Experiments of interference with coincident or shifted in time laser pulses

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Abstract. This article explores experiments on interference with electromagnetic waves. Some of the problems of the Copenhagen interpretation of quantum mechanics are discussed. The laws of interference with symmetric and asymmetric interferometers are discussed. With a permanently emitting laser source and artificially obtained (cloned) laser pulses. Coincident or shifted in the time when they reach the viewing screen. Two possible models of interference and experimental demonstration of the working model are examined.

Keywords: quantum optics, interference, photon, coherent, wave train, laser pulses

Content

Abbreviations:

QM - quantum mechanics
EMW - electromagnetic waves
CI - Copenhagen interpretation
WF - wave function
WFC - wave function collapse
IP - interference pattern
WFM - wave function model
MI - model of influence
MCU – microcontroller

1. Introduction

The birth date of quantum mechanics (QM) was considered to be 1900, when Max Planck, in order to solve the problem of the so-called ultraviolet catastrophe considered the emission of light as independent quanta with a discrete portion of energy. He introduces the constant h and accordingly the energy of each light quantum is proportional to the frequency of the electromagnetic waves (EMW),

$$E = h\nu, \tag{1}$$

where E is the photon energy, ν is the frequency of the EMW, and h is the Planck constant. Later, the light quantum was called a photon. In 1905 A. Einstein proves that not only the radiation, but also the interaction of light is carried out with discrete portions of energy in the external photoelectric effect. Like the energy of any discrete photon, it can only eject a photoelectron if the photon energy exceeds the so-called red limit. Experiments conducted over the next 15 years by A. Holly Compton, W. Georg Bothe and others unambiguously prove that the photon is an electroneutral, and indivisible quantum with energy $E = h.\nu$, without mass at rest. But in this situation, an indivisible and electroneutral photon with precisely defined energy, a discrepancy with the wave representations of the EMW is obtained: as diffraction and interference, which are an experimental fact.

To find a way out of this situation, part of the physicists, the so-called Copenhagen School, who are the creators of the Copenhagen Interpretation (CI), as well as the scientists gravitating around it, adopt the probabilistic model and the duality of the photon with the properties of both wave, so of the particle. But this leads to new problems for the required properties, the so-called wave function (WF) of the photon, such as: 1. The mysterious "knowledge" of the WF of a photon for the whole experimental set-up in the formation of a diffraction or interference pattern (IP). 2. Instantaneous collapse of the wave function (WFC). 3. Non-locality. 4. As well as the obligatory uncertainty of the photon path, which condition determines the formation of the IP (the probability of the photon to pass along each arm of the interferometer, but without information on which particular arm the photon passes).

While the other part of the physicists, whose main representative is A. Einstein, as a result of the discrepancies that follow from the CI, consider the probabilistic model as incomplete. They examine quantum objects and processes related to them by so-called realistic theories. Which is summed up by Einstein's famous thought God does not play dice with the universe, during the so-called Solvay Congresses.

In this article we will show that for the formalism of CI there are a number of unsolved problems expressed by many physicists over the years, as well as experimental results that clearly do not agree with CI. Basically, we will consider that in the interference experiments laser pulses are displaced in time. The predicted IP results of the two models discussed below give different and opposite results from which the working model can be experimentally determined.

2. Concerning some problems of the Copenhagen interpretation

The summary picture of the QM according to the CI is given by M. Dirac, with his first works in the 30's years of the last century. In [1], he describes the interference of a photon, with properties and regularities that must be valid for a true and working CI. The full nature of the CI and the required EMW interference properties described by Dirac can be seen in the paragraph cited below, which is divided into two sections for convenience of comment. In [1] §3 **Interference of Photons**, Dirac writes: *Suppose that we have a light beam consisting of a large number of photons, which is divided into two components of equal intensity. Assuming that the intensity of the beam is related to the probable number of photons, we get that half of the total number of photons will fall into each of the components. If these two components further interfere, then we must require a photon from one component to interact with a photon in the other component. Sometimes these two photons will be destroyed, sometimes they will become four photons. This would be contrary to the law on energy conservation*.

In this case Dirac makes the wrong conclusion, because in real experiments on EMW interference no photon destruction is observed, but there is a redistribution of photons from the two beams, leading to interference fringes. Such destruction, also called wave suppression (destructive interference), occurs only in mechanical waves, for example water waves. Where the wave passes through a double gap, in the location where the two parts are in counter-phase they are extinguished and where they are in phase (superposition) they are summed up, so in this case also the law of conservation of energy is not violated. While there is no extinguishing with the EMW, but redistribution of the photons from the two beams, so that all photons fall on the screen, i.e. all energy falls on the screen and accordingly we monitor the IP without breaking the energy conservation law.

From which we have to draw the following conclusion. Mechanical wave interference and EMW interference are different processes, despite some common visual patterns observed on the screen (i.e. shore). The automatic transfer of regularities and models with the corresponding mathematical apparatus from mechanical to EMW is not always justified, even in some cases is wrong.

The new theory that links the wave function to the probabilities of a single photon overcomes this difficulty by assuming that each photon is partially in each of the two components. Then each photon interferes with itself. Interference between two different photons never occurs. The above relationship between particles and waves applies not only to light, but also to modern theory, it has a universal character.

The duality of the photon with the properties of both wave and particle, considered by Dirac and CI, solves one problem, but at the same time creates many others such as:

1. Until now, there is no physical clarity and generally agreed consensus on what is WF and, accordingly, WFC, also called wave function reduction. In [2] D.N. Klyshko on QM formalism writes: Unfortunately, the effectiveness of formalism is confronted with insurmountable difficulties for its interpretation. In this case, so far no unified idea of the meaning of the concept of wave function (WF) has been formed. A similar uncertainty exists for another important concept - WF reduction.

In [3] Chapter 2, Sudbery A. on QM probabilities writes: Notes on probabilities. Because the term probability plays a fundamental role in quantum mechanics, it may seem surprising that we assume that the reader is familiar with it and do not give a strict definition to the term. The point is that a complete, consistent definition of the term probability cannot be given.

In [3] § 5.5. Interpretations of Quantum Mechanics, wrote: Nine Interpretations of Quantum Mechanics. QM interpretations - this is essentially the answer to the question

<< What is a vector of states? >>

Interpretations cannot be distinguished for purely scientific reasons - they do not lead to different experimental consequences; None of the interpretations is generally accepted.

2. The WF of each individual photon must collapse at a speed greater than the speed of light when conducting experiments and observing IP. Because the WF considered as: located simultaneously in both arms of the interferometer, all-knowing about the whole experimental set-up, must be an instantaneous process at the WFC itself. (Which requirements are required for the delayed choice experiments considered here.) In this case, the problem is the following. Assuming that the WF is just a mathematical apparatus without physical reality, as the idea of WF follows according to CI, then such a mathematical apparatus will not have the power to cause the considered, omniscient, located on both arms of the WF-interferometer to collapse instantly with the corresponding end result IP. Or, although the WF is not real, it does in some unknown ways lead to a real redistribution of the photon (photons) forming the IP.

Assuming that the WF is a physical reality, then such a physical reality of the WF needs a real carrier. But there is simply no such real carrier, which clearly goes against the Einstein's the special theory of relativity for the ultimate speed of light.

