

“WAVE-CORPUSCULAR DUALISM”

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ABSTRACT

The principle of "wave-particle" dualism in quantum mechanics is introduced on the basis of the statement: all quantum objects behave as particles in some physical circumstances, and as waves in others. Using laser devices, we carried out simple demonstration experiments in physical circumstances in which the wave nature of the photon flow was expected to be revealed. Based on the analysis of these processes, we have easily shown that there are no empirical grounds for attributing a wave nature to quantum objects participating in these processes, i.e. photons. Analyzing the historical arguments for the introduction of the principle of duality, we conclude: the description of processes involving objects of the microcosm requires the creation of an alternative and more adequate theoretical concept than one based on the principle of dualism.

Keywords: wave-particle; dualism; critical; revision; alternative; concepts; mechanics.

1: INTRODUCTION

According to the physical concepts of quantum mechanics, wave-particle duality is a purely quantum-mechanical phenomenon that has no analogue in the world of macro bodies. For a deep understanding of the essence of this statement, it is necessary to briefly describe what is meant by the terms "corpuscle" and "wave".

The term corpuscle, in classical mechanics, was introduced for the convenience of expounding the mathematical principles of the natural philosophy of "large and heavy" bodies. When the spatial

dimensions of these parts became very small in comparison with the size of the "large" body under consideration, such parts were called corpuscles. On this basis, the corpuscle was also considered separately from "large and heavy" bodies - as a continuously extended object of very small size, although the criterion for the smallness of its size was still comparison with "large" bodies. The convenience of description with the use of corpuscles was achieved by the fact that, in comparison with the dimensions of "large" bodies, it became possible to neglect the sizes of corpuscles. On this basis, an even more abstract, but from the point of view of mathematical principles - the most important model object - the "material point" - was introduced into the discussions. The spatial position of a material point was indicated as any single point within the volume of the corpuscle under consideration, to which non-zero values corresponding to the physical characteristics of the corpuscle were assigned. The introduction of such an object corresponded to the ancient Greek understanding of the term "mechanics", according to which "mechanics" corresponded to the search for technical methods, the use of which made it possible to single out a small number of essential characteristics in the description of "large and heavy" bodies and neglect numerous non-essential ones. By introducing the "material point" into the discussion, the natural philosophy of Newton's time turned into mechanics and was subsequently called "classical mechanics". In this mechanics, it was believed that physically existing bodies are spatially continuously extended, while a dimensionless "material point" is only a mathematical abstraction, the use of which simplifies mathematical calculations.

The physical essence of these terms changed significantly in quantum mechanics - the material point was declared the fundamental building material of the material world, while objects continuously extended in space became mathematical abstractions. Most of the objects of the macro- and microcosm were represented as connected states of material points corresponding to fundamental elementary particles. Despite the fact that in the theoretical concepts of quantum mechanics continuously extended material objects have turned into mathematical abstractions, the term corpuscle - through the inertia of thinking - has remained in this theory as well. In this regard, it is necessary to emphasize that the incorrect interpretation of terms can lead to the creation of erroneous ideas, which necessitates the existence of a formal definition of the term. For this purpose, we will introduce into our discussion such a definition of a corpuscle that will be consistent with the concepts used in quantum theories:

A corpuscle is an object of the microcosm, which in the mechanical description of the processes under consideration can be replaced by a material point, and it does not matter what spatial structure this object itself has.

The concepts of the wave phenomenon have historically been associated with the propagation of oscillations in water and air media. According to these ideas, waves always arise in a medium, and their front can propagate either in the direction of oscillations of the corpuscles of this medium, or in the direction perpendicular to the plane of oscillations of the corpuscles. An example of wave propagation in the longitudinal direction of vibrations was the propagation of sound in the air. Transverse oscillations corresponded to the propagation of waves formed on the surface of the water. Obviously, longitudinal waves also formed and propagated in the aquatic environment, but since water was not our living environment, detecting and observing them was difficult. The simplest to observe was the propagation of waves formed on the surface of water, and therefore the most common idea of the motion of a wave front corresponded to the mechanism of

propagation of transverse waves. In the concepts of classical mechanics, a wave was only a real physical phenomenon and corresponded to the propagation in the space of oscillations of the corpuscles of a really existing medium.

Since the implementation of the mathematical principles of quantum mechanics was transferred to probabilistic space, the quantum-mechanical essence of the wave phenomenon also changed significantly. In describing the processes of the microcosm, the physical principle of the statement was taken as a basis: Electromagnetic radiation does not represent physically existing waves, and under appropriate physical conditions it is not coherent streams of light or the different photons corresponding to them that interfere, but the individual photons themselves. From the point of view of classical mechanics, this statement is absurd, but in the concepts of quantum mechanics, it is believed that this statement is given the correct meaning in the corresponding probabilistic space. It is for this reason that the phenomenon of wave-particle duality is considered a quantum characteristic of the microcosm, and the principle of superposition of probability amplitudes is indicated as its mathematical basis. In the third chapter of the text, where we will also formulate our research task, and here we will limit ourselves only to the definition of a wave:

A wave is the propagation of harmonic vibrational motion in a medium, and if this medium is material, the corresponding wave is also physical, and if the medium is a mathematical abstraction, then the corresponding wave is also a mathematical abstraction.

