Light Propagation

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1 Abstract

"... assuming that the Miller experiments (and Michelson) are based on a fundamental error. Otherwise, the whole relativity theory collapses like a house of cards" ([1])
Albert Einstein, in a letter to Robert Millikan, June 1921

Light propagation is a stone in the construction of A. Einstein SR theory and the comment he made in 1921 is still relevant. The existence of or non existence of a medium for the light propagation has not yet been given a clear answer. It is admited nowadays that light propagates in "vaccum", without knowing its nature. Even if we call "vaccum" the medium for the propagation of light, to not say "ether", it is still a mystery how this medium behaves inside transparent matter in motion relative to space.
The negation of the term "ether" comes from debates about experiments made in 19th century when stellar aberration was discovered and which gave rise to the Augustin Fresnel proposition of the "entrainment of ether by matter". Hyppolite Fizeau validated this concept with an experiment in which light is propagating through moving water and which was confirmed by Michelson, a few years later, in water and air.
To have a clearer idea of the cohabitation of the two entities, matter and ether, Michelson initiated the issue of the behaviour of light in moving matter through ether ("ether wind") which was not treated by Fizeau experiment. The Michelson and Morley experiment was devoted to demonstrate the effect of the earth's motion through space on light propagation. The results obtained are still in controversial.
In this paper we shows that the results obtained by Michelson, which were not null, can be explained by a new model of light propagation in transparent matter in motion through space.

2 Hypothesis

It is hypothesized that the medium for the propagation of light is static in the universe, as defined by Maxwell, and that it embeded matter. This means that when an object is moving through space, all the constituents of this object are moving relatively to the medium.
The constancy of the speed of light in the medium (vaccum or ether) is a major hypothesis ([2]). Moreover, it is hypothesized that the speed of light remains constant in the interatomic void in matter, with the same value as in the medium alone. This fact has been mention in the past by Eugène Hecht ([4]), but the consequences were not seen at the time. Indeed, if the velocity stay the same in transparent matter, then the wave length stay identical, as the incident wave, which is not what is said in the literature.
The way the refraction phenomena is created in transparent matter has been given a recent explanation in the "Classical Model of Light Transmission in Optical Media: A Descriptive Study", by Declan Traill

([5]). This model will be extended in this paper to the dual behavior of light using De Broglie-Bohm quantum mechanics.
The phenomenon of refraction of light is causing a change in the light trajectory when it propagates in a transparent matter. This phenomenon is explained by the "vibration" of the atoms eletrons in matter, sollicited by the light electromagnetic wave, which will, after a delay, re-emit an electromagnetic wave at the same frequency ([3]) ([4]).
To prevent remarks on the above assumptions, that seem to contradict the known "apparent" motion of light, which is well described by snell's laws and Fresnel refraction index, it will be explained how with the above assumptions we can describe the reality of the propagation of light in matter and still derive the Fresnel partial dragging formula for matter in motion It will be shown that the Fresnel partial dragging is not due to Fresnel "ether" but due to the atoms of matter.
The duality of light, as a particle (photon) and its associated pilot wave, in the sense of the De Broglie-Bohm quantum mechanics theory, is considered here.
Starting from the classical model done by Declan Traill ([5]) for the modeling of the Fizeau experiment, and using Bohm's view for the photon propagation, it is shown that the index of refraction can be expressed with the material's characteristics such as the density, the atom molar mass, the response delay of an atom subjected to an electromagnetic wave and the constant of the speed of light.

3 Fizeau Experiment and Consequences

During the 19th century the propagation of light in outer space was supposed to be supported by a medium called "ether". When the phenomenon of stellar aberration seen by a telescope filled in with water was discussed, Fesnel proposed that the ether was partially dragged when entering in a moving body. It is known as the "Fresnel partial ether dragging formula".
Stellar aberration is a phenomenon which produces an apparent displacement of celestial objects about their true position, when observed by a telescope from the earth at two opposite positions on the earth orbit ([6]). If the telescope is inclined with a certain angle, depending on the velocity of the earth around the sun, then the observation of a star is possible, but it is displaced depending on the season.
It is easy to understand that doing the measurement at two oposite positions on the earth orbit, only the velocity of the earth around the sun will give this displacement, although the earth is going much faster in space, at about 350 km/s.
This phenomenon was also observed with a telescope filled with water and the inclination angle was the same as in vaccum or air, although there is refraction. It was explained by Fresnel with its formula of partial dragging of ether and by the motion of the earth around the sun.
According to Fresnel, the relative motion of the earth with respect to a static ether modifies the light velocity in a transparent material. The new velocity being given by:

