Towards a Full Verification of How Light Spreads at Large Distances

Corneliu I. Costescu (corneliucostescu@gmail.com)
Agora Lab
Ruxandra M. Costescu
National Institute of Materials Physics
Doina M. Costescu
Agora Lab

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TOWARDS
A FULL VERIFICATION OF
HOW LIGHT SPREADS AT LARGE DISTANCES

Corneliu I. Costescu[1,*], Ruxandra M. Costescu[1,2], Doina M. Costescu[1]

[1]Agora Lab, 1113 Fairview Ave, Urbana, IL 61801, USA,
[2]National Institute of Materials Physics, Romania
[*]Corresponding author, corneliucostescu@gmail.com

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Abstract. We recognize that the spreading of light at large distances (the whole space) is the only property which can decide by yes or no if light really behaves physically like waves, while the fit of the waves for describing the diffraction fringes is insufficient for this purpose. Indeed, the fringe space is too limited and hence, brings the possibility of misinterpretation. Hence, the experiment for the verification if light is spreading like waves at large distances is necessary in principle, and is crucial. However, very surprisingly and tragically, this experiment was totally missing in history. This experiment uses the simplest diffraction case, in which a beam of light falls perpendicularly with its axis on the line and the plane of a straight edge. Practically, this experiment verifies if there is a dependence of the diffracted light at large distances in the geometrical shadow on the changes in beam thickness traversal to a single straight edge, while the distribution of light along the straight edge remains the same. If this dependence exists, as the wave theory for light fundamentally predicts, then the wave approach to light is physically true. If there is no dependence then light cannot behave physically like waves. This experiment can clearly be developed and performed without any calculation from the wave approach, just by a careful measurement practice. However, for a broader view, we describe in detail wave results for spreading of light at large distance, which illustrate the experiment – what are the spatial points where the measurement must be done to see if the above dependence exists, and which is the big picture for the wave approach. We attempted this experiment for many years, but could not finish it because of the lack of resources to measure at 100 – 500 m. The present article will empower big labs to perform this experiment. However, we show alternatively that the answer to how light spreads also comes from comparing the well known data for the diffraction on macroscopic holes with relatively recent data for the diffraction on nanoscopic holes. This comparison clearly shows that light does not spread physically like waves, which makes necessary a new, non-wave but periodic structure for light. Such an alternative answer regarding the spreading of light also makes absolutely necessary to perform the above missing experiment, as a direct way that convinces anybody how light is spreading.

Key words: light spreading at large distances, missing experiment for the wave approach.

I. INTRODUCTION

We recognize an unsolved fundamental problem for the nature of light, namely we recognize that the spreading of light at large distances (the whole space) is the only property which can decide by yes or no if light really behaves physically like waves in propagation, while the fit of the waves for describing the diffraction fringes is insufficient for this purpose. Indeed, the fringe space is too limited and hence, brings the possibility of misinterpretation regarding the nature of light. Hence, the experiment for the verification of how light is spreading at large distances is necessary in principle and it is crucial, but it is still missing. This experiment is as follows. A stable laser beam falls perpendicularly with its axis on a straight diffracting edge, where the distribution of light intensity along the edge can be maintained constant, while the distribution of light transversal to the edge can be substantially broadened. For each case of transversal distribution of light, the intensity of the diffracted light is measured in a set of points at large distances in the geometrical shadow. If the results show a dependence of the intensity of light on the beam thickness transversally to the diffracting edge, as the Maxwell equations and the wave diffraction integral for light predict, then the wave theory of light is physically true. If there is no dependence, then light does not spread like the waves do, and a new physical approach is necessary for light, that is a diffraction mechanism that takes place only in the material edges. Hence, this experiment is crucial, and can be done without any wave calculation for defining the measurement points because these points can be found by a simple but systematic practice of light measurements at small and large distances.

The method for missing fact and broad views. Before introducing the methods for the measurements used in this paper, we describe the method necessary for naturally recognizing this missing experiment for light and its results, and hence, for avoiding to repeat in the future the case of the missing fact for heat (producing heat by mechanical action). From our lifetime work on light we found that both the case for light and for heat happened because the method of broad thinking on the major opposing views in a field, is not used systematically in the university, in society in general. For the case of light, the major opposing views are those on the origin of the diffracted light – as waves both inside and outside of the diffracting edge, or only inside the diffracting edge. A simple broad thinking on these opposing views shows to the regular student that there is no verification on how light spreads at large distance, and that the diffracted light is born only inside the diffracting edge, which makes impossible for light to physically behave like waves in diffraction (because if it did, the diffracted light would also be produced around the diffracting edges) … Only by using this broad thinking, we realized that there is a missing experiment at the foundation of light: how light spreads at large distances: as waves or not as waves. For heat, the opposing views were how the heat is produced – only by the vicinity with hot body, or both by this vicinity and by mechanical action … If the student is taught and allowed to practice this broad thinking he/ she will see the missing fact/

experiment, and hence, the theories that are based on missing fact will not survive/ repeat … On this line of thought, sooner or later this method will become a basic part in the education in science, for a scientist with the big-picture knowledge, in excess to the method for fast thinking for detailed knowledge … This method is also necessary for the society sciences. For instance a broad thinking on the major opposing views in society, namely those of liberals and conservatives, shows quickly that a major and simple system is missing in society/ democracy - the system for growing/ developing common ground, functional and wise broad views. In such a system the Constitution requires that a party and a candidate, in order to participate in elections, must prove that they know the method and have work to grow some common ground/ functional and wise broad views with their counterpart. It would also be a requirement that a non-government organization should enforce this system for common ground/ functional and wise broad views.

In Section II we present a detailed description of the crucial experimental setup which is necessary for the measurement of the dependence between the light in the geometrical shadow and the light above the diffracting edge, a dependence that is crucial for the nature of light. Performing this experiment does not necessarily need the wave calculations because the measurement points in the geometrical shadow can be found by a systematic practice. However, such calculations clearly illustrate how the waves generate the above dependence and where to measure. In Appendix we use the wave approach to illustrate approximately how the waves intrinsically produce the above dependence of the diffracted light in the geometric shadow, on the wave front above the diffracting edge. For this purpose we use in Appendix the scalar Rayleigh-Sommerfeld wave diffraction integral in the Fresnel approximation for a Gaussian laser beam. Such a diffraction integral is accurate in the wave picture (but not necessarily in the reality of light), if the following conditions are satisfied. (1) The diffraction aperture must be large as compared with the wavelength. (2) The diffracted light must be observed not close to the aperture. (3) The laser beam comes from a low power, helium neon laser (a Micro-g Lacoste laser - a high quality He-Ne, 1mW, stable laser) for which it is justified to use a single transverse mode (also called a pure or fundamental mode) Gaussian beam, that is an ideal mode beam. For higher power lasers, would be necessary to use more complex beams. However, since for our experiment, the wave calculations are necessary only as an illustration, that is, not as strictly necessary calculations, it is sufficient to use the single transverse Gaussian beam. We do these calculations to illustrate the wave big picture for the experiment, and to suggest the measurement points at large distance in the geometrical shadow, which otherwise can be found by a systematic measurement practice.