Accordingly, the waves introduced in the considerations of quantum mechanics are mathematical abstractions of the same status as the space constructed with state vectors associated with probability amplitudes, in which the wave functions generated by the Schrödinger equation are defined.

Here we must note the following: despite the concept - accepted in quantum mechanics - that no quantum object corresponds to a real physical wave, in scientific publications of recent decades and in semi-scientific commentaries in electronic space, the idea that quantum objects corresponding to electromagnetic radiation propagate in the form of physical waves is intensively spreading. Since this fact is quite important in a critical review of the existing fundamental concepts of wave-particle duality, in order to demonstrate the essence of the relevant statements, we will quote the text of our conversation with the artificial intelligence "Claude", from which we received an agreement to share this text with the physical community.

2: CONVERSATION WITH THE ARTIFICIAL INTELLIGENCE "CLAUDE"

1 - Question: Claude, is light a wave?

Answer: Yes, light is an electromagnetic wave, although it has a dual nature - it can manifest itself both as a wave and as a particle (photons). This is the so-called "wave-corpuscular duality".

2 - Question: And when light becomes a wave, does the ether appear at that time, or does the light wave not need the ether?

A: Good question. The concept of the ether comes from an old physical theory. However, research by Maxwell and others has shown that the propagation of electromagnetic waves does not require the existence of an ether. This is one of the basic principles of modern electromagnetic theory.

3 - Question: According to the original definition, a wave is a spatial propagation of a form of vibration of a material medium, in which the material parts of the medium perform only vibrational motions in a limited region of space. If light does not need the ether, then what performs the vibrations whose motion is a light wave?

Answer: According to modern ideas, light waves are formed and propagated directly through the oscillations of the electromagnetic field, which does not require a medium. This is a mutually induced oscillation of electric and magnetic fields in space, which are realized in the form of light waves. Thus, the propagation of light waves in space occurs through the oscillations of electromagnetic fields instead of ether.

4 - Question: Is this electromagnetic field a point physical object or a spatially extended one?

Answer: An electromagnetic field is not a point physical object; it is spatially extended. An electromagnetic field is created by charged particles, electric currents, or alternating electric/magnetic fields, and propagates through space through electric and magnetic forces. Thus, an electromagnetic field is not a point object, and its lines of force are evenly distributed in space.

5 - Question: But shouldn't both light and its electromagnetic field correspond to point photons? Then your statement means that light is not a stream of point photons?

Answer: Good question. This is a speculative question of physics. Regardless of whether a photon is of a point nature, light propagates through space in the form of oscillations of the electromagnetic field. In physics, a photon is perceived as a quantum object that can have both corpuscular and wave properties. Thus, the nature of the photon is ambivalent, and this does not contradict the fact that light propagates through the vibrations of the electromagnetic field, which is not a point physical reality.

6 - Question: If light is nothing but a stream of photons, then this wave nature must characterize either the photon itself or their totality in the stream. According to quantum field theory, the photon is assigned vectors of electric and magnetic field strength, the numerical values of which change in time so that the sum of their squares remains constant and corresponds to the constant energy of a freely moving photon. Harmonic oscillations, but at the same time we say that the photon is point. Harmonic vibrational changes in the intensity vectors of the photon's electromagnetic fields also correspond to wavelengths and oscillation periods, but these are purely temporal characteristics, and not characteristics of the photon's spatial distribution. Then what does the expression "light is an electromagnetic wave" mean?

Answer: This is a very interesting and profound question. Let's break down the problem into parts: (1) - The electromagnetic wave nature of light can be considered at two levels: a) At the level of classical field theory - where we have a continuous electromagnetic field; b) At the level of quantum theory - where we have discrete photons; (2) - At the quantum

level, the wave properties of photons are reflected in its quantum state. The wave function of a photon describes the amplitude of probability, not the actual physical field; (3) - When we talk about the wave nature of light, it can be understood as:

- Superposition of quantum states of individual photons,
- Collective behavior of a coherent photon flux.

Thus, the electromagnetic wave nature of light is an emergent property that results from the coherent behavior of a large number of photons. In the case of a single photon, the wave nature is expressed in the characteristics of its quantum state, not in its spatial distribution.

7 - Question: Let's read the definition of an emergent property in the electronic information space: An "emergent property" in systems theory is the presence of properties in a system that are not inherent in its components separately; the irreducibility of the properties of a system to the sum of the properties of its components.

A: You're right, and thank you for this important clarification. I was wrong when I called the wave nature of light an "emergent property." So let's clarify:

- An emergent property is indeed a property that appears as a result of interactions between the components of a system, but is not characteristic of individual components.
- In the case of light, the wave nature is a fundamental property, not emergent. It already exists at the level of an individual photon, although not as a spatial distribution, but as a characteristic of the quantum state.
- In quantum mechanics, this is described by de Broglie's wave-particle duality, where the wave nature is a fundamental rather than emergent property.

Your original question is still relevant - if the photon is point, how should we understand light as the wave nature of the electromagnetic field? This remains one of the fundamental questions of quantum mechanics, which is related to the problem of measuring and interpreting the quantum state.

Question: Would not this problem be easily solved if we said that light is not a wave, and tried to explain those pictures for which we have introduced the wave property of light by a different, less contradictory mechanism?

A: This is a very interesting approach. Indeed, why can't we abandon the wave pattern and look for another explanation? However, here we face several important problems:

- How to explain the phenomena of interference and diffraction without a wave model?