$$c' = \frac{c}{n} \pm (1 - \frac{1}{n^2})v \tag{1}$$

With n the index of refraction of the material and v the relative velocity of the earth with respect to the ether. This formula was proposed by Fresnel without demonstration, but it explained the aberration phenomenon of a telescope filled with water.
To test this hypothesis, in 1851, H. Fizeau conducted an interference experiment with light passing through moving water. In this experiment, a monochromatic light beam was split by a semireflecting mirror in two light beams which follow the same path, but in opposite directions, in a current of water. The motion of the flow of water is supposed to show a partial dragging of ether by matter in motion.
The time difference between the two light beams, supposing that the speed of light in water is c/n, and

using Fresnel partial dragging hypothesis, is given by:

$$\Delta t = L(\frac{1}{\frac{c}{n} + (1 - \frac{1}{n^2})v} - \frac{1}{\frac{c}{n} - (1 - \frac{1}{n^2})v}) \tag{2}$$

With L the length of one tube (each light beam go through the same distance), v the velocity of the water in the tube, n the index of refraction. Then, at the first order in n^2 we have:

$$\Delta t = -2\frac{L}{c}(1 - \frac{1}{n^2})n^2\frac{v}{c} \tag{3}$$

With $L = 2.974m, n = 1.33, v = 7.059m/s, \lambda = 526\ 10^{-9}m, c = 3\ 10^8 m/s$.
The fringe shift is then:

$$\delta = \frac{c\Delta t}{\lambda} \tag{4}$$

If we suppose that there was a total dragging of the ether, entraining the light beams, this should yield to interference pattern with a fringe shift of 0.47. In fact the fringe shift measured by H. Fizeau was much less than that, with a value around 0.23. Since the value obtained with the Fresnel partial dragging formula gives the value of 0.205, then it was a sufficient proof to accept the hypothesis of Fresnel partial dragging of ether.
But, in 1907, Max von Laue obtained a relativistic formula for the Fresnel dragging coeficient, by applying Einstein rule for the velocity addition of the speed of light in the dielectric when considered at rest (c/n) and the velocity of the motion of the dielectric (v) ([7]). At the first order, he obtains exactly the Fresnel partial dragging formula for the light velocity in moving water:

$$V = \frac{\pm\frac{c}{n} + v}{1 \pm \frac{\frac{c}{n}v}{c^2}} = \pm\frac{c}{n} + (1 - \frac{1}{n^2})v + ... \tag{5}$$

Some years later, Michelson and Morley conducted a similar Fizeau experiment with moving water and air ([8]), which confirmed the Fresnel formula.
With Max von Laue's formula and the result of Fizeau experiment in moving water, Einstein claimed that it was a demonstration of the validity of his special relativity theory. But how to believe that one can calculate the propagation of light in moving matter without knowing anything about the reality of the light propagation. And, as it will be shown in the following, the reality is somewhat more complex and impossible to describe by a relativity theory ([9]).

4 Classical Fizeau Experiment Interpretation

In his modeling of the Fizeau experiment, Declan Traill ([5]) describes the processes of light propagation in a transparent medium in those words:
"*It should be noted here that the optical process at work when the light passes through the water is really that the propagating light wave is actually the sum of the original light wave and of the light waves emitted by the charges which have been set into oscillation by the original light wave. The resulting electromagnetic wave sum would vary in propagation speed with distance from the oscillating charges in the water molecules, but from a modeling perspective and from a Theoretical Physics point of view, this can be simplified into two distinct stages of propagation: (1) The light traveling at the water's speed v whilst absorbed by the water as the energy of the oscillating charges. (2) The light moving at full speed of light c when traveling in the vacuum between water molecules*".
This model leads to Fresnel's formula, but without any partial entrainment of the ether. It is the moving atoms of matter that are slowing/accelerating the light, depending on the direction of the moving water, and which is giving a macroscopic reduced velocity.

Its hypothesis can be summarized as:

- the light wave is propagating in the static ether before encountering a matter atom and it is "absorbed" by this atom when it reaches it (in the volume of the travelling wave),

- after a delay, the atom re-emits a wave, at the same frequency, which is propagating at the same speed c in the static ether until it reaches another atom and the same processus continue.