Results. In section III we show that we designed and attempted this experiment for more than 10 years, with measurements up to 5 m distance in the geometrical shadow, from the diffracting edge. For these distances, we found no dependence of the diffracted light on the beam thickness above the diffracting edge, which is in accordance with the wave integral prediction. Due to the lack of resources to measure at 100 – 500 m, where the wave approach indicates the existence of such a dependence, we could not finish the experiment. But our documentation here for our experiment will allow that bigger labs develop and finish these measurements.

However, Section III also shows that by using the method reported above, namely the broad thinking on the major opposing view, we found that alternatively, the proof for how light spreads in general, surprisingly comes by recognizing the real significance of relatively new experimental data existing for the diffraction on macroscopic holes. This experimental data comes from measurements which analyze the role of the edges in the diffraction on nanoscopic and microscopic holes in nanoscopic walls. We show that the data from these measurements provides a simple case of reduction to absurd for the wave approach which demonstrates that light has physically a non-wave spreading. This conclusion makes necessary and important for the physics community to perform the above missing direct experimental verification, as a double-check. If correct, this conclusion makes necessary a new, non-wave but periodic, mechanism type structure for light. This situation would be similar but much more important than the case when the heat production by mechanical action was missing and then added in physics by the kinetic theory of heat instead of the model of the caloric fluid for heat. A new mechanism type structure for light would remove the non-mechanism, physically impossible ideas like "light spreads like waves, but nothing oscillates", while still allowing to use the wave approach as a formal way, valid for practical quantitative evaluations in the limited space of the diffraction fringe zones.

As a result of the proof presented in Section III, which is that light does not spread like waves at large distances, in Section IV we shortly introduce a new structure for light, its applications in optics, and its broad consequences. This part of the paper is presented in detail in our longer paper of 65 pages, which we Copyrighted but did not succeed to publish [10].

II. THE EXPERIMENTAL SETUP AND MEASUREMENTS

In our straight edge diffraction experiment, Fig. 1, a laser beam of light falls with its axis perpendicularly on a sharp edge and forms a luminous column on a screen at any distance from the diffracting edge in the direction of the light propagation. This column is perpendicular on the diffracting edge, and the part of this column with fringes is only in the directly illuminated area on the screen, while the non-fringe part is in the geometrical shadow of the diffracting edge.

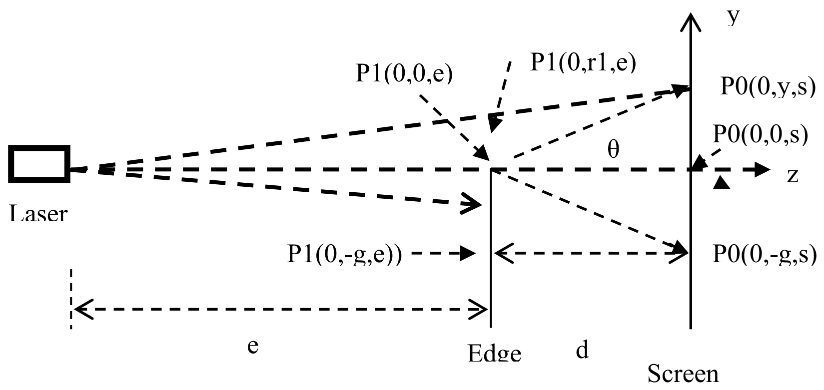

Fig. 1. Single straight Edge diffraction where θ can be positive (directly illuminated area) or negative (geometrical shadow).

In this experiment a laser beam hits perpendicularly with its axis a straight diffracting edge, and the intensity of light is measured in the geometrical shadow of the diffracting edge at points P0. This experiment verifies systematically if the intensity of the diffracted light in any point in the geometrical shadow, especially at large distances, increases when the thickness of the diffracting beam increases transversally to the diffracting edge. This dependence is more important than the diffracting fringes because it involves a very large (infinite) volume. Surprisingly, this dependence, although is the most fundamental prediction for understanding the spreading and hence, the nature of light, was not systematically measured yet.

This experiment tests if the Huygens principle, or the wave diffraction integral is valid for the diffracted light in the geometrical shadow, that is if the later depends on the thickness of the beam transversal to the diffracting edge, while maintaining the same distribution of light along the diffraction edge. We answer the following questions. What is the experimental setup? Where to place the diffracting edge? How the experiment can vary this transversal thickness of the beam and maintain the longitudinal distribution of light along the diffracting edge? At what distance from the laser we need to measure the light in the geometrical shadow in order to see if there is a dependence on the beam thickness across the diffracting edge? By the following a quick insight and systematic measurement, or by the calculations with the elliptical Gaussian beam, given in the Appendix, we answer these questions.

Our experimental setup includes three systems: a highly stable laser with a fine positioning/ orientation system, a fine edge/ slit system with micrometric positioning system, and a detector system: a linear detector - PDF10A, Femtowatt Photoreceiver from Thor, and a two-dimensional camera - the Little Guy beam

$\lambda = 6.32 \cdot 10^{-4} mm$), 1mW: with a highly stable in intensity and direction 1mW laser. For this Gaussian beam the minimum beam radius (waist, see Appendix) is ω_m = 0.3 mm at the exit from the laser, and with a beam divergence 2θ =1.3 mrad.

The measurements compare two basic experimental cases. Case 1: By placing the diffracting edge at s = 1500 mm from our laser, the beam waists across z axis are $\omega_x = \omega_y = \omega_m \sqrt{1+(s/z_0)^2} \approx$ 1 mm, where $z_0 = \pi\omega_m^2/\lambda \approx$ 450 mm. Case 2: With a cylindrical lens placed between the laser and the diffracting edge, with its axis parallel with the diffracting edge, and which intersects the z axis between laser and diffracting edge, it is easy to increase as necessary the beam waist along y axis at the diffracting edge, to ω_y = 3 mm for instance, while maintaining ω_x = 1 mm along the diffracting edge.