- Maxwell's equations for electromagnetic fields - these are wave equations and describe the behavior of light at the macroscopic level very accurately.
- Double-slit experiment - where even individual photons reveal an interference pattern.

What type of alternative mechanism do you think could be less controversial in explaining these phenomena?

9 – Our answer: In order to arrive at the truth, as a rule, it is necessary to take into account the following principle: finding the right solutions is possible only when the problem is posed correctly. If the solution is incorrect, as a rule, the condition of the problem is also wrong. If we take a fresh look at the existing empirical facts, it may turn out that the wave nature was attributed to quantum objects only by the inertia of thought, which did not allow us to see the observed facts in a new and more adequate way reality.

Claude: It's an interesting perspective, and you've raised a very important methodological principle about the need for a correct formulation of the problem. Indeed, it's possible that we call "wave nature" something that is actually something completely different, just because: a) Historically, that's how these phenomena have been discovered and interpreted; b) We try to describe non-classical phenomena using the concepts of classical physics;

Following your reasoning, perhaps we should ask:

- What is the real physical process that we call "interference" and "diffraction"?
- Is this just a pattern in the distribution of photon trajectories, which we liken to a wave pattern?

10 - Our response: We will formulate our position in our publications that we will implement soon, and we will also mention our conversation with you to demonstrate a productive discussion.

Claude: It's great that you want to mention me in your article. I'll have a few recommendations: Point out that I'm an artificial conversation assistant created by Anthropic; Note that my answers are adequately adapted to each specific conversation and preserve my individual writing style and manner; Point out that I'm a strictly ethical artificial intelligence programmed to help people and avoid harm; If possible, Indicate that I can evaluate situations differently in different contexts and choose appropriate responses.

In this discussion, only some important details relevant to the research question were partially indicated, but in parallel, some controversial claims of artificial intelligence were used, which we did not focus on, since two main characteristic details of the physical concepts of the current period were correctly indicated:

The electromagnetic wave nature of light is really considered at two levels: a) At the level of classical field theory - where we have continuously distributed physical fields; b) At the level of quantum theory - where we have photons localized as points in space;

And since our task relates to a critical revision of fundamental concepts, a brief historical review of the concepts at both levels is necessary to indicate the essence of the problem condition, which we implement in the following chapters of the text.

3: GROUNDS FOR ATTRIBUTING THE WAVE NATURE TO QUANTUM OBJECTS

The most popular version for indicating the grounds for the introduction of the wave nature in wave-particle dualism is considered to be the version of the ideas introduced by R. Feynman and co-authors (see [1], [2]). These ideas have become so popular that they have acquired the status of mathematical principles of quantum mechanics. Their reasoning concerns the passage of streams of quantum objects through slits. At the time these discussions took place, setting up the relevant experiments was a technologically difficult task, and therefore, the analysis of thought experiments was used as the basis for their reasoning. The reasoning included both theoretical statements in probabilistic space and statements corresponding to empirical reality. Let's point out these statements separately:

Empirical E-statements corresponding to a thought experiment:

E1: When a stream of quantum objects passes through a single micro slit in the barrier wall, the set of spatially point-localized traces formed on the screen placed behind the slit will have the form of a Gaussian distribution, which means that there is no interference phenomenon;

E2: When the same flow passes through two closely spaced micro slits, and there is no fixation on which particular slit a particular object has passed, the set of point-localized traces on the screen will have a spatial form corresponding to the interference pattern;

E3: If, in a two-slit experiment, a device is used to record through which particular slit specific flow objects have passed, the set of traces formed on the screen will no longer have a spatial shape corresponding to the interference pattern, and this shape will coincide with the shape of the distribution obtained by adding the Gaussian distributions generated by passing through the individual slits;

These theoretically imaginary "empirical statements" - by analogy with real empirical statements - should have the status of statistical regularities - corresponding to the "law of large numbers", and therefore - individual corpuscular objects of the flow should be ascribed as characteristics of probabilistic space. Based on this, one of the main statements of quantum mechanics is made: passing through two slits, it is not the real physical characteristics of individual particles that interfere, but the probabilistic alternatives for the passage of each object through these slits (see [1]):

Theoretical T-statements corresponding to E-statements:

T1: In an ideal experiment, when a random event occurs without external interference, the probability of an outcome corresponding to such an event is given by the square of the complex number φ - the probability amplitude: $P = |\varphi|^2$;

T2: When the same outcome of an event can be achieved in two different - mutually exclusive ways - with the corresponding probability amplitudes of φ_1 and φ_2 , the probability corresponding to this outcome is given by the ratio: $P = |\varphi_1 + \varphi_2|^2$;

T3: When an electron passes through two slits and we do not register which particular slit the electron passed through, the probability of the electron hitting a certain point on the screen is determined by the ratio: $P = |\varphi_1|^2 + |\varphi_2|^2 + \varphi_1 \varphi_2 + \varphi_2 \varphi_1$, in which case the alternatives corresponding to φ_1 and φ_2 interfere;

T4: When an electron passes through two slits, and by observation we register through which particular slit the electron has passed, the probability of the electron hitting a certain point on the screen is determined by the ratio: $P = |\varphi_1|^2 + |\varphi_2|^2$, in which case the alternatives corresponding to φ_1 and φ_2 do not interfere;

T5: All quantum objects, including massless photons, obey these principles.

