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Effect of Reflection from Revolving Mirrors on the Speed of Light:

A Brief Review of Michelson's 1913 Experiment

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Abstract:

In this review of Michelson's 1913 experiment, the combined method, for calculating predictions of multiple theories, is reexamined. And the prediction of each theory, regarding the experimental test, under discussion, is recalculated separately and compared to the experimental result, and to the prediction computed by A. Michelson.

Keywords:

Michelson's 1913 experiment; interference fringes; classical wave theory; new-source theory; elastic-impact theory; ballistic speed of light; relative speed of light.

Introduction:

The main objective of Michelson's 1913 experiment is to check, in a straightforward manner, for whether or not the velocity of light is independent of the velocity of the light source.

The experimental arrangement is simple, ingenious, and exactly what one expects from an experimenter as legendary as A. Michelson. And as such, this 1913 experiment has become a template and prototype for a whole host of similar experiments throughout the last century and in this century as well.

Michelson's computational method for extracting numerical predictions out of the physical theories to be tested, however, is not as good and robust as his experimental arrangement. In fact, his combined method of calculations has a number of basic flaws. It is by no means clear why Michelson has chosen to do calculations, for his current experiment, in such a partially tentative and partially arbitrary way over the more rigorous method based upon the concept of relative velocity and used extensively by him and Morley in their most famous experiment {*Ref. #1.c*}. For instance, according to the latter method, to determine the interval of time required for a fast moving object to catch up with a less fast moving object, one simply divides the initial distance between the two moving objects by their relative velocity; and that takes cares of the displacement made by the less moving object, during that period, automatically.

Nevertheless, ever since its first appearance in this experiment, Michelson's combined method of calculations has been used, repeatedly and without any modification, in many similar experiments; and its hallmark equation:

$$\overline{V} = V + vr$$

has become the standard formula for computing and testing predictions of alternative theories under the so-called "*Test theories of special relativity*".

But this method of combined calculations is inaccurate; and as a result, the conclusions of every experimental test, based upon it, are inaccurate and misleading to some degree as well.

In particular, the conclusion, drawn from this method of combined calculations, that time-of-flight predictions, based upon the assumption of the independent speed of light of the speed of the light source, and time-of-flight predictions based on the assumption of the dependent speed of light on the speed of the light source, can show numerical differences of the first order in interferometry experiments, is unwarranted and faulty.

The main reason for this, of course, is the fact that the displacement of the light source plays a major role in transit-time calculations in this sort of experiments. But as soon as the displacement of the light source is taken into account, time-of-flight differences between beams assumed to be traveling at the speed of c, and beams assumed to be traveling at the speed resultants of (c + v) and (c – v), are reduced to mere minute differences of the second order or even less. For it's clear that displacements made by the light source necessarily imply relative light speeds of (c + v) and (c – v), regardless of whether the speed of light is, actually, independent of the speed of the light source, or the speed of light is, in fact, dependent upon the speed of the light source.

Michelson's Experimental Arrangement:

In Michelson's 1913 experiment, two revolving mirrors are mounted on the shaft of an electric motor whose speed is measured by a speed counter, and can be varied from zero to 1800 revolutions per minute.

The distance between the centers of the two revolving mirrors is 26.5 cm.

And the distance between the axis of rotation O and the concave mirror E is 608 cm.

Light from a carbon arc is filtered through a gelatine film that transmits light at the mean wavelength of 0.6 µm.

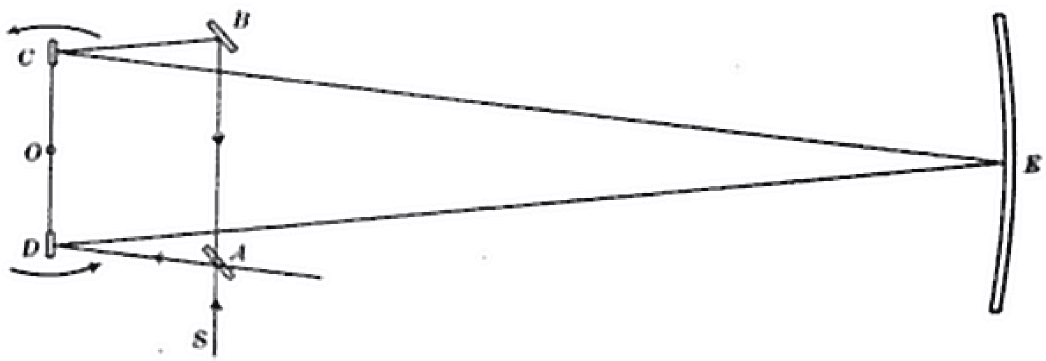

Fig. 1. — Diagram of apparatus

As illustrated in the diagram above, a beam of light, from a source S, is partially reflected and partially transmitted by the beam splitter A.