He then supposes that the refractive index n of the material is representing two properties:

“*- the number of water molecules encountered per second by light as it travels through the water.*

- the amount of time by which light is delayed by the processes of "absorption" and re-emission when it encounters water molecules”.

Declan Traill model, done with the above assumptions, leads exactly to the Fresnel formula. This is a very new way of modeling the propagation of light. However, this model of light propagation is not representative of the dual nature of light which is well documented. In the next chapter we will show how to deal with this real dual nature of light, as a particle and a wave travelling in a propagating medium.

5 Nature of Light

Since Huygens, the light phenomenon was well described as a wave-like behaviour. It is fully known nowadays that light is also of quantum nature, as a bundle of energy called a “photon”. This particle-like behaviour was demonstrated by Einstein when the photoelectric effect phenomenon was revealed. The corpuscule-wave duality has also been demonstrated by quantum mechanics experiments, in particular by Young’s double slit experiment with photons. The corpuscule behavior is now well demonstrated in the Hong Ou Mandel experiment with single photon ([10]). This experiment can be explained only with the corpuscule behavior of light.

It is known also that the wave-like propagation can be mathematically calculated, at the macroscopic level, with the use of Maxwell’s equations, by calculating the electromagnetic field propagating inside a medium.

The corpuscule wave duality is well described by the De Broglie-Bohm theory ([11]). A light photon is associated with a wave which they called a “pilot wave”. As its name suggests, the “pilot wave” can modify the trajectory of the photon in function of the electromagnetic environment, charges in particular. This can be seen in the refraction phenomenon of light, the angle of the incident light direction being changed when entering in a transparent medium having different electromagnetic properties. Since in Bohm’s theory every particle has an associated pilot wave, when a photon comes near the electrons in atoms, the pilot wave of the photon will interact with these electrons.

The De Broglie-Bohm theory uses the notions of “quantum potential” and “vector potential” to describe the dual particle. The notion of a vector potential $\vec{A}$, was defined by Maxwell and has been considered for a long time as a mathematical artefact, before experimentally being discovered as a real physical entity. The reality of the vector potential via the quantum potential has been demonstrated, in the case of electrons subjected to a "phantom" magnetic field, with the Aharonov-Bohm experiment in absence of direct electric and magnetic fields ([12]). In Young’s double slit experiment with an electron beam, if we create a magnetic field in such a way that it is closed from the trajectory of the electrons, but insulated such that the magnetic field is insignificant outside, this field will still modify the interference pattern given by the flux of electrons. This experiment can only be explained by the fact that the pilot wave of each electron is influenced by the quantum potential present in the experimental device, despite the isolation of the magnetic field!

This explanation will satisfy mathematicians, but as a physicist, the real nature of the quantum potential is obscure. I assumed however that due to this quantum potential, the electromagnetic field is the highest

near the photon particle and decreases elsewhere. This can explain the fact that the trajectory of the photon is going in a straight line in a homogeneous material, given an initial direction condition.
What is also important is that the De Broglie-Bohm theory explaines the experiments which are done with one photon at a time. The famous Young's double slit experiment has been done with the emission of single photon one at a time and a interference pattern is observable after a sufficient long time integration. The interference pattern is the same if it is done with numerous photons ([13]) ([14]).
The explanation is the following: if a single photon is emited in direction of a double slit experiment apparatus, the pilot wave of the photon goes through the two slits and the photon is passing through one of the slit. After the slits the pilot wave interferes with itself and conducts the photon to the sensor in function of the interference. After integration of a lot of single photons there is an interference pattern on the sensor. If the detector is placed too close to the slots there is an impossibility for the pilot wave to interfere and there is no interference pattern on the detector.
In a Michelson type interferometer, we have to take this phenomenon into account, the pilot wave of each individual photon going through the two arms. It is the integration of all the photons which will gives in turn an interference pattern or not.
It has been shown also that the lateral expansion of an electromagnetic wave with its surrounding is proportional to λ^3([15]), with a wave length λ. In fact, numerous experiments have been done, showing that no light energy can be transmitted through a hole whose dimension is less than $\frac{\lambda}{4}$. As said by C. Meis, a single photon is not a point particle, as developed by quantum electrodynamics, but is "a local "wave-corpuscule", guided by a non local wave function, and capable of interacting with charged particles". According to Bohm the wave function of the pilot wave is a real field which is hidden from us and is only revealed by its effect on the particle. It is also said by Bohm that the energy of the photon is "carried" by the pilot wave.
With the dimensions of atoms in matter, with a size around 10^{-10} m, a photon with a pilot wave of a wave length of 10^{-7}m (visible light), will interract, via its pilot wave, to an enormous quantity of atoms when entering in matter, due to the large volume of interaction of the photon pilot wave. For silica for example there will be about 10^5 atoms in interaction at each pulsation of the pilot wave.
Each atom will oscillate at the frequency of the pilot wave, but will react with a delay when the wave is said to be "absorbed" by it. In reality the photon is not absorbed by the millions of millions of atoms, it is just the wave energy which is interacting with an electron which will be restored in a fraction of second.