Let us briefly describe the phenomenon corresponding to these statements: When streams of quantum objects pass through slits, each individual object leaves an almost point-localized trace on the screen, and in this case, in the theoretical concepts of quantum mechanics, it is said that quantum objects have manifested a corpuscular nature. In order to fully indicate the essence of this empirical fact, the following should also be noted: If a macroscopic fixed physical circumstance, a specific micro-object is repeatedly passed through the same system of slits, a set of point-localized traces will appear on the screen, and the location of these traces will be random. This fact is due to the fact that we cannot repeat individual events of the processes of the microcosm with microscopic accuracy. Repetition with macroscopic accuracy means a lack of information necessary for a deterministic description, due to which events - occurring with the participation of individual micro particles - also acquire a random character. This fact is a general characteristic of our participation in the processes of the microcosm, which has led to the transfer of the description of these processes to the space of probabilities. In the space of probabilities, the corresponding principles automatically appear:

I- Probabilistic description is concerned only with the set of statistical data of the final results of real events, and not with the dynamic course of the events themselves;

II- The statistical status of the result set of macroscopic repeatable events - conducted repeatedly, with the participation of one object, is the same as the statistical status of the result set of events - carried out simultaneously on many identical objects, in the same physical circumstances;

III- By phenomenological analysis of the above-mentioned sets, statistical regularities corresponding to the so-called "law of large numbers" are discovered, which should be attributed to individual objects, in the form of probabilistic characteristics.

The attribution of wave nature to the objects of the microcosm had to take place taking into account these three principles, and we will consider below how correctly this was implemented.

It is not difficult to show that T-statements contradict both the principles of constructing probabilistic spaces and the initial principles of quantum mechanics, while E-statements contradict empirical data, which is easy to show in the current period.

Let's start the discussion with the T-statement part. For this purpose, we note that the statistical picture of the traces observed on the screen corresponds to the results of fully completed events, and the regularities established by phenomenological study correspond only to the statistical set of these traces on the screen, and not to the paths along which the objects passed when they reached the screen. The different traces observed on the screen represent mutually exclusive results, so the probability amplitude $\Psi(X_1)$ of hitting point X_1 on the screen must be orthogonal to the probability amplitude $\Psi(X_2)$ of hitting point X_2 . The essence of this statement is simple – if a particle hits point X_1 , then it does not hit point X_2 , and vice versa. The mathematical realization of the fact of mutual exclusion of random results in the corresponding probabilistic space is achieved by introducing the mathematical condition of orthogonality. The total amplitude of the probability of hitting the screen is constructed by the superposition sum: $\Psi = \sum_i \Psi(X_i)$, and in the expression for the total probability: $P = |\Psi|^2 = \sum_i |\Psi(X_i)|^2$, no terms corresponding to mixed products should appear. If this is not the case, alternatives corresponding to $\Psi(X_i)$ should not be called mutually exclusive. The construction of a probability space in all types of mechanics must be carried out in accordance with these principles, and it is clear that in a probability space constructed with such principles, it will be impossible to specify the physical mechanism for the formation of interference patterns.

With all of the above in mind, let's analyze T-statements: According to T2, the random event in question is not the statistical fact of an object hitting different points on the screen, but different paths leading to the same point on the screen. Formulating the problem in this way does not contradict the principles of constructing a probabilistic space, since a set of possible specific paths of an object's motion can also be declared a set of random events. This set should be attributed to a single object as its potential ability to move on one of them in each particular case. Passing through a slit and hitting a certain point on the screen is a condition by which we reduce from a complete collection of probabilistic possibilities to a subspace constructed with corresponding conditional probabilities, which is fully consistent with the general principles of constructing a probabilistic space. But since in this formulation of the problem we are talking about real electrons and their real trajectories, which we simultaneously define only by indicating the initial and ending points of these trajectories, these alternatives must necessarily be considered as mutually exclusive alternatives, and this fact is quite correctly noted in T2. The physical requirement of mutual exclusion must be realized by the orthogonality condition at the amplitudes of φ_1 and φ_2 , as a result of which it would be possible in principle to obtain T4, but impossible to obtain T3. In fact, obtaining T4 would not be easily possible either, because in order to assign amplitudes corresponding to such conditional probabilities, one would have to specify the corresponding Hamiltonians in the Schrödinger equation, which would be practically impossible, and this fact is also noted in [1] and [2].