The reflected beam strikes the approaching mirror D. The revolving mirror D reflects the approaching beam along the side DE of the isosceles triangle DEC towards the stationary concave mirror E. The concave mirror E reflects the incident beam along the side EC of the same isosceles triangle towards the receding mirror C. The revolving mirror C reflects this same beam towards the stationary plane mirror B. And the stationary plane mirror B reflects this beam back to the beam splitter A.

The transmitted beam falls on the stationary plane mirror B. The plane mirror B reflects the incident beam towards the receding mirror C. The revolving mirror C reflects this same beam along the side CE of the triangle towards the stationary concave mirror E. The concave mirror E reflects the incident beam along the side ED of the same triangle towards the approaching mirror D; where it's reflected back to the same beam splitter A.

Upon recombination, the two returning beams form a fringe-shift displacement of 3.81, which is observed with a telescope {*Ref. #1.a*}.

Remarks on Michelson's Calculations:

At the start of his calculations, Michelson states explicitly and accurately that, according to the undulatory theory, the velocity of light is unaffected by the velocity of the mirror, while the other two theories require that:

$$\overline{V} = V + vr$$

where $\overline{V}$ is the velocity of light after reflection, V the velocity of light before reflection and v the component of the velocity of the mirror in the direction of the reflected pencil, and r = 2 according to the elastic impact theory; while r = 1 if the mirror surface acts as a new source {Ref. #1.b}.

And accordingly, he carries out the following calculations:

The time occupied by the reflected beam DEC is

$$T_1 = \frac{2(D+d)}{V_1}$$

while that taken by the transmitted beam CED is

$$T_2 = \frac{2(D+d)}{V_2}$$

where D is the distance OE; d = distance the revolving mirror moves while light passes over DEC; and V_1 the resultant velocity of the first pencil; V_2 that of the second.

The difference in time, therefore, is:

$$T_1 - T_2 = 2\left[\frac{D+d}{V+vr} - \frac{D-d}{V-vr}\right]$$

But, then he assumes implicitly that all mirror displacements are equal, and uses this formula for computing all displacements made by the revolving mirrors:

$$\frac{d}{2D} = \frac{v}{V}$$

and to calculate differences in transit time

$$T_1 - T_2 = 4\frac{D}{V}(2-r)\frac{v}{V}$$

and corresponding displacement of the interference fringes

$$\Delta = \frac{V(T_1 - T_2)}{\lambda} = 4\frac{D}{\lambda}(2-r)\frac{v}{V}$$

for the undulatory theory, where r = 0

$$\Delta = 8\frac{D}{\lambda}(\frac{v}{V})$$

for the new-source theory, where r = 1

$$\Delta = 4\frac{D}{\lambda}(\frac{v}{V})$$

and for the elastic-impact theory, where r = 2

$$\Delta = 0$$

And so, that implicit and incorrect assumption, by Michelson, has rendered the rest of his calculations partially incorrect and inaccurate.

Each one of the theories, to be tested, in this experiment, has its own formula for computing mirror displacements:

For the undulatory theory:

$$d = v\left[\frac{2D}{c \pm v}\right]$$

for the new-source theory:

$$d = v\left[D\left(\frac{2c \pm v}{c^2 - v^2}\right)\right]$$

and for the elastic-impact theory:

$$d = v\left[\frac{2D}{c \pm 2v}\right]$$

But A. Michelson has used only one formula in his calculations, for the three of them.

In addition, each experimental beam, in this experiment, must traverse the displacement made by the mirror twice and at different speeds according to each theory:

For example, according to the new-source theory:
The reflected beam must fly at the speed of c , over the displacement made by the receding mirror, on its way to catch up with the mirror; and must fly one more time over the same displacement at the speed of (c - v) upon reflection from the same receding mirror.

Nonetheless, and in spite of these obvious flaws, the main numerical prediction calculated by Michelson, within the given range of mirror speeds in this experiment, is remarkably accurate.