This is the key to understanding why the speed of the photon will decrease while the pilot wave still propagates in the static ether at the speed c, which is explained in the following.

6 New Light Propagation Theory

When a light beam is entering a material with new electromagnetic properties, the phenomenon of refraction of light is well known. It is characterized by the so called index of refraction n, with which all the calculations can be done. This index of refraction can be easily related to the relative permittivity ε_r of a simple dielectric material, since n is define as:

$$c'^2 = \frac{c^2}{n^2} \tag{6}$$

From the two relations $c^2\varepsilon_0\mu_0 = 1$ and $c'^2\varepsilon_r\varepsilon_0\mu_0 = 1$, it comes:

$$n = \sqrt{\varepsilon_r} \tag{7}$$

Furthermore, when entering in a new electromagnetic material, it is known that the frequency is conserved, assuring the conservation of energy, although the wave length is said to be modified. For a simple material like water, it is said in the litterature that the wave length is given by:

$$\lambda' = \frac{\lambda_0}{n} \tag{8}$$

We will see in the following why this may be untrue.
In the Declan Traill model of the Fizeau experiment with water, cited above, it is supposed that the wave is always propagating at the speed c in the propagating medium (ether or vaccum) inside the interatomic void of water atoms. It is supposed that when the wave is encountering an atom of the material this atom wil be sollicited by the electromagnetic wave. The simplest way to understand this interaction is to model an atom as an electric-dipole reacting to the sollicitation.
Then the atom will re-emit a wave with a delay, at the same frequency and same wave length. This last characteristic of the re-emitted wave is due to the hypothesis of the constancy of the speed of light inside the transparent material.
In the literature, it is often said that the electromagnetic wave is absorbed and then is re-emitted by the atom. This has to be clarified since light is not only a wave but also a corpuscule. It must be understood that the photon particle is not absorbed in this process.
Due to the "stop and go process" of the atom reaction to the electromagnetic wave sollicitation, when going through a certain distance L, in a transparent material, if the wave length is conserved, there will be the same number of wave lengths to cross the distance L, but it will take some more time to travel the distance L.
The time to go through the light path can be calculated in two ways, one while supposing an "apparent" light speed of the wave given by $\frac{c}{n}$, with n the refraction index, and the second one supposing an aditional delay ΔT for the wave velocity c:

$$\frac{L}{\frac{c}{n}} = \frac{L}{c} + n_{at}\Delta t \tag{9}$$

with n_{at} the number of atoms encountered in the light path and Δt the delay of response of each atom, supposed to be a constant.
To calculate the number of atoms in the light path we have to take into account the spatial expansion of the wave. It has been shown that the lateral expansion of an electromagnetic wave is proportional to λ_0^3 ([15]), λ_0 being the wave length. Then, the number of atoms in the light path is:

$$n_{at} = \rho \frac{\pi \lambda_0^2}{m_{at}} NL \tag{10}$$

With ρ the material density, L the total path, N the Avogadro number,m_{at} the material atomic mass. Substituting (10) in equation (9) gives:

$$\frac{L}{\frac{c}{n}} = \frac{L}{c} + \rho \frac{\pi \lambda_0^2}{m_{at}} NL\Delta t \tag{11}$$

The index of refraction of a material is then:

$$n = 1 + \rho \frac{\pi \lambda_0^2}{m_{at}} Nc\Delta t \tag{12}$$

This equation can be rewriten as:

$$\Delta t = \frac{L}{c}(n-1)\frac{m_{at}}{\pi \lambda_0^2 \rho L N} \tag{13}$$

For water we have the following material properties: $n = 1.33$, $m_{at} = 18 * 10^-3\ kg/mole, \rho = 997\ kg/m^3$, with N being the Avogadro number $N = 6 * 10^{23}$. For a source light wave length $\lambda_0 = 52610^-9\ m$, the number of atoms per meter is:

$$n_{at} = \frac{\pi(526 * 10^-9)^2\ 997\ \ * 6 * 10^{23}}{18 * 10^-3} = 3 * 10^{16}\ at/m \tag{14}$$