A quick insight for where to measure the diffracted light in the geometrical shadow for these two cases, to see the difference between them, can be obtained by evaluating the radius of the first Fresnel zone on the integration domain of the diffraction integral. It is well known that this Fresnel zone is the main contributor to the value of the diffraction integral for any given point P0(0,-g,s) in the geometrical shadow. For d ≫ g a good approximation of the first Fresnel zone for the point P0(0,-g,s) is a circle segment, in the integration domain of the diffraction integral, with the center in P1(0,-g,e)defined by the straight diffracting edge (through the point P1(0,0,e) and by the circle, in the integration domain, with the center at P1(0,-g,e) and passing through the point P1(0,r1,e) – see Fig. 1, from the integration domain in the diffraction integral, where r1 is defined such as the distance between P0(0,-g,s) and P1(0,r1,e) equals the distance between P0(0,-g,s) and P1(0,0,e) plus $\lambda/2$ and hence, for d significantly larger than λ. If d ≫ g $r1 \approx -g + \sqrt{g^2 + \lambda d}$. For P0(0,-g,s) in the geometrical shadow with g = 10 mm and d = 5 m, 50 m, 100 m and 500 m, the results for the radius r1 of the first Fresnel zone is of the order of 0.15 mm, 1.45 mm, 2.77 mm and 10.4 mm respectively. For g = 20 mm and the same d values, the results for r1 are 0.08, 0.77, 1.52, and 6.76 respectively. This means that the difference between a case with a beam thickness of 1 mm (Case 1) on the diffracting edge, both longitudinally and transversally to the diffracting edge, and a case with a beam thicknesses of 1 mm longitudinally and 3 mm transversally to the diffracting edge (Case 2), can be seen by measurements of the light intensity at points in the geometrical shadow on the on the lines with y_0 = -10 mm and y_0 = -20 mm, at distances d in the range100 m – 500 m.

An analytical and numerical approach that shows the wave results for such values of g and d, based on using the diffraction integral, is given in Appendix. We use there the Rayleigh-Sommerfeld (RS) formula for the diffraction integral, which is simpler than the Fresnel-Kirchhoff formula and accurate at distances in the fringe zones, that is not close to the diffracting edge, and hence, it is expected to be accurate at larger distances.

The Appendix shows that the numerical calculations with our Fortran program Edgediffraction Gaussianbeam show the following differences between the light intensities for the two cases above (Case 1 and Case 2): 1) Less than 1% for d = 5 m, g = 10 mm below z axis, that is in the geometrical shadow. 2) 5% for d = 50 m, g = 10 mm below z axis, that is in the geometrical shadow. 3) Around 75 % for d = 100 m, g = 10 mm below z axis, that is in the geometrical shadow. 4) Around 250 % for d = 500 m, g = 10 mm below z axis, that is in the geometrical shadow. Therefore, these numerical results show that we need to measure the diffracted light in the geometrical shadow for d in the range from 100 m to 500 m, and with g in the range 10 – 20 mm. If we need to measure deeper in the geometrical shadow (at larger values for g) we will need to measure at larger values for d. the We needed a long time to explore by calculations where we need to measure. Initially we were looking at distances d from 5 m to 10 meters.

Again, how can accomplish experimentally the above Case 1 and Case 2? Experimentally, the beam waists for our laser are in the same place $z_{mx} = z_{my} = 0$ mm on the z axis, as described in the Case 1 above. Again, for Case 2, we place a divergent cylindrical lens of a certain focal distance f at a position z_l, before the diffracting edge for Case 1, with the axis of the cylindrical lens parallel with the x axis. Then the beam spreads more along y axis, as if a second beam waist ω_{new} along z axis (smaller than ω_{my} from the Case1) is created at the distance d before the lens, as necessary for the Case 2. By varying the position the lens position z_l and the focal distance f we can have the same distribution of light falling on the diffraction edge along the x axis, but a broader light beam transversally to the diffracting edge as necessary for good differences between the Case 1 and Case 2. Hence it is possible to reproduce experimentally the Case 1 and Case 2 above. Certainly the normalization of the beam at the diffracting edge for the two cases is necessary in order that the distribution of light along the diffracting edge be the same in the two cases.

III. RESULTS

1) The results from our experiment

Due to limited resources of our small lab, we could perform the measurements only at distances up to 5 meters from the diffracting edge. For these distances the differences between the above two cases for the diffracted light were very small, as the wave integral predicts. This means that we could not measure in the range of 100 m to 500 m where the wave approach displays a strong dependence of the diffracted light in the geometrical shadow on the beam thickness traversal to the diffracting edge. It took a long time, a lifetime for the authors to perform these steps. By this paper, our work could be the basis for future attempts to verify this dependence.

2) The alternative experimental proof that light does not spread like waves

As described above, the experimental verification of how light spreads at large distances is missing. In this context, we found that the experimental results from Ref. [2-9] are totally useful. These experiments analyze the role of the edges in the diffraction on nanoscopic and microscopic holes in nanoscopic walls. The results display a surprising extraordinary transmission-type of diffracted light, instead of the regular fringe pattern seen in the cases of macroscopic diffraction of light. The authors rightly conclude that the transmission, that is the spreading of light through the nanoscopic edges, have a major contribution to the diffracted light. And they extend the wave propagation in the nanoscopic walls to include this contribution and successfully describe the experimental results on nanoscopic and microscopic holes.