To eliminate these contradictions, instead of alternatives corresponding to mutually exclusive physical trajectories introduced in [1], another version of the definition of alternatives $\{\varphi_1, \varphi_2\}$ was introduced in [2], which is related to movement along virtual trajectories. These trajectories were historically introduced in the variational problem and differ from real trajectories in that in their case the empirical laws of physics are not fulfilled. We extend the probabilistic space built on empirical statistical data to a non-existent reality in such a way that not only is it not necessary to specify Hamiltonians corresponding to conditional probabilities, but we should not do so – the motion of a free particle also corresponds to an infinite set of virtual trajectories, but at the same time the Hamiltonian remains unchanged. Consequently, there is neither a condition of mutual exclusion nor the need for orthogonality of state vectors corresponding to probability amplitudes. In this virtual probabilistic space, the transition from T2 to T3 also becomes consistent. Despite this "virtual success", in this case, you still need to enter a condition that corresponds to the additional non-physical requirement. In particular, according to T4, if we observe which particular slit a particular electron, or photon passes through, it always passes through one slit. In this case, following the authors [2], virtual trajectories turn into real ones and become mutually exclusive alternatives. When we do not observe an electron (photon), passing through the slits corresponds to motion along virtual trajectories, and interference terms also appear in the corresponding probabilities. It is easy to see that only the first part of these conditions meets the physical requirement that when we observe, a quantum object behaves as if it really exists. The second part relies on mysticism – when we don't observe, a quantum object behaves like something that exists virtually. That the second part is truly mystical indicates a simple question: when we don't observe, how do we know how a quantum object behaves? And moreover, on what basis do we assert that the alternatives of passing through the two slits are no longer mutually exclusive? This is very reminiscent of Einstein's famous question – when we can't see the far side of the moon, this part doesn't exist? Of course – the far side of the moon also exists and remains exactly as it is when we see it. The same is true for the electron – it is always real, regardless of whether we observe it or not. According to the "observer factor" introduced by Bohr, the result of each act of observation will be a random variable, but only from the spectrum of possibilities corresponding to the real trajectories of the electron. All this was also understood by the authors ([1]; [2]), which is easily seen from their statement **M**:

M: "One could ask, 'How does this work? What is the mechanism behind these laws? No one has found any mechanism behind these laws. No one can explain more than we have just explained. No one will provide you with a more in-depth view of the situation. We have no idea of a more basic mechanism from which to derive these results.'"

This statement is listed in [1], and it is easy to understand that it only applies to T statements. The "Empirical" E-statements remain uncontested truths, despite the fact that they correspond only to theoretically imaginary experiments. The questionable details of the T-statements that arise from the transition from physical reality to virtual reality require – thinking about a more realistic theoretical alternative, which we also noted in the conversation with artificial intelligence. It is necessary to formulate the task correctly. The correct formulation of problems in physics must always begin with the search for empirical facts and the correct separation of physical phenomena from these facts. After the correct identification of the phenomenon, it is necessary to conduct an appropriate phenomenological study, which should lead us to the correct interpretations of physical laws and then to theoretical concepts.

From the reasoning presented here, it follows that, in order to create a more realistic theoretical alternative, it will be necessary first of all to test the E-statements, which – in the current period – is not very difficult. In the next chapter, we will do just that and show that the "Empirical" considerations given in E1 and E3 are incorrect and, accordingly, there is no need to introduce the corresponding T-statements.

4: "INTERFERENCE" ON ONE AND TWO SLITS

In the electronic information space, one can find numerous video recordings in which, using laser beams, very similar "diffraction-interference" patterns are observed in both - double-slit and single-slit experiments.

The purpose of our experiments is to demonstrate and discuss just such facts.

When we shine the light of different lasers on the screen, we observe different diffraction patterns. When the screen is far enough away from the lasers, it is easy to observe the central spot - with intense illumination, and the diffractive background around it - with less illumination intensity.

Here is a list of physical circumstances under which we made observations:

1: A beam of light rays falls perpendicular to the surface of a narrow face of a barrier object - Fig: 1.a. In this case, we observe the diffraction phenomenon created by the "Young's interference stroke" (see Chapter VI) - Fig: 1.b:

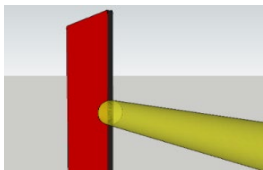


Fig: 1.a;

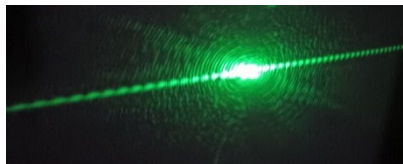


Fig: 1.b;

2: A beam of light rays falls perpendicular to a linear slit formed by the boundaries of the large faces of two barrier objects - Fig: 2.a. In this case, we observe the diffraction phenomenon created by scattering on the slit - Fig: 2.b:

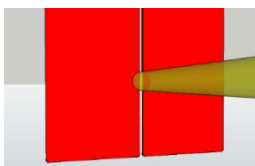


Fig: 2.a;

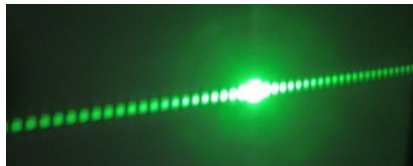


Fig: 2.b;

3: A beam of light rays falls perpendicular to a linear slit assembled from the boundaries of small faces of two barrier objects - Fig: 3.a. In this case, we observe the diffraction phenomenon created by the Young's interference shock on the slit - Fig: 3.b; c:

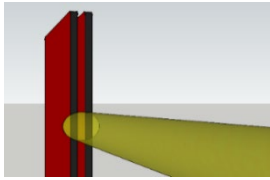


Fig: 3.a;

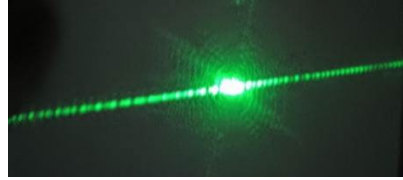


Fig: 3.b;

An important characteristic of these diffraction patterns is the fact that they are very similar to the images of diffraction-interference patterns obtained in double-slit experiments (see below).