And with light speed $c = 3 * 10^8\ m/s$, the atom time response:

$$\Delta t = \frac{1}{3 * 10^8}(1.33 - 1)\frac{18 * 10^-3}{\pi(526 * 10^-9)^2\ 997\ \ * 6 * 10^{23}} = 3.8 * 10^{-26}\ s \tag{15}$$

For air we have the following properties: $n = 1.000278$, $m_{at} = 29 * 10^{-3}\ kg/mol$, $\rho = 1.3\ kg/m^3$. For a source light wave length $\lambda_0 = 526 * 10^{-9}\ m$, the number of atoms per meter is:

$$n_{at} = \frac{\pi(526 * 10^-9)^2\ 1.3\ \ * 6 * 10^{23}}{29 * 10^{-3}} = 2.3 * 10^{13}\ at/m \tag{16}$$

And the atom time response for air:

$$\Delta t = \frac{1}{3 * 10^8}(1.000278 - 1)\frac{29 * 10^-3}{\pi(526 * 10^-9)^2\ 1.3\ \ * 6 * 10^{23}} = 3.96 * 10^{-26}\ s \tag{17}$$

The two atoms time response are very close but this could be by chance. This reaction time, for an atom subjected to an electromagnetic wave is very short but it is far greater than the Planck time which is about $5,4 * 10{-}44\ s$! This reaction time can be compared to the time for the light wave to travel one wave length, which is given by:

$$\Delta t_{\lambda_{wave}} = \frac{\lambda_0}{c} = 1.75 * 10{-}15\ s \tag{18}$$

We can see that atoms are reacting much faster than the exciting wave propagation.
It must be emphasized again that the atoms excitation doesn't correspond to an absorbtion of the photon by each atom encountered, which is often attributed to the “stop and go” process in the literature. In fact, it is the vibration given to the atoms electron (s), due to the field of force of the electromagnetic pilot wave of the photon particle. This vibration is restored to the medium by each atom, after the above delay, with the same wave length. Generally, in a simple material, no energy is lost in this process.
What happens to the photon velocity in this context?
David Bohm's deep conviction was that it is the whole which determines the properties of individual particles and their relationship, not the other way around Since the pilot wave of the photon, in the sense of the David Bohm theory, is directing the corpuscule and is delayed in its propagation, the photon himself, as a physical entity, has to have its trajectory modified. Due to the large quantity of interactions between the pilot wave of one photon and the atoms of matter, as soon as the wave is entering in a new medium, it is conceivable that this interaction changed the trajectory of this photon, according to Snell laws, and reduced its velocity to $\frac{c}{n}$, n being the index of refraction. This should be confirmed by the use of Bohm trajectory calculations.
With the hypothesis of Declan Traill given above, extended through the use of the Bohm quantum mechanics theory for a photon light, we can conclude that the phenomenon of refraction of light in a transparent material is due to the interaction of the pilot wave of a photon with the surrounding atoms on its way through the transparent material.
When von Laue derived the Fresnel formula, using Einstein SR theory, he was particularly satisfied with this demonstration, definitely burying the notion of the ether. But as we have seen just above the physical description of the propagation of the light in moving water has nothing to do with a moving particle in the sense of space-time coordinates. The physical aspect of the photon is not a point particle with space-time coordinates.

7 Michelson Interferometer

After the validation of the Fresnel partial dragging of ether by matter by the Fizeau experiment with matter in motion and that Michelson confirmed in water and air, Michelson wanted to verify Fresnel's