However, with regard to the calculated theoretical predictions, Michelson in his above calculations, obtains accurately, within the given speed range, the prediction of the undulatory theory, underestimates the prediction of the new-source theory by more than a quarter of the actual amount, and missed the true prediction of the elastic-impact theory altogether due, mainly, to a major and somewhat subtle oversight for which he is not to be blamed.

As demonstrated in the related articles [**#A & #E**], if light is reflected from a moving mirror in accordance with the elastic-impact theory, then the angle of incidence (θ) and the angle of reflection (θ') are no longer equal. Since it's clear that a straightforward application of the conservation of momentum and kinetic energy, in elastic collisions, to this particular case leads to the modification of the standard formula for reflection from a stationary mirror:

$$\sin\theta' = \sin\theta$$

and to produce two equivalent formulas:

One for reflection from an approaching mirror:

$$\sin\theta' = \left[\frac{c}{c+2v}\right]\sin\theta$$

and one for reflection from a receding mirror:

$$\sin\theta' = \left[\frac{c}{c-2v}\right]\sin\theta$$

And since, the optical path, in the experiment under discussion, is configured in the form of an isosceles triangle whose apex is the angle DEC, the change in the sine of the angle of reflection, upon the reflection from the approaching mirror D, by a factor of:

$$\left[\frac{c}{c+2v}\right]$$

must change the sine of the angle of incidence and the sine of the angle of reflection from the concave mirror E at the apex of this optical triangle by the same factor as well. And as a result, the path of the first beam from D to E to C is, now, equal to this:

$$2D\left[\frac{c}{c+2v}\right]$$

And in the same way, the path of the second beam from C to E to D changes by a factor of:

$$\left[\frac{c}{c-2v}\right]$$

and so, now, it becomes equal to this:

$$2D\left[\frac{c}{c-2v}\right]$$

Certainly, A. Michelson could have applied the rules of ordinary ballistics to this special case of elastic collisions to arrive at a similar conclusion. But the road from there to here was too long. And the elastic-impact theory wasn't one of his pet theories anyway.

Detailed Computations on the Basis of the Three Theories:

A better and more instructive alternative to the combined method, used in the above calculations, is to compute the prediction of every theory more comprehensively and to treat the three theories on one-by-one basis and separately. Then and only then, the predictions given by those three theories can be compared with each other and to the experimental results in an unambiguous and evenhanded manner.

Regarding the theories, under discussion, the following differences should be pointed out explicitly and made clear from the very beginning of these calculations:

Firstly, according to the undulatory theory, light is reflected from stationary mirrors and moving mirrors in the same way and without any changes in its speed or in its direction, as reckoned on the basis of the standard law of reflection {*Ref. #1.c*}.

Secondly, according to the new-source theory, light is reflected from a stationary mirror with the velocity of c, from an approaching mirror with the resultant of its velocity of c and the velocity of the approaching mirror, and from a receding mirror with the resultant of its velocity c and the velocity of the receding mirror v{*Ref. #3*}.

And thirdly, according to the elastic-impact theory, light is reflected from a stationary mirror with its incident velocity, from an approaching mirror with the resultant of its incident velocity and twice the velocity of the approaching mirror, and from a receding mirror with resultant of its incident velocity and twice the velocity of the receding mirror. In addition, reflected light by an approaching mirror must be reflected with the velocity of c from a mirror receding with the same speed but in the opposite direction to that of the approaching mirror; and vice versa {*Ref. #4 & #5*}.

There is also another important difference, within this context, that should be clarified.

Upon reflection from moving mirrors, moving aircraft, moving planets, etc., the measured Doppler shifts of the reflected light, in all such cases, are always twice their values in the cases of light sources moving with the same speeds in the same directions.

Now, is this experimentally verified difference between the Doppler effect on emitted light, and the Doppler effect on reflected light, consistent with the above differences in the treatment of the speeds of reflected light within the framework of each theory?

Clearly, the doubling of the Doppler shifts of reflected light is consistent with the change in the speed of incident light by twice the speed of the moving mirror, according to the elastic-impact theory, which has, in the two cases of direct approach and direct recession, the following Doppler formula:

$$f' = f\left(1 \pm {}^{2v}\!/_{c}\right)$$

where f' and f are the observed and emitted frequency respectively.