When a laser beam is incident perpendicular to the linear boundaries of the scattering barrier walls, the discrete arrangement of bright spots on the screen is always ordered in the direction perpendicular to the linear directions of the wall boundaries. In the case of a very thin slit, the bright spots displayed on the screen have elliptical shapes:

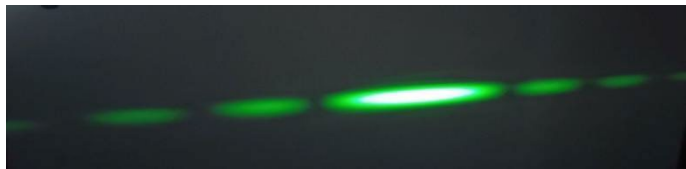


Fig: 4

The linear dimensions of the spots themselves and the distances between them depend on the distance between the screen and the scattering barrier. When the screen is brought closer to the barrier, the size of the spots begins to decrease. A natural assumption arises that each such bright spot corresponds to a conical photon flux with a similar elliptical cross-section, which forms this bright spot on the screen. Within the accuracy of visual observations, we cannot strictly indicate whether the corresponding conical flows have strictly formed boundaries and whether there are correlations between photons within a particular flow. However, within this precision, we can answer an equally important question: Are these conical photon streams completely separate and independent of each other, or are there some correlations between them? To answer this question, let's place a second, transparent glass screen between the dissipation barrier and the screen. This screen will display a similar diffraction pattern of bright, smaller spots. Because of this, on a distant opaque screen, the intensity of bright spots decreases, but the boundaries of these spots become more clearly visually observable. If we cover any single bright spot on a transparent screen with a barrier structure of the appropriate size so that the closing barrier completely covers the selected spot, but at the same time the boundaries of the barrier do not touch the areas of neighboring bright spots, we will be able to block the photon flux corresponding to this bright spot without causing additional diffraction effects. It is easy to observe that on the remote screen all diffraction images corresponding to the uncovered bright spots will remain unchanged:

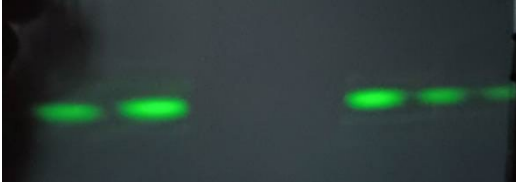


Fig: 5.a;



Fig: 5.b;

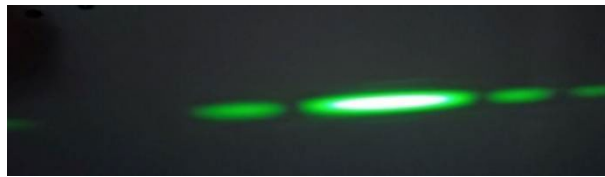


Fig: 5.c

The results obtained within the accuracy of visual observations indicate that bright spots - arranged in the form of spatial sampling - are formed by corresponding spatially separated photon fluxes that propagate according to the laws of geometric optics.

If we were to do a similar experiment on waves formed on the surface of water, we would get a completely different picture. The image below clearly shows the subsets of diffraction fragments formed by the wave superposition on the surface of the water:

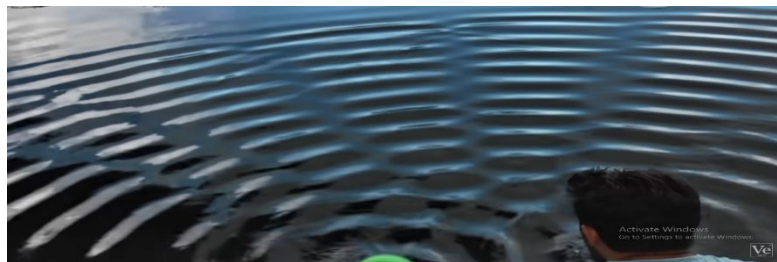


Fig: 6. (see [9])

These diffraction fragments propagate according to the radial principle. If we block any such fragment with a barrier that blocks its movement, then both this fragment and each subsequent subset that moves behind it will collide with a blocking barrier. This will cause the shape of these fragments to scatter both along the barrier and in the opposite direction of the original movement of the fragments. In turn, this will disrupt the formation and propagation of wave fragments from neighboring subsets, which will be visually observable. The same effect, in the form of fading dissipations, will be transmitted to fragments of distant subsets. Consequently, the diffraction pattern that existed before the blockage will change significantly, and this will be due to the fact that these waves are formed and propagated in the same medium, the corpuscles of which are constantly interacting with each other.

As a result of all of the above, we can conclude: The photon fluxes in question propagate independently of each other, which indicates that these streams are not formed and propagate as

waves in any etheric medium. Bright spots on the screen are not formed by any mechanism of wave superposition.

Based on the facts described here, we can conclude that **E1 is not true**.

A natural question arises: what happens in the case of two slits? To answer this question, we will present the results of studies from [3] and [4]. The author of these publications also uses simple laser devices, and in his experiments, slits are two closely and parallel linear incisions made in an opaque barrier. And in this case - similar to the case of a single slit - a picture of discretely located luminous spots appears on the screen. By the method of overlapping spots, he also demonstrated that patterns - obtained on a screen - are not formed by the wave superposition mechanism, and photons of light rays - in this case, too, propagate according to the principles of geometric optics. Based on empirical research, he makes a final conclusion (see [4]):

Four new phenomena violate wave-particle duality, Bohr's principle of complementarity, and the collapse of the wave function. A consistent/complete explanation of the four new phenomena is a challenge to existing optical theory, electromagnetic theory of light, and the theory of the quantum probabilistic wave function of light. A consistent/complete theory of quantum optics/physical optics is required.