3. There are experiments where, with reduced photon intensities, the observed interference and diffraction patterns worsen and disappear when single photon mode is reached. Such experiments have

been discussed in [4], and in addition to Verkhozin's author's experiment, previous ones have also been considered, as well as some of the so-called "forgotten" experiments, with the author concluding:

Low-intensity light beam experiments show that, unlike electrons, photon diffraction is a collective effect arising from the transition of a collective of large numbers of EMW photons. Therefore, to copy the wave properties of a single photon may not make sense.

4. Dirac's assertion of the universality of the new theory for all wave processes is inconsistent with the experiments observed. As discussed above, mechanical wave interference and EMW are different processes with different patterns. It turns out that the interference of electrons (particles with rest mass) and the interference of EMWs are also different processes with different regularities, although in some cases the visual patterns observed are the same. Demjanov in [5] performed a series of diffraction and interference experiments on EMWs and electrons. Performed on the same experimental set-up, for both EMWs and electrons. The standard diffraction and interference pattern observed with EMWs for electrons is quite different from that expected. There is a temperature dependence of the cover barrier (gap) on the passing electrons and there is no temperature dependence on the photons, as well as other observed effects, the author writes: *The data obtained show that the similarities between the behavior of the electrons and the EMWs are exaggerated. The purpose of this work is to clarify the extent of this exaggeration*.

In fact, the differences between electrons and EMWs should not be non-existent. Photons, whether single or multiple, are electroneutral. As long as the electrons are charged particles and each electron passes through the end of a barrier, a gap or in a crystal lattice, will interact with the electrons of the material environment, since Coulomb forces cannot be excluded in any way. Accordingly, the author [5] considers the possibility of interference and diffraction patterns in electronic ones due to ricochet effects and incorrect Coulomb forces accounting, necessitating a review and repetition of experiments giving these effects.

Note that the de Broglie particle with rest mass considered as a wave process at the beginning of the last century solves the problem of the accelerating electron in an atomic system and, respectively, the missing photon emission of the accelerated electron. But in 1965, De Broglie wrote in [6] the following: *The modern way of interpreting quantum mechanics does not coincide with the intention of my main idea. As I mentioned before, I thought then that there was a true existence of a wave and a corpuscle, closely interconnected, with the wave and the particle being physical realities defined in the ordinary way. In presenting the ideas of the Copenhagen School, I have reproduced some of these claims myself, but today my longer reflections on this topic make me think that they were wrong*.

The fact that the patterns of interference and diffraction in EMWs are different from the laws of mechanical waves and quantum particles with mass requires that we consider the laws of interference and diffraction in EMWs individually, and in this article we will only look at the properties and regularities of EMWs.

5. Dirac's assertion, taken as a basic rule in the CI that interference between two photons never occurs, is a major issue in this article, so we will look at this statement in more detail. In his 2005 Nobel Lecture. R. J. Glauber [7] writes: Obviously, Hanbury Brown and Twiss wanted to verify this claim in this regard as well; they conducted an experiment (Hanbury Brown and Twiss, 1956, 1957a, 1957b) to determine whether a pair of photons could interfere.

In [8] page 55, Glauber writes: *Recall that the Hanbury Brown and Twiss interferometer detect the incident light of two different receivers. Therefore, photons must participate in the interference effect in pairs, i.e. the output signal only arises when different photons hit each of the two detectors at the same time. This is where a serious dilemma arises: Does it follow to consider Dirac's claim that << interference between two different photons never occur >>*

In [8] **Lecture 16, Interference from independent light beams**. Glauber considered an experiment that could solve the issue of interference between photons from two independent lasers, where he wrote: *An elementary type of the experimental device is shown in Fig. 17. Two independent laser sources (or,* *perhaps, sources of another type) L1 and L2 project their beams in a direction close to parallel but slightly angled. The beams fall on the screen Σ and overlap their platforms. If the light intensity is sufficiently powerful or is possible to register for an extended period, it can be used as a photographic plate detector in the plane of Σ. If the conditions are not favorable for photography, a mosaic of photo detectors in the plane of Σ may be used. In all cases, interference fringes will be observed in the areas of beams overlap.*

Unfortunately, the experiment proposed by Glauber is not analyzed and carried out as a whole, but as uncomfortable for the CI is swept under the carpet, even contemporary authors who consider the raised case are limited to repeating the technical difficulties that the author shows in [8]. In the 1960s, there were no lasers with sufficient time coherence, which is a major technical difficulty for the experiment. Created in 1999, a laser [9] emits a visible spectrum with a wavelength λ=563nm. The laser (see Figure 1 of [9]) has a radiation spectrum width Δν = 0.9 Hz. So each zug (also called the wave packet) has a corresponding coherence time τ,

$$\tau = 1 / \Delta \nu, \tag{2}$$

And zug length l,

$$l = C * \tau , \tag{3}$$

where C is the speed of light. For references to τ and l, see references [10] (Chapter 7) and [11] (Chapter 4). In fact, the laser [9] (or [12] emitting in the infrared spectrum) has a time coherence of more than one second and a coherence length of more than one light second = 3.108 meters. (For ease of reference, we will use laser parameters [9] and average values for τ = 1 second time coherence and zug lenght l = 3.108 meters when considering actual experiments). So two beams of two independent lasers, for example [9], they will sometimes (only when two coherent zugs coincide in time) have a time coherence of one second, i.e. in the experiment proposed by Glauber, IP can be observed even with the naked eye. Or take multiple screenshots with an exposure time ≤ 1 ms (which corresponds to 1000 frames per second, what the exposure time for continuity is discussed later in the article), with most of the images being poorly contrasted , but some of the photos will be in good contrast to the IP.

2.1. Interference pattern of two different models

Let us make a brief analysis of the results of the experiment considered by Glauber [8] and Dirac (cited above in [1]), where they consider a similar experimental design. In order to observe (shoot) the IP screen on both, we have the same interference conditions as: two beams with equal number of photons (the same intensity as technologically possible), the same polarization between the two beams, the coherence between the two beams (in Glauber this coherence is a random process and for a limited time) and it is mandatory to intersect the two beams in space at a small angle before they hit the screen. If we do not fulfill the condition for the intersection of the two beams in space, then we will not observe the IR, and on the screen we will observe a Gaussian distribution (for a laser source for a beam with a transverse size much larger than λ).

According to the CI, the photon interferes with itself because when dividing the main beam into two betransams of equal intensities, for example, with a half-transparent mirror. For each photon, from the set in the beam, the path of the photon (or photon's arm) remains unspecified, a condition required by the CI. Accordingly, the WF of the photon (or the photon itself according to some interpretations) is located simultaneously in the two arms of the interferometer until a WFC occurs on the screen and we observe the final IR result. In this case, the problem for CIs is the following. Each photon from a light source is emitted and interacts as an indivisible discrete portion of energy. It is an experimental fact that each photon, from the multiple photons of the beam, passes only one arm of the interferometer after the half-transparent mirror. But, after a half-transparent mirror, each photon "acquires" the required wave properties viewed through WF. Like the WF itself, it is not a real physical quantity, only an idea of the internal coordination of the CI, but nevertheless, the WF "determines" the redistribution of photons on the screen to receive IR. For convenience, let's call the concept of CI as the wave function model (WFM).

According to Glauber's statement of [8], the two lasers are independent and in no way independent. As in the case, the path of the photon, or multiple photons in the beam of each laser, is determined, i. in this case, the "acquired" photon properties after the half-transparent mirror required by the WFM cannot be fulfilled. However, we still observe IR when the temporal coherence between the two independent lasers is satisfied.