But the undulatory theory and the new-source theory face theoretical difficulties, in this regard. However, according to H. E. Ives, the problem of doubling Doppler shifts, upon reflection from moving mirrors, can be resolved, in a satisfactory manner, if the shifted frequency of incident light is used recursively as the input frequency for the reflected light in accordance with this Doppler formula in the two cases of direct approach and direct recession:

$$f' = f\left[\frac{c \pm v}{c \pm v}\right]^n$$

where n is the number of reflections from the moving mirror {*Ref. #2*}.

A. The Prediction of the Undulatory Theory:

I. The Transit Time T_1 for the Reflected Beam:

According to the undulatory theory, the reflected beam by the beam splitter A travels at a speed of c towards the approaching mirror D. The approaching mirror D reflects this beam with the same speed of c towards the stationary concave mirror E. And the concave mirror E reflects the same beam with the same speed towards the receding mirror C.

And therefore, the transit time T_{DEC} over DEC for the reflected beam:

$$T_{DEC} = \frac{2D + vT_{DEC}}{c} = \frac{2D}{c - v}$$

On its way back to the beam splitter A, upon reflection with the same speed of c from the receding mirror C, the reflected beam must traverse for the second time the displacement d made by the receding mirror C; and hence, the transit time T_d over the displacement d:

$$T_d = \frac{vT_{DEC}}{c} = \left[\frac{v}{c}\right]\left[\frac{2D}{c - v}\right]$$

And so, the total transit time T_1 for the reflected beam is:

$$T_1 = T_{DEC} + T_d = \left[\frac{2D}{c - v}\right] + \left[\frac{v}{c}\right]\left[\frac{2D}{c - v}\right] = \left[\frac{2D}{c}\right]\left[\frac{c + v}{c - v}\right]$$

II. The Transit Time T_2 for the Transmitted Beam:

The beam transmitted by the beam splitter A travels at a speed of c towards the stationary plane mirror B. The stationary plane mirror B reflects this beam with the same speed of c towards the receding mirror C. The receding mirror C reflects this beam with the same speed of c towards the stationary concave mirror E. And the concave mirror E reflects the same beam with the same speed towards the approaching Mirror D.

And therefore, the transit time T_{CED} over CED for the transmitted beam:

$$T_{CED} = \frac{2D - vT_{CED}}{c} = \frac{2D}{c + v}$$

On its way back to the beam splitter A, upon reflection with the same speed of c from the approaching mirror D, the transmitted beam travels for the second time over a reduced distance shortened by the displacement $d = vT_{CED}$ made by the approaching mirror D:

$$T_d = \frac{vT_{CED}}{c} = \left[\frac{v}{c}\right]\left[\frac{2D}{c+v}\right]$$

And hence, the total transit time T_2 for the transmitted beam:

$$T_2 = T_{CED} - T_d = \left[\frac{2D}{c+v}\right] - \left[\frac{v}{c}\right]\left[\frac{2D}{c+v}\right] = \left[\frac{2D}{c}\right]\left[\frac{c-v}{c+v}\right]$$

And accordingly, the difference ΔT, between the transit time T_1 for the reflected beam and the transit time T_2 for the transmitted beam, as computed on the basis of the undulatory theory, is:

$$\Delta T = T_1 - T_2 = \left[\frac{2D}{c}\right]\left[\frac{c+v}{c-v}\right] - \left[\frac{2D}{c}\right]\left[\frac{c-v}{c+v}\right] = \left[\frac{8D}{c}\right]\left[\frac{v/c}{1-v^2/c^2}\right]$$

It follows, therefore, that the undulatory theory predicts a fringe-shift displacement, in this experiment, slightly higher by a factor equal to the reciprocal of $(1 - v^2/c^2)$ than the fringe-shift displacement of 3.61 computed by A. Michelson.

<u>B. The Prediction of the New-Source Theory:</u>

I. The Transit Time T_1 for the Reflected Beam:

According to the new-source theory, the reflected beam by the beam splitter A travels at a speed of c towards the approaching mirror D. The approaching mirror D reflects this beam with the speed resultant of (c + v) towards the stationary concave mirror E. And the stationary concave mirror E reflects the same beam with the speed of c towards the receding mirror C.

