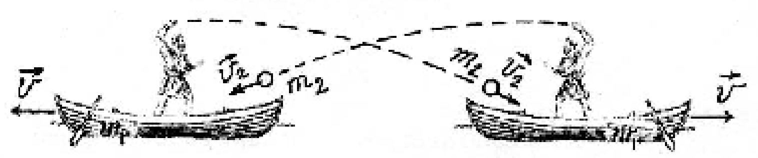

Fig. 10.4

Thus, **the usual exchange of particles** between the two bodies leads only **to the repulsion** of bodies. Therefore, if we consider, for example, the interaction of two cosmic bodies M_1 and M_2, which have mass, then each of them radiating particles in all directions, will remain in place. When taking hits of particles from each other, the bodies will be moving away from each other (Fig. 10.5). However, we are seeing attraction. Why is this happening ?

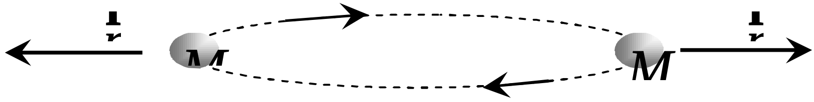

Fig. 10.5

In considering the mechanisms of interaction of bodies we considered the mass of emitted particles, their velocity, momentum, law of conservation of momentum. However, one essential fact was neglected: how emitted by bodies particles get impulses ? Radiation of special particles (gravitons), which causes the effect of attraction, is logical to associate with the transition from one state of matter to another, from a state of matter to the state of field, and vice versa in accordance with the known relation: $\Delta W = c^2 \Delta m$. In this case, the situation has changed drastically. Radiating gravitons, the body loses some mass that goes to the formation of gravitons and giving it momentum. If in the space between bodies (Fig. 10.5) there is not only the emission and absorption of gravitons (which should lead to repulsion and separation of bodies), but also is a restoration of body mass from absorbed gravitons ($\Delta W=c^2 \Delta m$), then as a consequence, there is momentum in the opposite (i.e. towards the second body) direction. On opposite sides of interacting bodies such restoration does not occur. Thus, the effect of repulsion and separation of bodies is compensated, and external radiation of gravitons in the opposite direction causes the convergence of bodies.

10.3. Experimental verification of the existence of gravitons

If gravitons interact with the body on which they fall, and the body mass is restored in accordance with the formula $\Delta W = c^2 \Delta m$, it is possible to establish the existence of gravitons through screening them away by different external mass. To prove this, the experiment for determining the gravitational constant can be used, by applying some changes to the experiment. It needs to be possible to detect absorption of gravitons by mass [22]. After all, if there is interaction, it should be also absorption of particles, which are the carriers of interaction.

In the Cavendish experiment two balls with masses M_1 and M_2 are attracted to each other (Fig. 10.6).

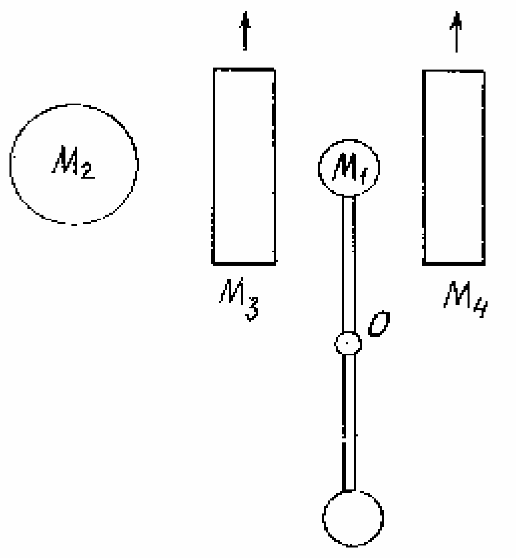

Fig. 10.6

The ball M_1 was fixed on the arms and was hung on elastic thread at the point *O*, so the force of interaction could be determined by the twisting of yarn, as was done in 1798 by Cavendish, and the gravitational constant was determined in accordance with the law of universal gravitation

$$F = G\frac{M_1 M_2}{r^2}.$$

In our case, the experiment has the following distinction: the mass M_1 is shielded from the mass M_2 by another mass M_3. To avoid additional attraction between masses M_1 and M_3 on the opposite side of the M_1 the mass M_4 is installed, which in size and shape is quite the same as the M_3 (in the form of the plate).

In this case, the interaction between the masses M_1 and M_2 will take place through the mass of M_3, which can absorb part of gravitons and thus reduce interaction. So if at first, the ball M_1 set midway between the M_3 and M_4 plates, and then the ball M_2 brought closer, then, if gravitons absorption exist, attraction between the balls M_1 and M_2 will be smaller than in case, when no shielding by mass M_3 is available.

Thus, putting the experiment on the basis of Cavendish experiment, it is possible to get more information about the mechanism of gravitational attraction of bodies through the exchange of gravitons as carriers of gravitational interaction.

Putting experiment
to identify absorption
of gravitons can give
some information about
the mechanism
of gravitation – attraction
of bodies through the
exchange of gravitons as
carriers of gravitational
interaction

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B.A. Sus', B.B. Sus', O.B. Kravchenko

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Comments and suggestions should be sent
to this address: **bogdansus@gmail.com**