hypothesis about ether being “at rest, except in the interior of transparent media”.
In his time it was inconceivable that ether can pass through matter other than transparent matter, and then a possible effect was possible on the earth surface. Since the “effect of the motion of the earth through the ether on the path of the ray at right angles to this motion was overlooked”, Lorentz convinced Michelson to do an experiment.
It was only the motion of the earth around the sun which was considered and the supposed effect they calculated with their views of light propagation could be measurable. In Michelson's experiment, the different mirrors were adjusted to have a good reception on the sensor. It was the modification of the path difference obtained by turning the apparatus of 90° which was looked at. This turning was to show the difference between the two arms in conditions at 90°.
We are not going to analyze in particular how Michelson was viewing the physical mechanism of the light propagation in transparent matter moving with respect to the static ether. We just recall that he obtains interference pattern, but not what he expected and it was declared a quasi null result. With this (considered by many) negative result, Michelson decided to stop the experimentation, which was due to continue.
Now we are going to look at a Michelson experiment with the new light propagation theory in air. In a Michelson type interferometer, the light is propagating in atmospheric air at the ambiant temperature in two perpendicular directions. We suppose that one arm is along the velocity of the earth in space, which is not practically the case for an apparatus on the earth floor.

7.1 Light Path Difference

We have to have in mind that the apparatus and the atoms constituent of the transparent medium air are moving at the same earth speed, which is taken to be 350 km/s in the following, instead of 30 km/s by Michelson.
Since the pilot wave will be separated in two ways, by the semireflecting mirror, each atom encountered by the pilot wave in both arms will react with a delay calculated above, according to the geometry disposition of the arm with respect ot the earth velocity.
In the perpendicular arm, since the effect of the earth motion on the atoms is perpendicular to the light path, the situation of light propagation is the same as in the medium at rest. Each time the pilot wave encounters an atom, there is a time response delay δt before the re-emission of the pilot wave. Then, using equation (9), the overall additional delay ΔT, due to the “stop and go” process in the perpendicular arm, is evidently:

$$\Delta T = n_{at}\delta t \tag{19}$$

with n_{at} the number of atoms encountered in the light path, given by equation (10). In air, for a length L = 1 m, we get:

$$\Delta T/m = 1.3 * \frac{\pi(526 * 10^{-9})^2}{29 * 10^{-3}} * 6 * 10^{23} * 4 * 10^{-26} = 9 * 10^{-13}s \tag{20}$$

In the case of Michelson experiment in air, the length of each arm was 11 m, then the overall additional delay of a round trip on the perpendicular arm, given by the “stop and go” process is around:

$$\Delta t = 2 * 11 * 9 * 10^{-13} \sim 2 * 10{-}11s \tag{21}$$

This delay, due to the “stop and go” process of each atom, is negligible compared to the time for the light to do the round trip on this arm, which is in air, with an index of refraction $n = 1.000278$, equal to $L/c \sim 7 * 10^{-8}$ s.
In the arm parrallel to the earth motion, the light path is constrained by the moving mirrors. This means that the total light path is $L + Vt - (L - Vt) = 2L$, with L the separation between two mirrors, t the round trip time, V the earth speed.

The number of atoms between the two mirrors stay the same, whatever the motion of the earth, which is a different situation from the Fizeau experiment. Since the number of atoms stay the same as in the perpendicular arm, the time delay of the "stop and go" process in the parrallel arm is about the same in the two arms, only the slight variation in the number of atoms in the two paths can gives a time difference.
In contrast there is a difference in the arrival position of the two light beams at the exit of the last mirror:

- For the perpendicular arm the spatial difference is: $210^{-11} * 310^{5} = 6 * 10^{-6}$ m.
- Instead, in the parrallel arm the deviation is due to the mirrors displacement, during the light travel time in the apparatus, which is in air $710^{-8} * 310^{5} = 21 * 10^{-3}$ m.

At the exit from the last mirror, the situation of the two pilot waves is like a two point sources, as in the Young's double slit experiment, but with a larger spatial separation of the sources. This separation can be remedied by the focalisation on a plane. Michelson used a telescope with an aperture of 3.3 centimeters, a focal length of 35 centimeters, and a magnifying power of thirty-five diameters. The telescope is focussed on the surface of the last reflecting mirror of the optical paths.
Then the two pilot waves emanating from the last reflecting mirror converge on the focal plane creating the interference pattern.