From the above conditions, both under Dirac and Glauber leading to the final result IP, we have the mandatory condition that the two beams intersect in the space at a small angle. It follows that with this compulsory intersection of the two beams, there is a possibility that photons from one beam will affect the photons from the second beam, so that we obtain a redistribution of the photons with the final result IR. For convenience, let's call the idea of such an impact between photons from both beams, such as the influence model (MI). The main purpose of this article is to experimentally demonstrate the effects of MB.

In fact, Glauber's experiment, despite its technical problems, clearly proves MI. (In this case, we need to clarify - although the experiment proposed by Glauber in [8] proves MI, the explanation and the result considered are not based on the influence between the beams according to the MI, but instead use the temporal correlation between the photons, which correlation with the corresponding properties is developing for the author himself for laser light, as he wrote later in [7].)

The main idea in this article is to consider an experiment where there are conditions for the IR for both models (for the WFM and for the MI), but to observe the IR only in certain cases, giving unambiguous proof which model is correct and working. A brief working hypothesis about the physical nature of the so-called influence is given at the end of the article.

3. Regularities, properties and binding conditions for the interference and intensity modulation with a Mach-Zehnder interferometer

In this section, we will briefly look at the basic properties, devices, and binding conditions for the interference and intensity modulation required for the experiments specifically discussed in the following sections.

We usually look at the so-called light beam consisting of photons and EMWs, and for ease of reference we assume that the EMWs have a plane front and the beam has a real transverse size much larger than λ. By the concept of EMW, we mean periodically emitted and propagated in vacuum photons, indivisible and electroneutral, with a given direction and polarization. For example, a constantly emitting idealized single-mode laser of 1W power, wavelength $\lambda = 500$ nm and frequency $\nu = 6.10^{14}$ Hz, emits photons with energy Ef = 2.481 eV, according to (1). For a unit of time, the laser will emit $\approx 2{,}515.10^{18}$ photons. As in each periodic emission of EMW, ≈ 4192 photons are emitted. In this case, it should be borne in mind that photons must necessarily be an integer, with real lasers having some minimal fluctuation in the number of photons. By the intensity (or photon flux density) we have to understand the number of photons emitted or detected per unit time or during a periodic emission of the laser, any other idea of the intensity may in some cases be wrong. (For convenience, we will further calculate and use values for $\lambda = 500$ nm, since the real laser [9] also emits in the visible spectrum $\lambda = 563$ nm.)

3.1. Regularities and conditions for interference

An interferometric system (which usually includes an EMWs source, interferometer, and screen) is used to monitor the EMW's IP. When we need a full quantitative analysis or IP is realized in a short time, we can replace the screen with a photo plate or CCD camera. Instead of observing, we capture, memorize IP for later comparison, measurement and analysis to newly acquired IP using standard technique [13, 14, 15].

Of the various types of interferometers that exist, the most suitable is the Mach-Zehnder interferometer, which has the following advantages: it can operate in interferometer mode or in intensity modulation mode (optical switch), has two outputs, the two arms can be separated at unrestricted distances, does not generate reflected waves to the source. (The latter advantage is especially important when dealing with single photons or pulses, where reflected EMWs (photons) are not correctly accounted for in time-correlation experiments between photons and in some cases are interpreted as evidence of the validity of CIs. The interferometer can be configured in various ways depending on the requirement for a specific experimental set-up [10, 16].

In Fig. 3.1. a) a Mach-Zehnder symmetric interferometer is shown. Laser - L emits an EMWs of intensity *Ii* to a half-transparent mirror P1, which divides the laser beam by intensity. The interferometer has straight arms ARM - 1 = ARM - 2, the mirrors M1 and M2 are reflective. Mirror P2 is also half-transparent and divides the intensity into two outputs, in this case we use only the horizontal one in the drawing. Accordingly on the screen (E) – we have the specific distribution of the photons, i.e. IP with corresponding regularities of interference maximums and minimums (see Fig. 3. (b) of [17], below both pictures).

Mandatory IP monitoring requirements, i.e. the interferometer to work as an interferometer is that the two laser beams make a small angle before reaching the screen (E) - in [10] (Chapter 7), different configurations are considered to achieve the desired angle. In Fig. 3.1. b) the so-called obligatory small angle - α is shown between mirrors M1 and M2 for operation as an interferometer; for the sake of clarity, the angle - α is increased. It is known that contrast IP occurs only when two coherent laser beams(with equal intensity and uniform polarization) intersect in space. This condition is reached in point - 3 Fig. 3.1. b) where the redistribution of the photons occurs and they reach the screen as IP.

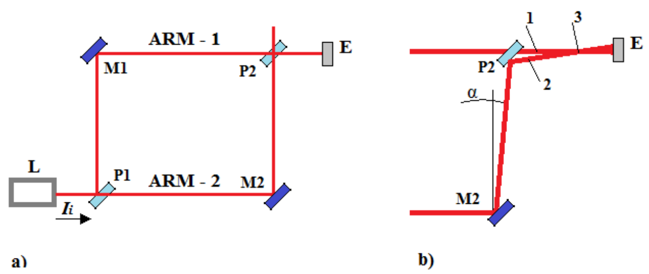

Figure 3.1. Mach-Zehnder symmetric interferometer. (a) Schematic diagram of the interferometer. b) Compulsory small angle-α between mirrors M1 and M2, for visualization angle-α has been increased. The numbers -1 and -2 show the points of the laser beams. The number -3 shows the point - 3 where the intersection and redistribution of the photons take place.

If we place in both arms of the interferometer, for example in point - 1 and point - 2, which are before point - 3, one half-transparent mirror and point the reflected beams towards the second screen. (The second screen, in order not to make it complicated, is not shown in the drawing.) Then, each of the reflected beams alone will not give the IP, and accordingly, if we provide an intersection for these two beams, we will observe the IP. But if we place a half-transparent mirror after point - 3 and point the reflected beam at a second screen, we will observe IP. Therefore, the redistribution of photons with the corresponding IP end result is carried out in space at the point so shown point - 3 of Fig. 3.1. b) The thus considered point - 3 should not be regarded as a mathematical representation, since it has very real dimensions, determined by the transverse size of the laser beams, the angle of intersection of the beams, and the parameters for a particular experimental set-up.

If we close one of the beams with non-transparent screen (for example, in point - 1), i.e. only one of the beams reaches the screen, the IP will not be observed, but we will observe the standard Gaussian distribution of the photons. The explanation for this result, according to the WFM is: the path of the photon is determined, the arm of the interferometer on which the photon passes. Whereas, according to the MI, the explanation is: one beam is missing, respectively, there are no conditions for influence between the two beams at the considered point - 3.

3.2. Regularities and conditions for an interferometer operating in intensity modulation mode

If the condition is that the two beams are parallel, then the Mach-Zehnder interferometer operates in intensity modulation mode. Accordingly, instead of IP, we will observe a Gaussian distribution of photons, the so-called zero-order fringe, see Fig. 3 b) of [17] above.