And therefore, the transit time T_{DE} over DE for the reflected beam:

$$T_{DE} = \frac{D}{c+v}$$

And the transit time T_{EC} over EC for the reflected beam:

$$T_{EC} = \frac{D + vT_{EC} + vT_{DE}}{c} = \frac{D + vT_{DE}}{c-v} = D\left[\frac{c+2v}{c^2 - v^2}\right]$$

And hence, the transit time T_{DEC} over DEC for the Reflected Beam:

$$T_{DEC} = T_{DE} + T_{EC} = \left[\frac{D}{c+v}\right] + D\left[\frac{c+2v}{c^2-v^2}\right] = D\left[\frac{2c+v}{c^2-v^2}\right]$$

On its way back to the beam splitter A, upon reflection with the speed of (c - v) from the receding mirror C, the reflected beam must traverse for the second time the displacement d made by the receding mirror C; and hence, the transit time T_d over the displacement d:

$$T_d = \frac{vT_{DEC}}{c-v} = D\left[\frac{v}{c-v}\right]\left[\frac{2c+v}{c^2-v^2}\right]$$

And so, the total transit time T_1 for the reflected beam is:

$$T_1 = D\left[\frac{2c+v}{c^2-v^2}\right] + D\left[\frac{v}{c-v}\right]\left[\frac{2c+v}{c^2-v^2}\right] = D\left[\frac{2c+v}{c^2-v^2}\right]\left[\frac{c}{c-v}\right]$$

II. The Transit Time T_2 for the Transmitted Beam:

According to the new-source theory, the transmitted beam through the beam splitter A travels at a speed of c towards the stationary plane mirror B. The stationary plane mirror B reflects this beam with the same speed of c towards the receding mirror C. The receding mirror C reflects this beam with the speed resultant of (c - v) towards the stationary concave mirror E. And the stationary concave mirror E reflects this same beam with a speed of c towards the approaching mirror D.

And therefore, the transit time T_{CE} over CE for the transmitted beam:

$$T_{CE} = \frac{D}{c-v}$$

And the transit time T_{ED} over ED for the transmitted beam:

$$T_{ED} = \frac{D - vT_{ED} - vT_{CE}}{c} = \frac{D - vT_{CE}}{c+v} = D\left[\frac{c-2v}{c^2-v^2}\right]$$

And hence, the transit time T_{CED} over CED for the transmitted Beam:

$$T_{CED} = T_{CE} + T_{ED} = \left[\frac{D}{c-v}\right] + D\left[\frac{c-2v}{c^2-v^2}\right] = D\left[\frac{2c-v}{c^2-v^2}\right]$$

On its way back to the beam splitter A, upon reflection with the speed resultant of (c + v) from the approaching mirror D, the transmitted beam travels for the second time over a reduced distance shortened by the displacement $d = vT_{CED}$ made by the approaching mirror D:

$$T_d = \frac{vT_{CED}}{c+v} = D\left[\frac{v}{c+v}\right]\left[\frac{2c-v}{c^2-v^2}\right]$$

And so, the total transit time T_2 for the transmitted beam:

$$T_2 = T_{CED} - T_d = D\left[\frac{2c-v}{c^2-v^2}\right] - D\left[\frac{v}{c+v}\right]\left[\frac{2c-v}{c^2-v^2}\right] = D\left[\frac{2c-v}{c^2-v^2}\right]\left[\frac{c}{c+v}\right]$$

And accordingly, the difference ΔT, between the transit time T_1 for the reflected beam and the transit time T_2 for the transmitted beam, as computed on the basis of the new-source theory, is:

$$\Delta T = T_1 - T_2 = D\left[\frac{2c+v}{c^2-v^2}\right]\left[\frac{c}{c-v}\right] - D\left[\frac{2c-v}{c^2-v^2}\right]\left[\frac{c}{c+v}\right] = \left[\frac{6D}{c}\right]\left[\frac{v/c}{1+v^4/c^4-2v^2/c^2}\right]$$

It follows, therefore, that the new-source theory predicts, in this experiment, a fringe-shift displacement equal to

$$\left[\frac{3/4}{1+v^4/c^4-2v^2/c^2}\right]$$

of the 3.61 fringe-shift displacement calculated by A. Michelson.

<u>C. The Prediction of the Elastic-Impact Theory:</u>

I. The Transit Time T_1 for the Reflected Beam:

According to the elastic-impact theory, the beam reflected by the beam splitter A travels at a speed of c towards the approaching mirror D. The approaching mirror D reflects this beam with the speed resultant of (c + 2v) towards the stationary concave mirror E. And the stationary concave mirror E reflects the same beam with the same speed resultant of (c + 2v) towards the receding mirror C.