However, the authors of these measurements did not see that this important contribution from the edges in the diffraction on nanoscopic holes, brings the following absurd contradiction in the wave approach for the diffraction on macroscopic holes. Indeed, the edges in the macroscopic holes necessarily have a macroscopic surface area with nanoscopic terminal shapes, and hence, according to the above findings, these macroscopic edges necessarily contribute an important part of the diffracted light. Such an important contribution is also supported by the direct observations with the naked eye, from all directions and from all distances, around the illuminated spots on the diffracting edges in the macroscopic case. The brightness of these spots is even bigger than some of the diffraction fringes. This clearly shows that the brightly illuminated spots on the edges are a source of diffracted light both for the directly illuminated area of the diffraction pattern, and for the shadow area of the diffracted light. However, in the wave approach, the diffracted light is sufficiently described by the diffraction integral applied only on the inner/ empty space of the macroscopic hole, that is without any illuminated spot on the diffracting edge. And what is the contribution from the edges in this wave approach? If the wave diffraction integral is extended inside the diffracting edges of the hole, the contribution from these edges to the wave diffraction integral is small as compared with the contribution of the wave front on the inner space of the hole. This is a direct result of the fact that the waves on the inner space of the hole can produce by itself the diffraction fringes, and is in total contradiction with the above conclusion from the experimental data of [13-20] that the diffraction edges have an important contribution to the diffracted light. (However, this result from the wave approach for the light diffracted inside the edges, is used in existing books and discussions to wrongfully claim that the edges have physically only a small contribution to diffraction, and hence, justifies ignoring the related questions on the wave nature of light.) Based on this contradiction of the wave approach with the results from [1-8] we have a clear case of reduction to absurd for the wave approach, and hence, light does not spread as the waves do.

This means that in the wave approach, the real problem is replaced by a formal approach valid only in the fringe zones: the fringes are formed mainly by the inherent capability of spreading and interfering of the wave-front which passes through the inner space of the hole. But even this formal fit which the waves give in the fringe zone of the macroscopic diffraction, leads to some poor results, as the diffraction on a simple straight edge (not a hole) shows. Indeed, there is a simple experimental proof [9] that the waves do not give the right position of the diffracting fringes.

These conclusions make necessary and important for the physics community to perform the above missing experimental verification, as a double-check that convinces everybody what the nature of light is. If correct, these conclusions make necessary a new, non-wave but periodic, mechanism type structure for light. In a separate development for a new physical model for light, that is for a non-wave but periodic model, we show that this model is feasible and brings mechanism-type explanations for all the optical phenomena. This would be similar but much more important than the case when recognizing the heat production by mechanical action made necessary and feasible a mechanism-type model, which is the kinetic theory of heat, instead of the model of the caloric fluid for heat.

IV. THE FEASIBILITY OF A NON-WAVE, MECHANISM-TYPE STRUCUTRE FOR LIGHT, APPLICATIONS AND CONSEQUENCES.

1) The feasibility of a non-wave but periodic model for light

The above experimental verification of how light is spreading at large distance, and the above proof that light does not spread as the waves do, is the missing fact at the foundation of the current understanding of light. This is similar with the missing fact, long ago, of how heat is produced by mechanical action, at the foundation the old caloric fluid understanding of heat. This missing fact for heat showed the necessity of a new type, mechanism-type understanding for heat, and similarly the current missing fact for light, shows the necessity for a new, non-wave, mechanism-type understanding for light.

In Ref. [10] we present as follows the feasibility for a new, non-wave but periodic, mechanism-type understanding for light. We propose the bi-structure of light based on the concept of finely dispersed or dark matter, and show that it offers easy, mechanism-type explanations and quantitative descriptions for all the optical phenomena. In Ref. [10] we also present the major consequences, of this new approach for light, for understanding the electromagnetism, gravity, atomism and condensed matter.

This bi-structure concept is based on two necessities. First, on the necessity for a non-wave model, which is a result of the fact described in this paper, namely that light does not physically spread like the waves do in free space at large distances. Second, the bi-structure is based on the necessity that light produces, by much stronger forces than the instantaneous mechanical forces, collective electron oscillations (the Lorentz model), photoeffects or electrical currents on the surface of matter. Hence, the bi-structure is based on the following two facts. a) The existing verifiable concept of the electron or lattice oscillations in condensed matter. Currently these oscillations are described with the electromagnetic equations for plasmons and for ultrasound. b) The need for a non-wave but periodical structure in free space that produces the phenomenon of interference. In this attempt/ quest we propose that a light beam propagating in free space and in transparent matter is a bi-structure, that is a structure of two parts: 1) A set of collective longitudinal electron oscillations propagating in transparent or absorbing condensed matter. 2) A corresponding set of periodic trains of bursts of finely dispersed mater – a concept similar with the dark matter, in free space. 3) These two parts are transforming, by a strong resonant momentum transfer (non-instantaneous effect), into each other on the surface of the condensed matter, depending on the direction of the propagation – towards the matter or outward from the matter. The bursts have a limited transversal section, and the number of bursts in a train can vary as dictated by the physical characteristics of the cases. These trains are randomly distributed across the transversal area of the beam. The number of trains per unit area in the beam light can vary and defines the intensity of the beam, and fluctuates which is the basis for the random aspects of light.

For the bi-structure, the periodicity and the discontinuity of light in free space are main factors for its properties and effects. When a train of bursts impinges on the surface of body it produces, by its periodicity, a resonant momentum transfer, and hence, collective longitudinal electron oscillations which propagate mainly forward in a transparent material, as the bi-structure part of light in condensed matter, or produce effects on the surface in a metal – photo effect for instance. At the exit surface from a transparent material, the arriving collective electron oscillations throw in space a train of finely dispersed matter. The non-wave but periodic structure in free space and the interaction of the two parts through resonant momentum transfer are the essential ideas of this bi-structure. The resonant interaction between the two parts of the bi-structure through momentum transfer replaces the action of the electromagnetic field on electrons, by the action of periodic trains of bursts for the same purpose, namely producing collective electron oscillations that propagate in matter in the direction of propagation of light. The idea is that the strong action of the electromagnetic forces, that has no mechanism, can be replaced with the same effect (collective electron oscillations) by a time-taking resonant process based on momentum transfer, a process that is based on a mechanism-type interaction, between a moving field of finely dispersed matter (dark matter) and particles like the electrons. Such a structure, discontinuous longitudinally and transversally can be tested in an imaging experiment by transforming a narrow beam into a strongly divergent beam that falls on a large array of very small light detectors, to study their random flickering as a function of intensity. We show first the bi-structure applications in Optics.

Four simple models are necessary for explaining and describing the optics phenomena in direct comparison with the electromagnetic approach. This direct comparison starts with the most fundamental case/ model (Model 1) – the model of the structure of light in free space and its propagation. The second model (Model 2) describes the local production of collective electron oscillations on the surface of condensed matter. The third model (Model 3) describes the propagation of the collective electron oscillations in bulk matter (the bulk part of the bi-structure), in comparison with the electromagnetic waves propagation in matter. The first three models are necessary for describing the propagation of light through free space and materials. The fourth model (Model 4), together with the first two models, shows the simple mechanism for light diffraction/ spreading across the macroscopic and nano-structure edges, and for the propagation of light and electron oscillations/ currents (plasmons) in surface nanostructures, in contrast with the formal electromagnetic approach. These four models can be used to explain in a mechanism way the light phenomena in Optics, for instance the Michelson-Morley experiment, with broad applications and to see broad consequences in Physics.