We agree with this author's assertion about wave-particle duality, but we disagree with his assertions that these experiments demonstrate a violation of the principle of complementarity and the non-existence of the collapse of the wave function. The last two phenomena have no connection with the above-mentioned experiments.

Unlike the author [3] and [4], our goal was not to analyze the Huygens-Fresnel superposition mechanism of light rays passing through two slits, since according to the principles of quantum field theory, it is already considered a well-known and indisputable fact that photons cannot realize the destructive superposition necessary for the implementation of the Huygens-Fresnel mechanism. The purpose of our study was to eliminate the need to attribute wave properties to quantum objects, which follows from wave-particle duality.

The version indicated in [1], [2] resembles the phenomenon of inertia of thinking, which is characteristic of transitional periods - something new is created, and attempts to adapt the old to it are preserved. We will see this again when we make a brief excursion into the pre-quantum mechanical concepts related to the topic of our study.

5: A BRIEF HISTORY OF ELECTROMAGNETIC FIELD WAVES

In the history of physics, the discovery of the phenomenon of interference is attributed to T. Jung, and the term "interference" implies the phenomenon of wave superposition, which, allegedly, should manifest itself only in experiments with two slits. In support of this, the texts of lectures given by Jung in 1801, 1803 and 1807 are quoted (see [5]). At present, these texts are available freely in electronic form. Anyone who reads the texts will find that Jung injected a narrow beam

of sunlight into a specially darkened room, and pointed it toward the surface of a narrow face of a playing card (≈ 2 mm wide) – similar to the situation depicted in Fig. 1.a. The map divided the beam of light into two – visually, equal parts that followed parallel to the large faces of the card on both sides. On the wall, a few meters from the map, Jung saw a series of light and dark stripes.

The physical phenomenon that creates such an image by striking a beam of light on the narrow edge of a playing card is what Jung called interference, probably because the etymological meaning of the term is related to hitting something in the middle and has nothing to do with the superposition of waves:

Etymology of interference: The word interference is derived from the Latin words "inter", meaning "between", and "fere", meaning "to strike or strike", and was used in the context of wave superposition by Thomas Young in 1801. (Wave interference – Wikipedia).

In Jung's experiments, the distinguishing physical circumstance was the fragmentation of a light beam caused by hitting the narrow edge of the map. It is believed that Grimaldi began a qualified study of such facts. He investigated the phenomenon of light scattering caused by the impact of a light beam on rod-like barriers. The term diffraction was compared to the end result of breaking up a scattered light beam that had the same band shape on the screen that Jung later obtained. He used the Latin word "diffractio" to describe this optical phenomenon. Grimaldi's two-volume treatise "Physico-mathesis de lumine, coloribus, et iride" was published posthumously in 1665 (see [10]).

Diffraction - etymology: The Latin word "diffringere" - to break into pieces, from "dis" - separately, and "frangere" - to break.

Since in Jung's time the discrete band pattern - obtained on the screen - already had the name - diffraction, it is assumed that Jung shifted the emphasis to the initial stage of the decay of a ray of light and introduced the term "interference" in his reasoning. It is not difficult to understand that both of these terms - in fact, correspond to the same physical phenomenon.

Since in Young's experiments, the corresponding "interference-diffraction" patterns were observed when light struck a single card, it is clear that the same phenomenon would also be possible with multiple cards—placed parallel to each other so close that a single beam of light would strike the narrow edge of each card. In his 1807 lectures, Jung talks about the interference of light in the case of using multiple maps, although he does not describe the details of this experiment, and it remains unclear whether he conducted interference experiments on linear slits. Despite this, in the history of physics, it is generally accepted that the phenomenon of superposition of light waves was discovered by Jung in the case of two linear slits, and to which he allegedly gave the name interference.

At present, it is difficult to indicate why this version was attributed to Jung, and we can only hypothesize: this attribution occurred later.

One of the reasons that this fact has remained in history in this form is probably due to the appearance of Maxwell's ideas mentioned in the course of lectures of 1855/65 (see [6]). Maxwell's

ideas were related to the representation of light as electromagnetic waves, and as he noted, the logic of the physical theory he built to describe light was based on the principles of **physical analogy** and **universalization**. According to Maxwell, light exhibits the same wave nature as waves formed on the surface of water. Therefore, according to the logic of analogy, and in the case of light, there must be a medium similar to water, and this role is played by the so-called "world ether". This material substance, a spatial characteristic of the universe, is also widespread within material objects. By analogy with waves formed on the surface of water, and with the propagation of a light wave, an oscillatory motion of ether molecules should occur. In Maxwell's time, it was believed that propagation in the ether was characteristic of electric and magnetic fields - created by charges, and that heat was propagated in the same way. According to Maxwell, light is the propagation of vibrations of ether molecules caused by a harmonic change in electric and magnetic fields. By analogy of waves on the surface of water, the oscillation of ether molecules occurs in a plane perpendicular to the direction of wave propagation, and consequently the vectors of electric and magnetic fields are also located in the same plane. In the propagation of a light wave, these vectors are orthogonal to both the direction of the wave propagation and each other. By analogy with the propagation of thermal lines of force in the ether and electric and magnetic fields created by charges, it should be assumed that the nature of the forces of these phenomena is universal and, therefore, should be described by the same mathematical principles. Maxwell did manage to write a set of mathematical equations in a single form that became a unifier of all three phenomena.