In Fig. 3.2. a) is shown a parallel-beams Mach-Zehnder symmetric interferometer with intensity modulation mode. If the EMWs of the two beams reach the second half-transparent mirror of the same phase, then at both outputs of the interferometer, the two photo diodes D1 and D2, we will measure equal intensity. But, if we somehow change the phase of one beam (we change the optical path), the intensity of the horizontal output, for example, will increase and with the same value, the intensity of the vertical output will decrease. As with a given phase difference, all the intensity of the two arms will be obtained at one output only, i.e. in this case, the Mach-Zehnder interferometer operates in intensity modulation mode as an optical switch. Changing the phase between the two beams can be done by lengthening or shortening one of the arms with the help of a micrometric screw, which is suitable for initial adjustment, but the process is mechanical and the phase change is relatively slow. The Kerr or Pokels effect [18] (Chapter 20) can be used for rapid phase change. In Fig. 3.2. a) a Mach-Zehnder interferometer operating in the intensity modulation mode is shown, with a Pockels-PC cell (with corresponding control electrodes) placed in the ARM-2 arm. When a control voltage is applied to the electrodes, it changes the optical path and phase of the laser beam, thus the instrument's transmittance factor, for a given output, is a function of the applied voltage. In this way, the interferometer can operate as an optical switch.

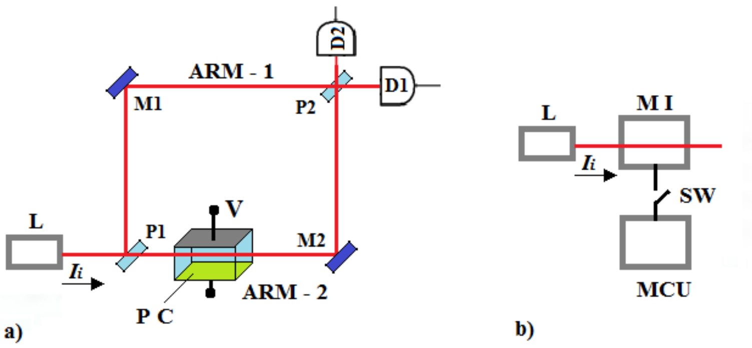

Fig. 3.2. a) Principle of operation of a Mach-Zehnder parallel-beam interferometer operating as an intensity modulator. b) Block diagram controlled by MCU mode. To obtain a permanent laser beam when the switch (SW) is off. Or laser pulses when the switch (SW) is on.

In Fig. 3.2. b) is shown a block diagram of a combination of; laser - L, intensity modulator operating as optical switch - MI and microcontroller - MCU controlling MI by applied voltage. The advantage of the MCU is that we can set pulse times and frequencies according to the so-called PWM electronics. When the SW switch is off, we have a continuous laser beam at the horizontal output of MI, and when the SW switch is switched on, we have pulses with parameters set by the MCU. This block diagram from Fig. 3.2. b) with which we can obtain a continuous laser beam or the pulses we need, will be used in all the experiments discussed below.

4. Real experiments on interference

At this point we will look at experiments that can uniquely determine which model, WFM, or MI is correct and working. For convenience and logical consistency, we consider the experiments as different variants, using as a basis the classical interference experiment, which we upgrade to the specific consideration in the following variants.

To evaluate the contrast or visibility of the interference pattern, A. Michelson introduced the IP visibility parameter V.

$$V = Imax - Imin \,/\, Imax + Imin, \tag{4}$$

where *Imax* and *Imin* is the maximum and minimum illumination (intensity) of the interference fringes (lines). If, the source is monochromatic and the other optical aids of the interferometer Fig. 4.1. a) are idealized, the visibility of IP will be V = 1 according to (4). But in this case, we use a real laser, real optical aids, so that the IP visibility for a Mach-Zehnder symmetric interferometer Fig. 4.1 .a) will be close but smaller than one (see [10] Chapter 10, [11] Chapter 4). But in this case, for example with the modern laser [9], we will have the most contrasting real IP with maximum visibility, which can be observed in principle, which we will conditionally call and refer to as Vmax.

In this case, since by default the experiments for the different variants that we will be looking at are performed on the same experimental set-up (where possible) and the exposure time for IP capturing is the same. We have continuity (full or partial) so we can use Vmax as a benchmark. Observed, filmed in one variant of the experiment to another, using a standard technique [13, 14, 15].

Variant - 4.1. In Fig. 4.1. a) an experimental set-up of a Mach-Zehnder symmetric interferometer with straight arms ARM - 1 = ARM - 2 is shown. In variant 4.1, the switch(SW) is not switched on and we have a continuous laser beam at the input of the interferometer, which is generally standard operation of the interferometer. Accordingly, on the screen we will observe IP with visibility Vmax. As a rule, in order to be able to compare the visibility V of the IP to the other variants, we shoot the IP.

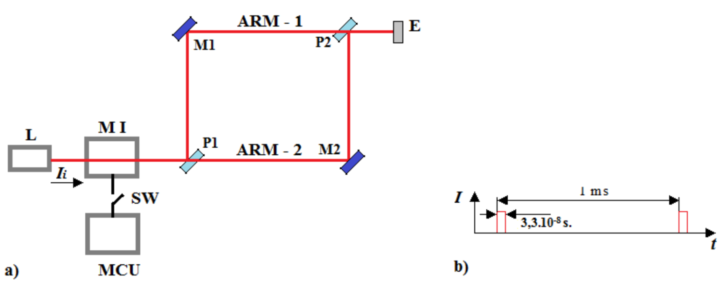

Figure 4.1. a) Mach-Zehnder symmetric interferometer capable of operating in MCU mode. b) Time diagram of laser pulses with switch(SW) on. Pulse duration 3,333.10^{-8}[s] and pulse frequency 1[ms].

Another effect that we can observe is the shift of the maximum of the IP relative to a specific marker on the screen, when the phase of the EMW of one beam is changed. Which is, if we change the length of, for example, the arm ARM - 2 (optical path in the arm) of the interferometer with a distance equal to λ/2. (Which change can be made with a micrometer screw introduced by Michelson, not shown on the figure). The maximum of the IP located on a specific marker on the screen will be displaced by the marker and in its place a minimum of IP will be observed. The effect of shifting the location of the maximum will be monitored in the following considered variants as the phase difference is a fundamental regularity affecting the IP.

Variant - 4.2. In this variant of the experiment, we use the same symmetric Mach-Zehnder interferometer Fig. 4.1. a) but in this variant the switch(SW) is on. In this case, rectangular electrical impulses are controlled by the MCU that control the MI, i.e. MI works as an optical switch and at its output we have laser pulses set by the MCU. Accordingly, at the input of the interferometer there are continuously receiving laser pulses with a period of 1[ms] and a duration of each pulse of $3{,}333.10^{-8}$ [s] Fig. 4.1. b) After the half-transparent mirror P1, each of the periodic pulses is divided by intensity, so that in each arm of the interferometer there are pulses of the same duration and intensity (called for convenience “cloned laser pulses”). The frequency and duration of the laser pulses are selected in order to have continuity with the following variants, as well as to be convenient for analysis and calculation. The only condition is that the pulse duration (or pulses in the other variants) is less than the time that the light travels the distance in the interferometer arm.

In order to be able to compare the visibility V of the IP to the other variants, we conditionally shoot the IP synchronized by the MCU pulse with a period of 1ms (1000 frames per second) and an exposure time $t \leq 1$ms. In this synchronization mode, on each photo of the IP during the exposure time only one of the periodic pulses of Fig. 4.1. b) will be capture.

The fact that impulses are coming to the screen, instead of constant laser radiation, will reduce the IP visibility according to variant - 1 that we took as a basis. But this difference will be minimal and in the case of convenience we can consider the visibility of IP for the variant - 4.2 as Vmax. If we change the arm length of ARM - 2 with $\lambda/2$, the maximum will be shifted.

Variant - 4.3. In Fig. 4.2. a) a non-symmetrical Mach-Zehnder interferometer is shown, capable of operating in MCU mode. For the case under consideration, and for the sake of continuity, the following asymmetry was selected for all variants, the arm ARM - 1 is 90 m long, the arm ARM - 2 is 130 m long, and the asymmetry of the interferometer is 40 m.