2. The non-wave model in free space for light

Four simple models are necessary for explaining and describing the above phenomena in direct comparison with the electromagnetic approach.

Model 1 – The periodic momentum carried by a train of bursts, and the resonant action. The free-space periodic part of the bi-structure is based on the concept of finely dispersed matter, or dark matter, present and moving in space and being in equilibrium with the bodies of condensed matter.

This paragraph gives a short quantitative description of the periodic trains of bursts of finely dispersed matter in free space, and of its effects on condensed matter, in direct comparison with the electromagnetic approach. The distance between the centers of two bursts in the train is λ and there is a finite number of bursts in any train. Each burst carries a momentum spatially distributed over the space/ shape of the burst. We assume that this momentum distribution along the line/ axis of propagation in a burst is like the positive part of a cosine, and is zero on the segment where the cosine has negative values. The zero segment defines the space between two bursts. Therefore, the propagation of the momentum carried by the burst on the train axis can be described approximately/ generically by

$$p(z,t) = A \cdot pc(kz - \omega t) = A \cdot \cos(kz - \omega t))$$
$$when \quad \cos() \geq 0\, and\, 0 \quad otherwise. \qquad (1)$$

or by $$p(z,t) = A \cdot (1 + \cos(kz - \omega t)) \geq 0\,,$$

where "pc" equals cosine values when cosine is positive or zero, and equals zero when cosine is negative. Here $k = 2\pi / \lambda = \omega / c$, where c is the propagation speed of a burst and hence $\omega = 2\pi / \lambda / c = 2\pi / T$, where T is the period in a train of bursts, or the minimum time necessary that the burst propagation repeats the momentum distribution around position z. The quantity A is a positive quantity on a traversal area S around the axis z of the train, and zero outside of it. Interestingly enough, the above p(z,t) although is not a plane wave, it satisfies a wave equation along the direction z of propagation of the periodic train of bursts, while a plane wave satisfying the wave equation for the electric field in the electromagnetic theory, has both positive and negative values, oscillating transversally to the propagation direction z in free space.

In the bi-structure the polarization can be simply understood in the terms of the traversal section of the bursts in the trains of the finely dispersed matter of a beam of light. A round cross-section for the bursts defines an un-polarized train/ beam, while an ellipsoidal cross-section explains the polarization of the train/ beam. A non-polarized beam can also be a mixture of randomly oriented polarized trains. An expression for a polarized beam in the bi-structure approach can be obtained by transforming the current wave expression for the elliptic Gaussian beam (see Appendix I, eq. (6)) into a train of bursts that is not spreading in space. This is done by taking the beam parameters constant along the train propagation direction z, with $R \to \infty$,

$$p(x, y, z, t) = A \cdot pc([kz - \omega t]) \exp(-x^2 / a^2 - y^2 / b^2)\,, \quad (1')$$

where the ellipsoidal shape of the bursts across the propagation direction is characterized by the parameters, A, a and b. From this expression, a train with spreading bursts while propagating along z can be written by choosing an adequate dependence on z of the elliptic parameters a and b.

The intensity of the beam of light is determined by the number N of trains of bursts per unit of time and surface, which is a fluctuating number, and by the average of *p(x,y,z,t)* over the surface S= πab transversal to propagation direction (z in this case). The intensity can be approximated by,

$$I = \gamma \cdot N \cdot c \cdot transversalaverage(p(x, y, z, t)) \qquad (2)$$

where c is the speed of light, and γ is an adjusting constant. This is because the transversal average of $c \cdot p(x, y, z, t)$ is an energy at a given (z,t). Notice that I / c can be experimentally determined from measurements of the dependence of the momentum loss by producing pressure. The surface S could be determined from near field studies.

Such a periodic momentum causes, when falling on surface of condensed matter, the following effects: collective longitudinal electron oscillations, a current of electrons, or both, propagating inside the material. All these depend on the characteristics of the trains of bursts and of the material. For non-conductive materials which are transparent to light, the collective electrons oscillations dominate. For quasi-free or light-bounded electrons the momentum transfer will produce a forward motion of electrons, that is a current of electrons in the material, or photoelectrons from the surface. In metals such currents dominate over the electron oscillations At this time, lacking a better insight regarding this momentum transfer we assume for the force acting on a single electron, a proportional expression for this force to the above momentum, rather than its time derivative,

$$f(t) \approx \alpha\, A \cdot pc(kz - \omega t) \geq 0 \qquad or \qquad f(t) \approx \alpha A(1 + \cos(kz - \omega t)) \geq 0 \quad (2')$$

where α is a proportionality constant (1/sec).This force exerted by a burst through momentum transfer to a bounded electron is only in the forward (propagation) direction and is localized spatially in the traversal area of the burst. The bounded electrons move inward (toward the bulk of the material) when they receive momentum from the incident bursts and move outward in the pause between the arrivals of two consecutive bursts. Because of the periodic nature of action by the incoming train of bursts, resonance phenomena in the forced oscillations can be expected when adequate electron binding energy is present. When the frequency is large the magnitude of the effect of the force (2) is large and produces forward moving electrons. Hence, the bi-structure produces asymmetrically forced collective electron oscillations and/ or current in the forward direction which is the z axis here. This is in direct contrast with the symmetric traversal electron oscillations produced in electromagnetism by the electric field. A direct comparison of the electromagnetism and the bi-structure in this respect can be done, Ref. [10].

3. The part in condensed matter for the bi-structure

Model 2. When such a train of bursts falls on a surface of matter, the periodicity of the bursts produce, by resonant momentum transfer, collective electron oscillations (CLEO) for the electron population mainly around the longitudinal direction of the incident train. The formation in matter of such a CLEO is the central effect of the action of light on matter (as is the Lorentz model in the electromagnetic approach for light) and is driven by the angle of the direction of the incident train with the surface, by the nature of the material, and by the geometry and dimensions of surface. The nature of the material is characterized by the broad concepts of conductor and non-conductor, and by the dielectric function that depends on the periodicity of the incoming light (periodic trains of finely dispersed matter).