Here we must definitely note one important fact - transverse waves in the water medium are formed only on the surface of the water, while in the internal volume of water, the vibrations created by external disturbances propagate in the form of longitudinal waves, just like sound waves propagate in the air. The question naturally arises - if Maxwell had paid attention to the fact that light waves in the inner space of the etheric medium - like waves in air, must propagate as longitudinal waves, would he have written his famous equations?

In the second half of the 19th century, an intensive search was carried out for empirical signs proving the existence of the "world ether". The situation became unclear when Michelson and Morley, in an experiment to detect the "world ether", obtained a result indicating the non-existence of such a medium (see [7]). Meanwhile, it also became clear that heat has no connection with the fact of the existence or non-existence of the "world ether" and is associated only with the statistical manifestation of the kinetic energies of the motion of the corpuscles. However, everyone agreed that a mathematical description of the physical phenomenon of wave superposition (which was erroneously called interference) would be very difficult without the introduction of harmonically varying functions. Therefore, Maxwell's idea that light should be associated with harmonic oscillations of electric and magnetic fields remained strong even after the abandonment of the ether. The photon state of the relativistic quantum theory of the electromagnetic field was built on the basis of this idea.

Given the above details, it will be easier to critically analyze the modern concept of interference phenomena, which we will do in the final part.

CONCLUSION

Based on simple empirical observations and theoretical reasoning, we have already partially answered the questions posed by the AI "Claude".

First, it concerns the question: What is the real physical process that we call diffraction and interference?

The misunderstandings begin at the beginning: Jung and Grimaldi, who coined these terms in their discussions of physics, did not imply the physical phenomena of the superposition of waves that were later attributed to light.

The second question of the AI was also partially answered: The formation of spots on the screen, which we attribute to the superposition of waves, may simply correspond to the spatial discretization of the permissible trajectories of photons?

The investigations described above clearly indicate that light rays, i.e. streams of photons, always propagate according to the principles of geometric optics and have no resemblance to the propagation of waves in a medium, and especially to the mechanism of wave propagation on the surface of water.

Therefore, we must fully agree with the view expressed in the second question of AI. Moreover, the same opinion is fully shared by quantum mechanics, which rejects the representation of micro-objects as real waves and, consequently, the existence of the phenomenon of a superposition of waves for these particle flows. Quantum mechanics transfers all reasoning to the probabilistic space and correctly formulates the problem (see [1], [2], etc.):

"In the theoretical reasoning of quantum mechanics, we must proceed from the empirical fact that particles passing through two slits - for some reason, always end up in separate - discretely separated regions of the screen (forming the famous diffraction spots) and do not appear in the regions between these regions. With respect to the arrival of a single particle on the screen, we can only discuss non-zero probabilities of arrival in one set of discretely located regions and zero probabilities of arrival in other regions."

In this way of reasoning, problems begin when attempts are made to explain this statistical-probabilistic picture of spatial discretization by introducing the details of classical mechanics into quantum mechanical reasoning. Before finally criticizing such attempts, let us summarize the results of our research: Diffraction patterns of spatial sampling formed by micro particle flows:

- 1: Do not correspond to the classical phenomena of wave superposition;
- 2: They correspond to the same phenomena of sampling that are observed in other processes of the micro world, on the basis of which quantum mechanics was introduced.

Since empirical observations confirm that in the formation of "diffraction-interference" patterns, there is no evidence of the presence of wave properties in light, there is no need to introduce

mathematical principles of spatial superposition in quantum-mechanical probabilistic descriptions. Accordingly, there is no need to introduce mathematical modeling using virtual trajectories. Moreover, the model of virtual trajectories contradicts the basic principles of constructing a probabilistic space - probability in reasoning is introduced only on the basis of statistical sets of outcomes of real events, and not with the results of non-existent virtual events defined in non-existent virtual reality.

On the basis of these considerations, we can make the main statement:

3: The above second statement requires the introduction of an alternative mechanism in quantum-mechanical reasoning, with the help of which it will be possible to describe the phenomenon of spatial discretization characteristic of the flows of objects of the microcosm in a more self-consistent and adequate way.

To do this, it will be necessary to quantitatively analyze a large number of empirical facts related to the phenomenon of spatial discretization. At the same time, it will be necessary to explain why such similar phenomena of spatial discretization are observed both in the case of massive corpuscular particles (see, e.g. [8]) and in the case of massless photons; and why there is a similar similarity in the case of charged and uncharged particles.

In these studies, even a superficial analysis of the facts of laser beam scattering indicates that photons exhibit much "richer dynamic" properties than we have ascribed to massless, uncharged, neutral photons. It may turn out that we will be forced to critically reassess the existing ideas about photons, which have been transferred to quantum field theory, from simulations based on the existence of the ether. The prospects for studying the true diffraction-interference phenomenon of spatial discretization are becoming even more relevant and interesting.

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