And therefore, the transit time T_{DEC} over DEC for the reflected beam:

$$T_{DEC} = \frac{2D\left(\frac{c}{c+2v}\right) + vT_{DEC}}{c+2v} = \left[\frac{2D}{c+v}\right]\left[\frac{c}{c+2v}\right]$$

On its way back to the beam splitter A, upon reflection with a speed of c from the receding mirror C towards the stationary plane mirror B, the reflected beam traverses for the second time the displacement d made by the receding mirror C; and hence, the transit time T_d over the displacement d:

$$T_d = \frac{vT_{DEC}}{c} = \left[\frac{2D}{c+v}\right]\left[\frac{v}{c+2v}\right]$$

And so, the total transit time T_1 for the reflected beam is:

$$T_1 = T_{DEC} + T_d = \left[\frac{2D}{c+v}\right]\left[\frac{c}{c+2v}\right] + \left[\frac{2D}{c+v}\right]\left[\frac{v}{c+2v}\right] = \frac{2D}{c+2v}$$

II. The Transit Time T_2 for the Transmitted Beam:

The beam transmitted by the beam splitter A travels at a speed of c towards the stationary plane mirror B. The stationary plane mirror B reflects this beam with the same speed of c towards the receding mirror C. The receding mirror C reflects this beam with the speed resultant of (c - 2v) towards the stationary concave mirror E. And the concave mirror E reflects the same beam with the same speed resultant of (c - 2v) towards the approaching Mirror D.

And therefore, the transit time T_{CED} over CED for the transmitted beam:

$$T_{CED} = \frac{2D\left(\dfrac{c}{c-2v}\right) - vT_{CED}}{c-2v} = \left[\frac{2D}{c-v}\right]\left[\frac{c}{c-2v}\right]$$

On its way back to the beam splitter A, upon reflection with the speed of c from the approaching mirror D, the transmitted beam travels for the second time over a reduced distance shortened by the displacement $d = vT_{CED}$ made by the approaching mirror D:

$$T_d = \frac{vT_{CED}}{c} = \left[\frac{2D}{c-v}\right]\left[\frac{v}{c-2v}\right]$$

And so, the total transit time T_2 for the transmitted beam:

$$T_2 = T_{CED} - T_d = \left[\frac{2D}{c-v}\right]\left[\frac{c}{c-2v}\right] - \left[\frac{2D}{c-v}\right]\left[\frac{v}{c-2v}\right] = \frac{2D}{c-2v}$$

And accordingly, the difference ΔT, between the transit time T_2 for the reflected beam and the transit time T_1 for the transmitted beam, as computed on the basis of the elastic-impact theory, is:

$$\Delta T = T_2 - T_1 = \frac{2D}{c-2v} - \frac{2D}{c+2v} = \left[\frac{8D}{c}\right]\left[\frac{v/c}{1-4v^2/c^2}\right]$$

And it follows, therefore, that the elastic-impact theory predicts a fringe-shift displacement, in this experiment, slightly higher by a factor equal to the reciprocal of $(1 - 4v^2/c^2)$ than the fringe-shift displacement of 3.61 computed by A. Michelson.

Conclusion:

As demonstrated above, for mirrors revolving within a range from 1 to 1800 revolutions per minute, the undulatory theory and the elastic-impact theory give the same numerical prediction of 3.61 fringe-shift displacement produced by the two beams in this experiment. Thus, as ingenious as really is, the aforementioned optical arrangement by A. Michelson cannot, in practice, lead to any experimental evidence for or against either one of these two theories.

Concerning the third member of Michelson's triplet of theories, the experimental situation is a bit unclear. The new-source theory predicts a numerical amount of about 2.71 out of the calculated 3.61 fringe-shift displacement in the Michelson's 1913 experiment.

However, the new-source theory has a peculiar aspect that may well, upon further inspection, turn things around for it and in its favor. Michelson has configured his optical apparatus in such a skilled way that the transit times for both beams over AD, AB, DA, and BA cancel each other out automatically in time-of-flight calculations. But that is true only for beams coming back to the starting point at A with the same initial speed of c. On the basis of the undulatory theory and the elastic-impact theory, the two beams do return to A with the same initial speed of c. But according to the new-source theory, by contrast, the transmitted beam leaves A with the speed of c, and reflects back to A from D at the speed resultant of (c + v), while the reflected leaves A with the speed of c, and on its way back, goes first from C to B at the speed resultant of (c – v); and then it goes from B to A at the speed of c. And so, it's very likely that, upon taking into account the additional times of flight over these implicitly defined distances, more comprehensive calculations, on the basis of the new-source theory, will produce better and more accurate results.