In the case of the bi-structure, in contrast with, but simpler than in the case of the electromagnetic case, the oscillations for the electron population on the material surface are asymmetric and are along the propagation direction z. For all the electrons on the material surface, in the path of a moving train of finely dispersed matter which define the light beam in free space, of the oscillations are dictated by the periodic and longitudinal force f(t) from eq. (2'),

$$m\ddot{z}(t) + m\gamma\dot{z}(t) + Kz(t) = f(t)\,. \tag{3}$$

These collective longitudinal electron oscillations have sufficient energy to propagate in a transparent material, or to be reflected by a metal surface back in the free space as a non-wave but periodic structure. The propagation in the transparent material can be characterized, Ref. [10], by the displacement of the elementary volume in a homogeneous electron population that behaves as an elastic medium, instead of the independent electron trajectories z.

Model 3. Model 3 describes the case of propagation in the bulk macroscopic and microscopic systems, and Model 4 describes the propagation of CLEO on macroscopic surfaces and nanostructure/ microscopic surfaces which happens in diffraction for instance. When the incidence angle of the light beam is large, we have the Model 3 for CLEO which is the basis for the reflected and refracted light. On the exit surface, these CLEO throw in free space by their interaction (momentum transfer) with the finely dispersed matter, periodic trains of bursts of finely dispersed matter. When the material is a non-transparent metal this Model 3 gives only CLEO near the surface, and hence, only reflected light (periodic trains of bursts) is produced.

In the electromagnetic approach the propagation of light in a transparent material without electrical charges and currents, and without magnetization, is described by traversal waves. In the bi-structure approach for a transparent material the two parts, namely the trains of bursts and the collective electron oscillations, are transforming completely into each other on the surface of the macroscopic body of condensed matter, through periodic resonant momentum transfer, mainly in the direction of the beam propagation. We describe shortly below the propagation of collective longitudinal electron oscillations (CLEO) in a continuum of electrons in a transparent material. The equations for the propagation of a CLEO, i.e. for the propagation of the light beam in condensed matter should be similar with the equations used for charge density waves (plasmons). A CLEO equation for the longitudinal/ dilatation/displacement s of the electron population in the simplest case – the homogeneous case, is as follows,

$$\frac{\partial^2 s}{\partial t^2} = c^2\nabla^2 s - B(\vec{r})\frac{\partial s}{\partial t} - D(\vec{r})\cdot s\,. \tag{4}$$

Here, s is the displacement of the elementary volume in a homogeneous electron population that behaves as an elastic medium. With eq. (4) the elastic waves propagate with the speed $c = \sqrt{Y_d / \rho_e}$ in this elastic medium of density ρ_e and dilatational modulus Y_e, B is a dumping coefficient, and D brings a variation in elasticity. For an infinite one-dimensional geometry with B and D constants on the entire space, we can easily verify that an elementary solution propagating in the z direction is,

$$s(z,t) = A\exp i(kz \pm \omega t)\exp(-Bt/2) \quad , \qquad (5)$$

where $k = (1/c)\sqrt{\omega^2 + B^2/4 - D}$. For B = D = 0 we have the standard relation $k = \omega / c$ for the perfectly elastic medium. Eq. (5) needs to be added with a limited ellipsoidal traversal area as in eq. (1'), in order to describe the limited transversal area of a CLEO:

$$s(z,t) = A\exp i(kz \pm \omega t)\exp(-Bt/2)\exp(-x^2/a^2 - y^2/b^2)\,, \quad (5')$$

As mentioned in the introductory text for the bi-structure, at the exit surface from a transparent material, the reverse process to that at the entrance surface, occurs. The collective electron oscillations transfer a part of their momentum to the finely dispersed matter and naturally produce a train of bursts which propagate outward from the surface.

In the optical fibers the longitudinal collective electron oscillations described by eqs. (4, 5, 5') are the driving force of the light propagation. With this concept, the propagation of light is easy to comprehend in comparison with the propagation of light based on the transversal and longitudinal electromagnetic field. Along their propagation in the optical fiber the electron oscillations are accompanied by a displacement back and forth of the finely dispersed matter. At the end of the optical fiber these electron oscillations throw in free space a train of bursts of finely dispersed matter.

Model 4: When the incidence angle is very small, like in the diffraction of light on an edge, then we have the model of a CLEO propagating on the surface - a curved line over the top surface of the edge and producing the diffracted light (trains of bursts) tangential to the curved propagation line. This model is directly applicable to describe the diffraction cases on both a macroscopic and a nanostructure edge and hence, their comparison is essential for a mechanism understanding of the behavior of light in diffraction and in propagation of light in nanostructures.

A general description of this model is as follows. When a train of periodic bursts of finely dispersed matter (of limited traversal area) falls, close to a tangential direction, on an edge the following process takes place. A streamline of collective electron oscillations propagates on the surface towards and across of the top of the edge, and on the other side of the edge that is in the geometrical shadow. This propagation is accompanied by a dumping process. For a non-conducting material there is also a propagation inside the material, while for a conductor there is an attenuation that stops the electron oscillations to propagate inside the material. Along the streamline of the propagation on the surface of the electron oscillations there are two kinds of attenuations in each of this points. One due to the intrinsic dumping of the oscillations in the electron population on the surface, and one due to the production of trains of bursts of finely dispersed matter in a direction tangential to the surface, by the collective electron oscillation propagation on the surface. These two dumping actions makes the intensity of collective electron oscillations to strongly decrease as the streamline advances in the geometrical shadow. A tangential train of bursts is produced in each segment along the streamline by the interaction of the collective electron oscillations with the finely dispersed matter that is the basis of the formation of the atom and of the condensed mater. The result is that a spray of diffracted light goes up of the diffracting edge, and in the geometrical shadow of the diffracting edge as a result of the propagation of electron oscillations along the propagation streamline. The intensity of the diffracted light strongly decreases as its angle of propagation increases towards deeper regions in the geometrical shadow. This is because of the decrease of the intensity of the electron oscillations along their propagation streamline. This way for forming the diffracted light produces the column of light present in the edge diffraction and is essentially dependent on the material and spatial form of the edge. Also this bi-structure approach to the diffracted light can clearly explain the diffracting fringes as shown in Ref[10].

In the case the diffraction on macroscopic edges, light has a broad spread (a large column) behind the edge, both above the edge and in the geometrical shadow. For a nano-structure edge, like in the diffraction on well-controlled holes/ slits in thin, sub-wavelength, the edge itself is basically a flat surface. If so, the streamline of collective electron oscillations is basically a straight line and hence, the diffracted light, produced as tangent to this stream line, is a forward cone of light, that is not a broad column of diffracted light. We show that this brings a simple and clear mechanism-type explanation for the diffraction of light on nano-structure holes, and for the propagation of light on surfaces in nano-structures.