In Fig. 4.2. a) the so-called micrometric screw MMS (is shown, which can be used to change the length of the ARM-2 arm by $\lambda/2$, while simultaneously displacing the reflecting mirrors M3 and M4, which are attached together to a separate stand from the rest of the interferometer. Mirrors M2, M5 and M6 are reflective and through them we achieve the necessary asymmetry, while the other mirrors are analogous to the previous variants. Apart from the asymmetry of the arms, the other parameters of the experimental set-up are the same as the variants considered so far.

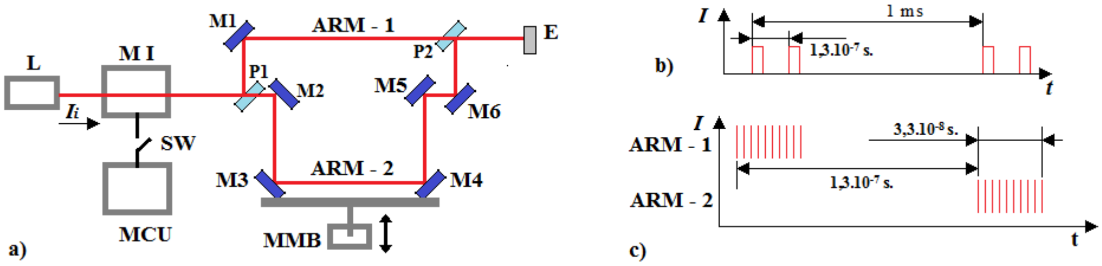

Figure 4.2. a) Asymmetric Mach-Zehnder interferometer with MCU mode capability. b) Time chart with SW turned on. At the output of the interferometer, a pair of cloned laser pulses with a period of 1ms and a delay between pulses of $1{,}333.10^{-7}$ s. c) A pair of cloned EMW laser pulses (vertical lines such as plane EMWs) crossing the shorter arm ARM-1 and the long arm ARM-2 are shown graphically. Each pulse has a duration of $3{,}333.10^{-8}$ s and a delay time between the two pulses of $1{,}333.10^{-7}$ s.

Let's look at variant 4.3 with the switch(SW) off. The visibility of IP due to the fact that the ARM-1 ≠ARM-2 will be worse than the Vmax we took as a basis. Note the visibility of the asymmetric interferometer with Vnes, then Vmax > Vnes. In the case of approximation, we can define the value of Vnes as the ratio of the asymmetry length of the interferometer of 40m to the length of the zug *l* (2), (3) of the laser [9]. In the literature [10] Chapter 10, [11] Chapter 4, the main regularities for visibility V of IP in quasi monochromatic sources and arms asymmetry are discussed, which is a complex process, and in this case we do not need full consideration. In this case, we will limit ourselves to Vmax > Vnes and the possibility to compare the results of a picture of an IP for a variant - 4.3 with the other variants that we shot. Accordingly, if we change the length of the ARM-2 on the interferometer Fig. 4.2. a) by means of an MMS with λ/2, the maximum will be shifted.

Variant - 4.4. In variant 4.4, we use the same asymmetric Mach-Zehnder interferometer Fig. 4.2. a), but with switch (SW) turned on. At the input of the interferometer there are continuously incoming laser pulses with a period of 1ms and a duration of each pulse of $3{,}333.10^{-8}$ s (as in variant - 4.2). The half-transparent mirror P1 divides the intensity (number of photons) of the incoming pulse equally into the two arms of the interferometer. But due to the asymmetry of 40 m, each of the laser pulses reaches the screen at a different time, and the pulse passed on the ARM - 2 will be delayed compared to the pulse passed on the ARM - 1 by $1{,}333.10^{-7}$ s, as shown graphically in Fig. 4.2. b), c) So at the output of the interferometer we have two cloned laser pulses, the same in duration and intensity. But with shifted, delayed in time, reaching the screen and, respectively, passing at different times at the so-called point - 3, Fig. 3.1. b). Therefore, the condition of influence will not be fulfilled and accordingly we will not monitor the IP according to the MI, ie. the visibility of the IP for variant - 4.4 will be V = 0. While, according to the WFM, the IP must necessarily be monitored because all the conditions required by the CI are fulfilled. For example, if we make an analogy with variant 4.3, where we have a definite experimental result, see the literature [10, 11], we have to observe the IP with Vnes visibility, according to the WFM, and for variant 4.4.

In the considered variants - 4.1, 4.2 and 4.3, from the end results, where we always have IP, it is not possible to determine which of the models is correct. Because the interference conditions are fulfilled for both models. However, in the case of variant 4.4, the condition of influence is not fulfilled, respectively, from the two models considered, two completely different and opposite experimental results for IP follow (are predicted). Therefore, from the experimental result of IP in variant - 4.4, we can uniquely determine which of the two models, MI or WFM, is true and working.

By default and for variant 4.4, in order to be able to compare the visibility of V with other variants, we shoot the screen synchronized by MCU pulse with an exposure time t ≤ 1ms (as in variant - 4.2). Accordingly, if we change the length of the APM-2 with λ/2, then we will not see a maximum shift according to MI on the screen because there are no maximum. Whereas, according to the WFM, IP and maximum shift must necessarily be observed.

Variant - 4.5. The purpose of the experiment, in version - 4.5 Fig. 4.3 is to get four cloned laser pulses. As two of the impulses to coincide at a time for which the condition of influence considered under the MI is fulfilled. Whereas, the other two impulses do not coincide in time with each other or with the two impulses for which the condition of influence will not be fulfilled.

In Fig. 4.3. a) two consecutively coupled asymmetric Mach-Zehnder interferometers, Interferometry-1 and Interferometry-2, are shown. Both interferometers have asymmetry and dimensions equal to the interferometer of Fig. 4.2. a) (Variants 4.3 and 4.4). However, Interferometry - 1 operates in intensity modulation mode and setting phase difference between the beams, using MMS, for 50% intensity of both outputs (we use this intensity setting for continuity and in this case we use only the horizontal output).

Short deviation. << A slight deviation from the main consideration is required. Apart from monitoring the IP, the fidelity of the MI or WFM can be proven by measuring the change in intensity between the two outputs of a Mach-Zehnder interferometer operating in the intensity modulator mode. For this case, we can use Interferometry - 1 from Fig. 4.3. a) operating in this mode, also using its vertical output (not shown in the drawing). The essence of which is, instead of shifting the maximum when changing the length of the ARM - 2 with λ/2, we will observe a change in the intensity between the two outputs of the interferometer operating in the intensity modulation mode. As, according to the MI, when the laser pulses coincide during (similar to the considered variants - 4.2) there will be a change in the intensity between the two outputs, and when the laser pulses do not coincide in a time (similar to the variants considered - 4.4) there will be no change in the intensity between the two exits.

Note that to the so-called vertical output of Interferometry - 1, we can include a third additional interferometer also operating in the intensity modulation mode, thus we will have logical continuity of the experimental set-up to the variant under consideration - 4.5 with four pulses for IP monitoring. As in the case where the so-called a third additional interferometer operating in the intensity modulation mode, we will measure the intensity change at its outputs. For coincident laser pulses, in case of phase change by λ/2 by MMS (similar to the variants considered - 4.5.a). Accordingly, there will be no change in intensity for non-coincident laser pulses upon phase change by λ/2 via the MMS (similar to the variants considered - 4.5.b).