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Appendix:

The Prediction of the New-Source Theory in the Presence of Stationary Air:

In the above calculated prediction of the new-source theory, it's implicitly assumed that the light path between the mirrors is free of air and very close to vacuum.

However, if the two experimental beams travel in air, which is at rest in the reference frame of the laboratory, then the two experimental beams will lose their speeds of (c + v) and (c - v), immediately upon reflection from the moving mirrors. And that is because the stationary air, in this particular case, absorbs and re-emits incident light at the speed of c, according to the new-source theory; i.e., the stationary air becomes a new source of light. And this is one of the main reasons why it's called the 'new-source' theory in the first place.

And accordingly, the calculated prediction of the new-source theory becomes, under such conditions, effectively identical to the computed prediction of the undulatory theory.

I. The Transit Time T_1 for the Reflected Beam:

According to the new-source theory the reflected beam by the beam splitter A travels at a speed of c towards the approaching mirror D. The approaching mirror D reflects this beam with the combined speed of (c + v), which is quickly transformed, due to the presence of stationary air, to the speed of c towards the stationary concave mirror E. And the concave mirror E reflects the same beam with the same speed towards the receding mirror C.

And therefore, the transit time T_{DEC} over DEC for the reflected beam:

$$T_{DEC} = \frac{2D + vT_{DEC}}{c} = \frac{2D}{c - v}$$

On its way back to the beam splitter A, upon reflection from the receding mirror C with the combined speed of (c - v), which is quickly transformed, by the stationary air, to the speed of c, the reflected beam must traverse for the second time the displacement d made by the receding mirror C; and hence, the transit time T_d over the displacement d:

$$T_d = \frac{vT_{DEC}}{c} = \left[\frac{v}{c}\right]\left[\frac{2D}{c - v}\right]$$

And so, the total transit time T_1 for the reflected beam is:

$$T_1 = T_{DEC} + T_d = \left[\frac{2D}{c - v}\right] + \left[\frac{v}{c}\right]\left[\frac{2D}{c - v}\right] = \left[\frac{2D}{c}\right]\left[\frac{c + v}{c - v}\right]$$

II. The Transit Time T_2 for the Transmitted Beam:

The beam transmitted by the beam splitter A travels at a speed of c towards the stationary plane mirror B. The stationary plane mirror B reflects this beam with the same speed of c towards the receding mirror C. The receding mirror C reflects this beam with the combined speed of (c - v), which is quickly transformed, by the stationary air, to the speed of c towards the stationary concave mirror E. And the concave mirror E reflects the same beam with the same speed towards the approaching Mirror D.

And therefore, the transit time T_{CED} over CED for the transmitted beam:

$$T_{CED} = \frac{2D - vT_{CED}}{c} = \frac{2D}{c+v}$$

On its way back to the beam splitter A, upon reflection from the approaching mirror D with the combined speed of (c + v), which is quickly transformed, due to the presence of stationary air, to the speed of c, the transmitted beam travels for the second time over a reduced distance shortened by the displacement $d = vT_{CED}$ made by the approaching mirror D:

$$T_d = \frac{vT_{CED}}{c} = \left[\frac{v}{c}\right]\left[\frac{2D}{c+v}\right]$$

And hence, the total transit time T_2 for the transmitted beam:

$$T_2 = T_{CED} - T_d = \left[\frac{2D}{c+v}\right] - \left[\frac{v}{c}\right]\left[\frac{2D}{c+v}\right] = \left[\frac{2D}{c}\right]\left[\frac{c-v}{c+v}\right]$$

And accordingly, the difference ΔT, between the transit time T_1 for the reflected beam and the transit time T_2 for the transmitted beam, as computed on the basis of the new-source theory, is:

$$\Delta T = T_1 - T_2 = \left[\frac{2D}{c}\right]\left[\frac{c+v}{c-v}\right] - \left[\frac{2D}{c}\right]\left[\frac{c-v}{c+v}\right] = \left[\frac{8D}{c}\right]\left[\frac{v/c}{1 - v^2/c^2}\right]$$

It follows, therefore, that the new-source theory, in the presence of stationary air, predicts a fringe-shift displacement, in this experiment, slightly higher by a factor equal to the reciprocal of $(1 - v^2/c^2)$ than the fringe-shift displacement of 3.61 computed by A. Michelson.