Here we attempt a simplified quantitative description to the above general description of the model for producing the diffracted light by an edge for a macroscopic edge, while the case of nano-structure edge is discussed separately. Generally, a macroscopic edge is not a combination of flat surfaces but displays a myriad of terminal shapes. However, from the point of view of the propagation of the collective electron oscillations we can describe the traversal shape over the edge by a function $y = y(z)$ where z is perpendicular on the plane of the edge and y is along the height of the edge, and y(z) is continuous and has a continuous derivative. A good choice for y for a sharp edge is a parabola with the tip placed on the top of the edge and with the branches along the sides of the edge $y = a(z - z_e)^2 + b$, where z_e is the position of the diffracting edge along the z axis, and a and b coefficients chosen to fit the form of the edge. If so, the length *l* on this curve starting at a point z_0 and ending a point z is,

$$l(z) = \int_{z_0}^{z} \sqrt{1 + (y'(u))^2}\, du \qquad (6)$$

Eq. (5) above suggests that we can replace $Bt/2$ with $\alpha \cdot l$, that characterizes how the CLEO propagates and attenuates along the curve $y = y(z)$. If the incoming train of bursts hits the edge surface at point z_0 then the intensity *I* of the collective longitudinal electron oscillations (CLEO) along the curve $y = y(z)$ can be described approximately by $I_{cleo}(l) = A\exp(-\alpha l) = A\exp(-((\alpha_{cleo} + \alpha_b)l)$ where A= I_{cleo} (0) and α is the total attenuation coefficient of the surface oscillations both by the intrinsic dumping of the collective electron oscillation (cleo) and by the dumping from production of a train of bursts. The tangential direction to $y = y(z)$ is given by the angle $\theta(l)$ with $\tan\theta(l) = y^{'}(z)$.Then the intensity of the train of bursts produced by the streamline of collective electron oscillations on the edge surface at point *l* on the tangential direction $\theta(l)$ can be taken as $I_b(l) = \alpha_b I_{cleo}(l)$ which is the derivative of $I_{cleo}(l)$ when only the production of bursts is considered. Given that the function $\theta(l)$ is reversible we can also write $I_b(l) = \alpha_b I_{cleo}(l) = \alpha_b I_{cleo}(l(\theta))$. Therefore, a train of bursts, incident on an edge, initiates on the edge surface a propagation of longitudinal collective electron oscillations (cleo), which in turn produces at each segment around point *l* along its path a train of bursts that propagates, in free space, tangential to edge surface $I_b(l) = \alpha_b I_{cleo}(l)$.

When all the trains in the incoming beam are considered, the regular columnar diffracted light is formed. A practical description of the intensity of light in this column, including the fringes, requires an expression f(z,θ) for the dependence of the number of trains of the bursts generated on the sharp diffracting edge, at the distance z from the edge along the incident beam of light, and of the above angle θ. The case is complicated in general because we need to consider an adequate summation of the contribution the diffracted light produced by the many trains of burst incoming and falling the diffracting edge. For such a macroscopic case a working expression can be found for the complicated dependence f(d,θ) of trains of bursts that arrive at the point (d,θ) on a screen at distance d from the diffracting edge, by considering for instance only one incident train on the edge at the point $(z_0, y(z_0))$ which produces an average streamline of cleo. Then for the given θ we can find the corresponding z from $\tan\theta = y^{'}(z)$, and hence, we can find $l(z)$ from the above expression. Then the diffracted light produced at the position (d,θ) is characterized by $I_b(l) = \alpha_b I_{cleo}(l)$. We can take

$$\begin{aligned} f(d,\theta) = NI_b(l) = N\alpha_b I_{cleo}(\theta) = \\ N\alpha_b A\exp(-\alpha l) = N\alpha_b A\exp(-((\alpha_{cleo} + \alpha_b)l) \end{aligned} \tag{7}$$

where N is the number of trains per unit surface in the incident beam diffracting on the edge. This expression will need to include a certain spreading in space around the direction θ.

Note. We can see that the bi-structure approach is a mechanism-type approach that is related to the basic idea from the geometrical theory of diffraction – the luminous spot on the diffracting edge

4. The applications in optics and to gravity

Based on the above 4 models it is linear, although not easy, to see that the bi-structure offers simple, mechanism-type explanations to the main optical phenomena: reflection, refraction, diffraction, polarization, the Arago spot, the photoelectric effect, and the Michelson-Morley experiment. The photoelectric effect is a simple manifestation of the periodic and resonant action of a train of bursts, to make the electrons escaping from its binding configuration. Due to the short space in this paper, we choose to skip describing the linear application of the bi-structure models to the regular cases of light phenomena. But we shortly describe the extraordinary important and simple cases of the Michelson-Morley experiment and of the statistical optics.

The Michelson-Morley experiment. The bi-structure offers a trivial/ prosaic explanation of the Michelson-Morley (MM) experiment, with a major consequence for the speed of light/ relativity theory. In the bi-structure model, the light coming to the beam splitter in this experiment becomes localized collective oscillations (CLEOs) in this beam splitter, and the latter are the real source of the light towards the mirrors in the MM experiment. Hence, the bursts of finely dispersed matter created in this beam splitter, (i.e. the light beam propagating along and transversal to the incoming beam) have naturally the same speed towards the two mirrors of the experimental apparatus, one in the direction of the earth motion, and one in the direction across the earth motion. If so, the motion of the earth cannot have any influence on the fringes, i.e. there cannot be any fringe displacement when the apparatus is rotated. This is a simple, mechanism-type explanation of the result that there is no fringe displacement in the MM experiment. No "ether as a support for the electromagnetic waves", no its rejection, and no independency of the speed of light from the motion of reference system, as for the wave structure of light. Therefore, by this mechanism-type explanation for the result of the MM experiment, the relativity theory looses its basic support.

The statistical optics. Fig. 1.2 and 4.6, and the related comments from Ref. [11] indicate that the statistical nature of the diffraction and image formation is basically due to the statistical nature of the light beam, that is due to its discontinuous and random structure as the bi-structure has. Such a basic need cannot be offered be the continuous structure of a light beam in the wave approach, but is intrinsic and obvious for the bi-structure of light.