(Note that the full consideration of variant 4.5 for IP observations follows below in the text, therefore, it is advisable, first, a full consideration of the interference variants and then consider the so-called short deviation, on changing the intensity between the two outputs, for which inconvenience I beg your pardon.)

The corresponding change in intensity between the two outputs, for the so-called third additional interferometer, can be measured with an oscilloscope, which is technologically more convenient. Thus, for coincident impulses, we can simultaneously observe the IP at the output of Interferometry-2. Fig. 4.3, so as to measure the change in intensity between the two outputs, if a so-called third additional interferometer is fitted.

In addition, when measuring the change in intensity between two outputs we have the opportunity to investigate. The duration of a particular zug, the phase change between two successive zugs and the processes associated with this change, as to date, to the best of my knowledge, no study of these parameters has been performed experimentally. However, in this case more variants and individual cases need to be considered, from which the basic idea of influence will be considerably complicated, so the measurement of the change in intensity between the two outputs is considered only informative and briefly in this article. >>

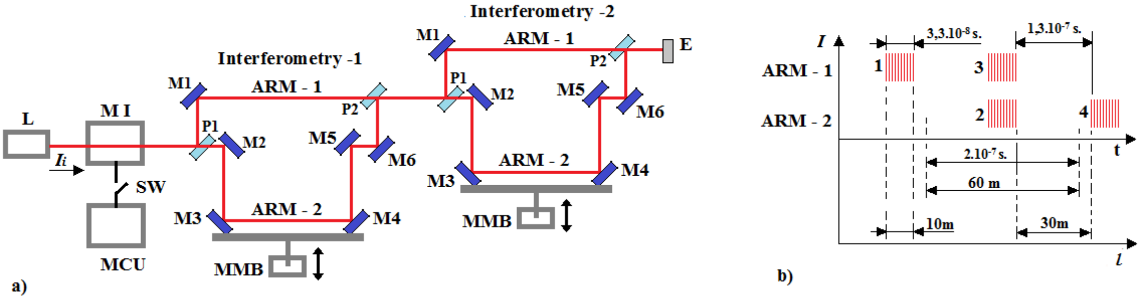

Fig. 4.3. a) Two sequentially connected asymmetric Mach-Zehnder interferometer with switch(SW) on. The first Interferometry -1 operates in the intensity modulation mode and the second Interferometry -2 operates in the interferometer mode. b) Time diagram of the four cloned pulses at the output of interferometer-2, graphically shown as vertical lines. Below is the abscissa l, shown as the distance in meters of pulse length and delay. As well as exposure time 2.10^{-7} s expressed in length in meters 60 m.

Second, Interferometry - 2 of Fig. 4.3, operates in interference mode and is identical to the interferometer of Fig. 4.2. a), with the relevant parameters and regularities considered for variant - 4.4. With two consecutively asymmetrical interferometers connected and a switch(SW) turned on, at the output of Interferometry - 2 we will have 4 cloned pulses, as shown graphically in Fig. 4.3. b). Because at the output of Interferometry - 1 we have two cloned pulses, which are cloned again in Interferometry - 2 and at its output we already have 4 pulses.

The coincidences and discrepancies in time, of impulses are obtained as follows, logic. The first, tentatively called the fasting impulse - 1, runs along the short arms of both interferometers. The second, impulse - 2 is a clone of impulse - 1, but passes over the long arm of Interferometry - 2. The third, impulse - 3 passes over the long arm of Interferometry - 1 and the shorter arm of Interferometry - 2. So that both impulses (impulse - 2 and impulse - 3, see Fig. 4.3. b)) arrive at the output of Interferometry - 2 simultaneously, as each impulse passes one short and one long arm of the two interferometers. Fourth, the impulse - 4 passes only the long arms of both interferometers and is therefore delayed relative to the others.

Checking the sequence, duration and shift considered during the four impulses thus examined, as well as the impulses considered in variants 4.2 and 4.4. We can perform by placing in each arm of the interferometer an additional half-transparent mirror (not shown in the drawings), and the reflected impulses are measured with photo detectors and an oscilloscope, using pulses from the MCU for synchronization.

Note that the placement of so called additional half-transparent mirrors will not impair the visibility of the IP that we see on the screen. It will not violate the uncertainty of the photon path, which precondition for uncertainty is mandatory according to the CI for IP monitoring. Because every photon (from the multitude in the impulse), reflected by the so-called additional half-transparent mirrors will be detected (or collapsed according to the WFM), but these reflected photons do not participate in the formation of IP observed on the screen. Whereas, each photon went through the so called additional half-transparent mirrors will participate in the formation of the IP observed on the screen, but for the photons that have passed, the hit on the screen (or collapse) is realized on the screen itself. In fact, the requirement under the CI is not to know which of the arms of the interferometer a particular photon (from the multiple photons in a beam or pulse) passes or so called uncertainty in the photon path. It is not violated for any of the variants, i.e. for each photon that hits or collapses on the screen, we cannot determine which arm it went through. Because after the first half-transparent mirror, the condition of uncertainty in the photon path required by the CI is fulfilled. Assuming that the uncertainty of the photon path is impaired as a result of using or measuring impulses, such consideration naturally arises in the analysis of experiments. Such a violation must be valid for all variants when using laser pulses, which is clearly not the case, because in variant - 4.2 and variant - 4.5 a) we use impulses, but nevertheless we observe IP.

In Fig. 4.3. b) as a function of the time above the abscissa t is given the time of each impulse $3{,}333.10^{-8}$ s, as well as the time $1{,}333.10^{-7}$s of the delay and accelerating impulse relative to the coincident impulse - 2 and impulse - 3. For convenience, below the abscissa *l* is shown as the distance in meters of impulses and delay, as well as the exposure time - 2.10^{-7} s when shooting only the impulses that coincide in time, expressed as the distance in meters - 60 m.

For laser pulses obtained in this way, by quickening, matching, and delayed laser pulses if we take a photo with an exposure time $t \leq 1$ms, what time we use for continuity. The IP that we are shooting will have a worse visibility than Vnes, according to MI, because the interference of the two coincident pulses will overlap with the uniform distribution of the photons of the two non-coincident pulses. While according to the WFM, the visibility of the IP must be Vnes, because for all four impulses reaching the screen all the conditions required by the CI are fulfilled.

But if we use a ultrahigh-speed camera synchronized with the pulse of the MCU, with an exposure time of 2.10^{-7} s corresponding to 5.10^{6} frames per second. For each pulse from the MCU, since the monitoring screen will receive self-timing pulses, we will have three consecutive shots; 1st of the so-called accelerating impulse - 1, 2nd of the coinciding during impulse - 2 and impulse - 3, 3rd of the so-called delay pulse - 4. In this way we have the opportunity to compare and analyze the visibility of the IP for the matching and non-matching laser pulses. As for coinciding laser pulses, there is a condition of influence, while for non-coincident conditions there is no influence, ie. we will have a definite experimental result for the correctness of one of the two models considered. For convenience below, we look at the result for matching and non-matching impulses separately.

Variant - 4.5. a) Consider option 4.5.a), in which we take a picture only of impulse-2 and impulse-3 coinciding. Fig. 4.3. b), which simultaneously reach the screen and respectively pass through the point so considered - 3 Fig. 3.1. b). Accordingly, the visibility of the IP will be Vmax, as in variant - 4.2, because the condition of influence is fulfilled. In fact, such a result is generally not contrary to the WFM (if we ignore the asymmetry).