7.2 Michelson Non Null Result

It is common knowledge that Michelson experiment was declared a "null result" and this affirmation was used to proclaim Einstein SR theory to be valid. However, it is very clear that SR theory is not modeling the propagation of light in general and above all when the pilot wave is split into two different light paths. Then, using the fact Michelson didn't obtained the value he was expecting, and by far, it was an error to use this as the validation of Einstein SR theory. In truth, it was not only a non null result but also a result which was varying with the earth rotationnal sidereal time, which could infer an impact of the motion of the earth in space, because the projection of this earth velocity on both axis of the Michelson apparatus, is varying with the earth rotation (or the apparatus rotation).
In the folowing we are going to analyze the conditions for which we can obtain the measured value and the variation with the earth's rotationnal sidereal time or the apparatus rotation. Instead of obtaining an interfringe of 0.04, for an earth speed of only 30 km/s, Michelson observed a measured value at the most of 0.01 of the distance between two fringes. This difference is largely more significant since we know that the earth is moving about or over 350 km/s in space. An interfringe is given by: $\frac{c\delta t}{\lambda_0} = 0.01$ light paths, with λ_0 the wave length of the pilot wave.
Then the time difference δt between the two light paths, to obtain an interfringe of 0.01, must be equal to:

$$\delta t = \frac{0.01 * 526 * 10^{-9}}{3 * 10^{8}} = 1.75 * 10^{-17} s \tag{22}$$

Which has to be compared with the total time delay from the atoms encountered in the propagation of the light in the atmospheric air, due to the "stop and go" process, which is for the total light path in one arm of 2*11 m, equal to $2 * 10^{-11}$ s. The time difference between the two light paths is then about 10^{-6} times the total time delay, which is very little. The variation in the number of atoms encountered by the light beam, in its 22 m journey, should be:

$$\delta n_{atome} = \frac{1.75 * 10^{-17}}{2 * 10^{-11}} n_{atome} = 0.875 * 10^{-6} * 5 * 10^{14} \sim 4 * 10^{8} atoms \tag{23}$$

Which led to the necessary number of air atoms in the light path to give the time difference between the two arms:

$$n_{atome} = 5 * 10^{14} \tag{24}$$

This variation is very tiny to be controlled during an experiment with the apparatus turning between each measurement.

It can be concluded that the effect of the earth motion in space cannot be precisely demonstrated with a Michelson type interferometer, and this comment has been emphasized by Rudolf Vrnoga ([9]). The time variation of the measurements, observed in function of the earth rotational sidereal time, is due to the variation of the earth velocity through space projected on the two arms of the apparatus.

8 Conclusion

> For most optical phenomena, the distinctly quantum mechanical characteristics of light are obscured and its wave nature is the most prevalent manifestation.
> Eugène Hecht and Alfred Zajac (Optics)

These comments by Eugène Hecht and Alfred Zajac in their book "Optics" tells us that to understand the light phenomenon we must not only reason in terms of wave propagation. The hidden part of the light has been totally neglected and all the reasoning done in the 19th century is obsolete without the quantum aspect. Einstein's SR theory is also concerned by this failure to not take the quantum aspect into account.

Light is composed of a particle, called a photon, and a pilot wave as in the De Broglie-Bohm theory. The pilot wave is hypothesized to control the trajectory of the photon. The pilot wave is transporting polarisation, impulse, energy, etc.

We must go back to the fundamental for the propagation of light, which needs a medium for the support of this propagation, even if we don't yet know its nature. It is hypothesized that the medium responsible of the propagation of light is static in the universe and embeded in all matter. All the objects in the universe are moving relatively to it. The speed of light is a constant wherever it propagates, either in space or in the interatomic void in transparent matter.

The phenomenon of refraction of light is due to the response time of the atoms to the electromagnetic field variations of the photon pilot wave. The index of refraction of a transparent material can be approximate by:

$$n = 1 + \frac{\rho \pi \lambda_0^2}{m_{at}} N c \, \delta t \tag{25}$$

with ρ the material density, λ_0 the wave length of the photon pilot wave ,m_{at} the atomic mass of the material, N the Avogadro's number, c the constant of the speed of light, δt the response time of an atom to the electromagnetic field of the pilot wave .

When light propagates in a moving transparent material, the photon is dragged by the atoms motion due to their response time, in the direction of the object velocity. This model for the propagation of light, done with this hypothesis, allows us to derive the Fresnel dragging formula for light propagation in moving water, which has been validated numerous times experimentally.

Application of this model for the propagation of light to the case of the Michelson and Morley experiment shows that the non null result can be explained by the dispersion of the atmospheric air density in the apparatus. The variation with respect to the earth rotational sidereal time is due to the projection of the earth velocity through space on the two arms of the apparatus.

Since Einstein SR theory is not modeling the real behavior of the propagation of light in a moving transparent material, the Fizeau and the Michelson and Morley experiments cannot be considered as a validation of this theory.

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