5. The broad consequences of the bi-structure of light in Physics, and a necessary criticism

We found that the bi-structure concept of finely dispersed matter/ dark matter, with its motion and interaction by periodic and hence, resonant, and fluctuating momentum transfer, suggests a mechanism-type understanding of gravity, electromagnetism and thermal radiation, of atomism – including the steady-state Schrodinger equation, and of the formation of condensed matter, the electromagnetism.

A broad-line of reasoning and a criticism can be given on how the concepts of the bi-structure suggest crucial consequences for the electron, atom, condensed matter, for the electrical current and for electromagnetism in general. 1) The propagation and action of light on matter can be understood by replacing the instantaneous interaction of the electrical charge of the electron and the electromagnetic field with the interaction by resonant momentum transfer from the trains of finely dispersed matter to a neutral electron. 2) The concept of the instantaneous electric/ magnetic interaction between the electrons and nucleus is replaced by a fluctuating 1/r potential established in a mechanism way at the atomic level by a field of finely dispersed matter incoming from all directions towards the nucleus. 3) This fluctuating 1/r potential offers a mechanism-type understanding of the atom orbits as the proper functions for the characterization of the oscillations, fluctuations and transitions of the electron population. 4) The Schrodinger equation for this potential. 5) The formation of the condensed matter as a result of an equilibrium between a group of atoms and a field of moving finely dispersed matter. 6) The voltage battery must be understood in the terms of two poles, one where a dense population of electrons is under an oscillation regime, and one where there is a depletion of electrons. This is an energy (or voltage) difference between the two poles, an energy difference that can decrease if the two poles can communicate through an external wire. 7) When the circuit is closed with a wire then the oscillations propagates with a high speed from the first pole to the second pole. This propagation causes an electron movement / current along the wire, with a slow effective speed. These propagations produce a perturbation in the equilibrium between the metal wire and its exterior through the field of finely dispersed matter. This propagation-perturbation is the mechanism for the magnetic field produced by the electrical current. 8) If so, all these mean that the concept of the electron loaded with an electric charge can be removed. 9) An effort must be made for a new understanding of the proton, neutron, alpha particle, and the nucleus in general. A necessary serious criticism of these ideas will develop based on the publication of this paper.

However, the limited space of this paper does not allow the presentation of such broad-line of reasoning and criticism. Instead, we present here only the simple model, offered by the bi-structure concept, for the gravity. This simple model shows a crucial effect of gravity, which was ignored along history: the gravity produces the heating of planets …

The gravity. The case of gravity is the simplest. An isotropic flux of finely dispersed matter that is defined for each small volume in space pushes two bodies of matter towards each other proportionally to its masses and inverse proportional with the square distance. A star of big body and mass necessarily establishes a system of planets.

We show here how the phenomenon of gravity can be related to a type of finely dispersed matter (FDM).The requirements for a type of FDM as a basis for gravity are as follows. a) In free space this penetrative FDM is a
flow present in any point of the universe and passes in all directions. b) It must penetrate even through bodies of big mass. There is however, a momentum and energy transfer from the passing FDM to every point in such bodies of matter, i.e. a loss of FDM occurs. When two bodies are at distance r in such a field of FDM, they shadow each other by diminishing the flow of FDM coming on the inner distance and hence, each body diminishes the momentum transfer from the FDM in the other body on the path between them. As a result the two bodies are pushed towards each other. If the effective traversal areas of the two bodies are ΔS_1 and ΔS_2, then the solid angles that the two bodies see each other are $\Delta\Omega_2 = \Delta S_2 / 4\pi r^2$ and $\Delta\Omega_1 = \Delta S_1 / 4\pi r^2$ respectively. Hence, the two bodies are shadowing each other from FDM on the line between them, proportionally with these solid angles. At the same time the two forces are proportional respectively with the masses of the two bodies $m_1 = \rho_1 h_1 \Delta S_1$ and $m_2 = \rho_2 h_2 \Delta S_2$. Hence, the forces that push the two bodies towards each other are respectively and approximately,

$$F_1 \approx \rho_1 h_1 \Delta S_1 \cdot \rho_2 h_2 (\Delta S_2 /(4\pi r^2)) = k \cdot m_1 m_2 / r^2 \qquad (8)$$
$$F_2 \approx \rho_2 h_2 \Delta S_2 \cdot \rho_1 h_1 (\Delta S_1 /(4\pi r^2)) = k \cdot m_1 m_2 / r^2$$

where k and is a constant, h and ρ are respectively the effective thicknesses and densities for the two bodies, m are masses, and $F_1 = F_2$. Notice that $\Delta S \neq 0$ in order that $F \neq 0$. Hence the idea of point masses can only be an approximation.

A way to verify this mechanism of gravity is to verify its prediction that FDM with periodicities produces heat in the bodies under its action. The energy transfer from FDM to matter is an important source of heat in any body of matter in space. This prediction would allow understanding why the temperature increase in the depth of any big body, such as planets and stars. Such an effect is not predicted by the current theory of gravity. A third prediction of the FDM approach is that gravity is not an intrinsic power, but rather an effect of the motion of the FDM. It does not imply an infinite energy in the attraction power inside each body of matter. And as soon this FDM flow modifies, the gravitation modifies too. This is in total contrast with the current theory in which gravity is an intrinsic property of matter which generates an infinite attraction energy, because it can last an infinite time.

V. CONCLUSIONS

This paper shows the experimental design of the missing experiment and crucially necessary at the foundation of the wave theory of light: the experiment for the verification if light spreads at large distances as the waves do. We designed and developed the experimental setup, and used it for measurements up to 5m from the diffracting edge, but we could not finish the experiment because of the lack of resources to measure at 100 – 500 m. We present in this paper our analysis and the design of the experimental setup. This design makes easier for a lab, like the one in Magurele, Romania, to start and repeat this absolutely necessary experiment. The alternative experimental proof that light does not spread like the waves do, presented in Section III, makes necessary and important for the physics community to perform the above missing experimental verification, as a double-check that convinces everybody what the nature of light is. If correct, this alternative proof that light does not spread like the waves do, makes necessary a new, non-wave but periodic, mechanism type structure for light. In a separate development for such a non-wave but periodic model, that is for a new physical model for light, we show that this model is feasible and brings mechanism-type explanations for all the optical phenomena. This would be similar but much more important than the case when recognizing the heat production by mechanical action made necessary and feasible a mechanism-type model, which is the kinetic theory of heat, instead of the model of the caloric fluid for heat.

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