To be completely correct in saying that Vmax of variant - 4.2 taken as the basis of comparison, will be equal to Vmax of variant - 4.5. a). Than laser pulses must travel the same distance to the screen for both variants. Thus, the length of the interferometer Fig. 4.1. a), for which no value has been given for its size in meters so far, we can assume for this case to be equal to the distance traveled by the impulses in the two interferometers of Fig. 4.3. a) .

For the sake of continuity for all variants, the sizes of interferometers and the required times selected are determined mainly by the ability to match the exposure time when we capture the two matching pulses. Developed photo and CCD cameras can handle millions of frames per second. In this case too, we selected a time of 2.10^{-7} s for exposure to capture only the matching pulses (see Fig. 4.3. b)) corresponding to 5.10^{6} frames per second. But we can also shoot in a lighter mode by taking just one snapshot of the matching pulses, with each pulse set by the MCU, ie. we shoot at 1000 frames per second synchronized with the MCU, but with an exposure time of each frame 2.10^{-7} s.

Except that the IP visibility will be Vmax for the coincident impulse-2 and impulse-3, then if we change the arm length ARM-2 to Interferometry-2 from Fig. 4.3 with $\lambda/2$, similar to the previous variants, the maximum will be shifted.

Variant - 4.5. b) The purpose of the variant - 4.5. b) is to take a picture, only on impulse-1 or only on impulse-4, without the so-called matching impulses. All considered times and exposure start times, similar to the variants discussed earlier, are relative to the clock pulse of the MCU. Given that impulse - 1 is accelerating and impulse - 4 is delayed (relative to coincident), we are not limited by the exposure time 2.10^{-7}s shown on Fig. 4.3. b) required for option 4.5. a), i.e. can be shot in a lighter mode when shooting only the pulse or only the delay pulse.

The result for the IP of the photos for impulse - 1 or impulse - 4 will be according to the regularities considered in variant - 4.4, i.e. coincidence at time in point - 3 Fig. 3.1. b) and there is no condition for influence between the laser pulses. Therefore, according to the MI, the visibility of the IP for option - 4.5. b) it will be V = 0 and there will be no maximum displacement. While, according to the WFM, the visibility of the IP for option - 4.5. b) must be Vnes, as in option 4.3. Accordingly, if we change the arm length ARM-2 to Interferometry-2 from Fig. 4.3 with $\lambda/2$, the maximum will be shifted according to the WFM.

5. Summary

The purpose of the experiments discussed in point 4 is to experimentally verify which of the two models, the WFM or the MI, is true and working. According to MI, the principle of locality is true. Accordingly, the end result IP will only occur with coincident laser pulses (or beams) and no IP will be observed when the laser pulses are shifted (divergent) during the point considered already in point - 3 Fig. 3.1. b). As well as shifting the maximum, when the optical path in one arm is changed by $\lambda/2$, there will only be available with laser pulses coinciding in time. While according to the WFM, based on the probabilistic model and the duality of the photon, according to the required properties of the WF and

WFC. Accordingly, the IP result must always be present, as well as the maximum shift, regardless of whether the laser pulses coincide or do not coincide in time at the point - 3 - considered here Fig. 3.1. b). For convenience, as experiments, some technical solutions and logic are considered in a new way, the results and parameters of the individual variants are shown in Table - 1. The symbol "X" in each column indicates the active option used for a particular variant.

Table - 1. Variants and results of experiments from point 4.

Variant	Symmetrical	Asymmetrical	Switch on SW	Matching beams (pulses)	Shift maximum	Visibility (V) of IP	Disagreement with the WFM
4.1	X	-	-	X	X	Vmax	-
4.2	X	-	X	X	X	Vmax	-
4.3	-	X	-	X	X	Vnes	-
4.4	-	X	X	-	-	V = 0	X
4.5. a)	-	X*	X	X	X	Vmax	-
4.5. b)	-	X*	X	-	-	V = 0	X

* variant with two asymmetric interferometers in series.

Important in this case are the last 4 columns of which we will make a brief comment;
Column - 5, matching beams (impulses): Simultaneously at the point considered in this way – 3 Fig. 3.1. b) that the coincidence or mismatch of the impulses is indicative of the correctness of one of the models.

Column - 6, maximum displacement: When changing the optical path in one arm by λ/2. Which, according to the WFM, should always lead to a maximum shift. Whereas, according to MI, maximum displacement will only occur with coincident beams or impulses at the considered point -3.

Column - 7, IP visibility V: This column gives values (stored, captured) for the observed IP visibility V, using as a basis variant - 4.1 (or variant - 4.2) for comparison, analysis to other variants.

Column - 8 does not agree with the WFM: when the result for the visibility V of the IP and the maximum shift does not meet the WFM requirement under the CI.

Specifically for individual variants;

Variant - 4.1, 4.2 Fig. 4.1 is a standard experimental set-up of a symmetric interferometer, giving a standard IP with Vmax visibility. Consideration of these variants, in addition to introducing the basic patterns of interferometers on which we base the upgrade on the following variants, is essential in order to have a stored result (photo) of IP with Vmax, which we can use to compare and analyze the pictures of the other variants.

Variant - 4.3 Fig. 4.2 is an experimental set-up of an asymmetric interferometer with a permanent laser beam at the inlet. As in this case, due to the asymmetry of the two arms, the visibility of the IP is Vnes. If we change the optical path in the ARM - 2 arm with λ/2, for variants 4.1, 4.2 and 4.3, we will observe a maximum shift.

Variant - 4.4 Fig. 4.2. b), c) is an experimental set-up of an asymmetric interferometer and the switch (SW) which is turn on. The experiment variant - 4.4 is crucial for the loyalty of the WFM or the MI. It is particularly important in this case that, despite the elementality of variant 4.4, the two models give completely opposite and definite results regarding the observed IP and shift of the maximum, so that one can unambiguously reject or confirm which model is correct and working.

The whole point of the experiments considered and the ability to prove which of the models is working is as follows. In version 4.3, we have a non-symmetric interferometer and continuous laser beams, respectively, we have a condition for influence between the beams, and on the screen we will observe IP with Vnes visibility. In variant 4.4, we use the same asymmetric interferometer, but with the SW switch on. Accordingly, the cloned laser pulses do not coincide at point - 3 Fig. 3.1. b) and we do not have the condition of influence, therefore we will observe an IP with a visibility of V = 0, according to MI. Whereas, according to the WFM, IP is the result of the interference of each individual photon (from the multiple photons in a pulse or beam). Therefore, according to the WFM, the IP and the maximum shift must necessarily be observed for variant 4.4 as all the required conditions are fulfilled as in variants 4.1, 4.2 and 4.3.

Experiments variant 4.3 and variant 4.4 are run on the same non-symmetric interferometer under the same conditions for both variants, the only difference being that in variant 4.4 the switch(SW) is switched on instead of the Vnes IP view for variant - 4.3, we will observe IP with visibility V = 0 for variant - 4.4. Which can be observed even with the naked eye, if we hold the SW key (manual or automated) for 10 seconds, then the observed IP for both variants will alternate in tact with holding the SW key.

As noted earlier, for the sake of continuity and more convenient analysis, for all variants of the experiments, a certain duration of laser pulses, length of interferometers, and pulse period were accepted. Which are optional if we focus only on variants 4.3 and 4.4 so that the most appropriate technical parameters can be selected and implemented, i.e. we can reduce the duration of the laser pulses in one order, the length of the interferometer arms, and accordingly the asymmetry decreases by one order (in this case becomes 4 m), and the pulse frequency of the MCU remains the same, since it does not relate to the visibility V of the IP and conclusions.

Experiment variant - 4.4 is crucial for the correctness of the WFM or MI, logically elementary and technically easy to perform or, in short, a student-like experiment, and can be performed in any optics laboratory without requiring sophisticated instrumentation. The only requirement is that the laser has a time coherence and a length of zug that exceeds the asymmetry of the interferometer many times. In order to have a good enough IP for variant - 4.3, to compare to variant - 4.4, where according to the MI the IP will not be observed. While, according to the WFM, IP monitoring is mandatory, i.e. of the two completely opposite results, the maximum requirements for the technical parameters are not imposed. Note that if we want to perform a complete qualitative and quantitative analysis of the IPs under consideration, then we must necessarily use the best parameters for both the laser and the other aids, as we theoretically consider in most of the article.

Such a result, an IP with a visibility of V = 0 for variant - 4.4, necessarily follows from the Glauber experiment [8] considered for two independent lasers. In fact, the experimental variant - 4.4 is partially performed whenever working with laser pulses shifted during the time required under some modes in experimental optics and spectroscopy. As the results considered in our case, IPs with visibility V = 0 were obtained and observed by the experimenters, but no relevant conclusions and analyzes were made. Indirect confirmation of the fidelity of the MI can be found in other experiments and observations of the IP, but in most cases interpreted only in a logic consistent with the WFM.

Suppose that the experiment variant - 4.4 gave the result of IP with visibility Vnes, which is the requirement according to the WFM and all gravitational around the CI representations. Such a result will confirm the credibility of the CI in a definite way, since even in the most successful experiments described in [19] (ie, briefly summarized A. Aspect experiments), they "prove" the CI. Result with IP quality with Vnes visibility, with the corresponding intensity (number of photons) not reached, i.e. another reason for the experiment to be conducted and analyzed. In fact, in the experiments in [19] there is no observation of the IP, and based on the temporal correlation of the detected photons for a long time an IP is formed. But in this case too, a number of technical parameters are far from desirable for us to consider the experiments to be completely correct.

Variant - 4.5 Fig. 4.3 is an experimental set-up of two asymmetric interferometers connected in series and the switch(SW) is switched on, respectively, at the output of the second interferometer we have 4 cloned laser pulses. As impulse - 2 and impulse - 3 coincide at the point considered in this way - 3 Fig. 3.1. b) for which the condition of influence is fulfilled and we will accordingly monitor the IP with visibility Vmax (similar to variant 4.2), this result is also consistent with the WFM. Until, for impulse - 1 or impulse - 4, the influence condition is not fulfilled and we will accordingly observe an IP with a visibility of V = 0, according to MI (similar to variant - 4.4). But such a result is inconsistent with the WFM.

The experiment variant 4.5 is technically more complex and not performed as a whole, but if we proceed from the results of variant 4.2 and variant 4.4, we can assume that the result obtained will be consistent with the MI. Although more complex, the experiment is also feasible and deserves to be performed and analyzed as a whole. Since, from one laser pulse, we clone four, and the corresponding IP for the matching and non-matching pulses can be explained by the influence in the considered point -3 Fig. 3.1. b).

In the case of three consecutive pictures, for the matching impulse - 2 and impulse - 3 we will observe an IP with visibility Vmax and a maximum of IP on a certain marker on the screen. However, if we change the length of the Interferometry - 2 ARM - 2 arm by $\lambda/2$, with the next pulse set by the MCU and three new sequential shots taken, the maximum for the matching pulses will shift. While for impulse - 1 or impulse - 4, IP and maxima are not observed. For convenience, the results for variant 4.5 are shown separately in Table - 1, for variant 4.5.a) we consider only the laser pulses coinciding, and for variant 4.5.b) we consider only non coinciding or so-called time shift during laser pulses.

6. Conclusions

One of the questions and problems in the QM that emerged at the beginning of the last century is the question of the essence of light interference. The experimental fact of the observed IP up to the beginning of the last century is explained by the wave properties of light. But with the proof that light is quantum in nature, these newly proven properties must necessarily be matched qualitatively and quantitatively with the experimental fact of interference. The explanation according to the WFM (imposed by CI) is that every discrete photon, from the multiple photons of the interfering beams in the interferometer, "acquires" and "possesses" the property of both wave and particle. But the so-called wave-corpuscular dualism imposed for WFM internal coordination leads to new discrepancies when fully considering the nature of interference. The considered wave-corpuscular dualism of the photon is not accepted by Einstein, and he writes to Schrodinger [20] p. 527: *Heisenberg's soothing philosophy (or religion?) - Bohr helps the believer obtain a pillow for a restful sleep. You can hardly get him out of this pillow. Let him lie down. But this religion has a devilishly little effect on me, and I nevertheless say: Not "E and ν", but "E or ν". It is not ν but E - after all, it is this magnitude that holds reality*.

The main problem is that the photon emits and interacts as an indivisible discrete portion of energy. It is an experimental fact that each photon, from the multiple photons of the beam, passes only one arm of the interferometer after the half-transparent mirror. As it falls (or collapses viewed under the WFM) on the screen, again as an indivisible discrete portion of energy. But in order to explain the observed experimental fact of IP, according to the WFM, it is necessary to require, after half-transparent mirror of the interferometer, a photon on unknown paths to "acquire" the required wave properties. The photonic wave properties considered by the WFM through the WF of the photon have no real physical value. However, the WF under consideration "manages" the superposition of something mysterious and unproven but leading to the end result of the IP.

With the EMW interference experiments considered, the two models MI and WFM give for IP different and opposite results for certain variants (see Table - 1). As in this case, relatively simple experiments can prove the working model. The advantage of MI over the WFM is that the redistribution of photons with the corresponding IP final result occurs in the space where the two beams or impulses intersect, i.e. the influence have local character. Thus, all the properties required and imposed by the WFM for internal coordination in explaining the IP, such as: "spilled" into both arms of the interferometer WF of photon, with the corresponding instantaneous WFC and nonlocality, uncertainty in the photon path, and the wave-corpuscular dualism of light, disappear as unnecessary. Therefore, the almost 100-year dispute in the QM between Einstein and the CI can be resolved in favor of Einstein, i.e. God doesn't play dice.

A brief working hypothesis about the physical nature of the so-called influence. If we quantize the physical vacuum (space), then the vacuum will be made up of the smallest cells with a size commensurate or smaller than 10^{-35} [m], which we can conveniently call the name Planck – plancks. Each discrete photon transmits energy and impulse in a particular direction, figuratively speaking, the photon "leaps" from planck to planck and "excites" each planck through which it passes, so that in this case, the photon is not required to be of size, mass and may exist only on the go. But apart from the longitudinal impulse (responsible for the so-called linear, "standard motion" of the photons in the vacuum), each "excited" planck, in response to the "passing" photon, creates a local temporary fluctuation in the vacuum, curvatures in the space of distances smaller than the wavelength. Which curvatures in space are responsible for the so-called influence between photons. In its own diffraction beam, as well as the influence of single-beam photons on second-beam photons in interference (when the condition of intersection of both beams is provided).

The very nature of the impact is voluminous, complex to consider, with a full analysis of all particular cases of interference and diffraction, and is not a goal in this article, but we can use it as a temporary working hypothesis. And in this case, we limit ourselves only to the experimental demonstration of the effects of the influence between two intersecting laser beams or pulses.

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