Man in the spotlight, an optical study of the aura (Part II)

This second text follows : "Man in the spotlight, an Optical Study of the Aura, Part I." We assume that the reader or reader is sufficiently familiar with the optical concepts explained there. Going into it in more detail, for those who wish to make sense of these experiments, possibly for those who wish to redo them on the optical bench itself.

The Michelson and Morley experiment conducted in 1887 occupies an important place in this text. It then sought to show that in the universe there is no need to assume the existence of an evenly distributed fine substance called the ether. However, in a somewhat modified form that we present here, and with an accuracy that may not have been possible at that time, this experiment does appear to demonstrate the very existence of an extremely fine substance, albeit in a non-uniform manner. And this seems to us to be a curious twist of fate: the same experiment then leads first to a falsification, and 125 years later and in a slightly modified form of it, to a verification. All this, and more, we want to explain in detail below.

Just about in all times and in many cultures one hears testimonies of people who claim that we not only have a biological body but that we also possess a set of subtle material bodies, the so-called "aura". In Western philosophy today, the subject is hardly ever discussed. Also current natural science is - to put it mildly - not too interested in this theme and is not really overflowing with any research in this area. Understandably, one does not look for something whose existence is denied. Yet it was one of the most important themes among the founders of our philosophy: the ancient Greek thinkers. Also in Christianity - the second pillar of our Western civilization - the belief in the existence of a fine substance is never far away. At the end of the 19th century, the theme seemed to briefly return to scientific interest, in the midst of all the controversy that surrounded the famous "Michelson and Morley experiment. Reason enough to take a closer look.

1. The Michelson and Morley experiment.

Everyone has had the experience of sitting in a stationary train next to a second train. If a train then gently departed, it was not immediately clear whether it was one's own train or the other, and one had to search for a fixed point of orientation, such as the station or the platform itself. Thinking on this further, finding such a fixed point of orientation, anywhere, seems far from simple. The earth rotates around its axis, and around the sun, which itself is also part of a rotating galaxy, and all of them, moreover, belong to an expanding universe. So does a fixed point exist somewhere in space?

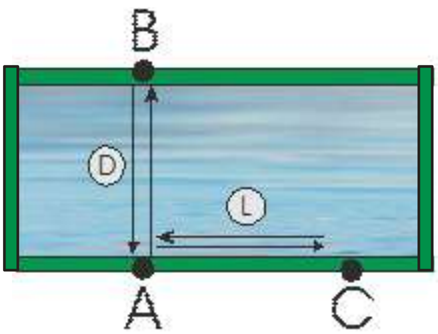
In his *Philosophia Naturalis* (1687), Isaac Newton adopted the concepts of absolute time and absolute space. He assumed that time passes uniformly, completely independent of anything else. And also space was a kind of fixed standard, which made it possible to determine the correct position of every object in the universe. Something in space played the role of a fixed coordinate system and ensured that place and motion could be fixed in an absolute way. In his time, this did not pose an immediate problem for ordinary people.

Advancing science did see a difficulty here. If all motions are only motions relative to something else, is there such a thing as a fixed reference point in space, or does all celestial mechanics rest on quicksand?

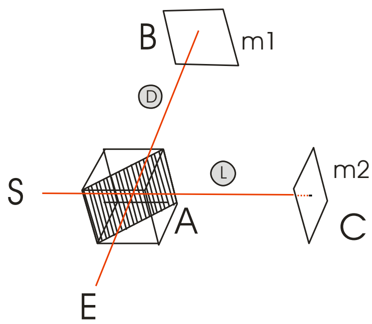
The waves moving in water have this water as their medium, and sound uses air to propagate itself. So it doesn't seem so farfetched to assume that the light from the sun and stars reaching the earth does so through a medium. And so physics welcomed a hypothetical medium, an extremely fine intermediate substance called "ether," which evenly fills all of space, and which could likewise serve as a standard for absolute measurements of time and space. The question was whether and how its existence could be demonstrated experimentally. Such an experiment was conducted in 1887 by Michelson and Morley, - henceforth abbreviated in this text as the 'M&M experiment' - with a device based on interference of light.

Clarify below. The drawing on the left (1a) represents a still water, e.g. a swimming pool, with points A, B and C at its edges, and such that the distance AB equals AC. D and L are two swimmers, swimming equally fast. D crosses the pool from A to B and back, L swims longitudinally from A to C and back. It is therefore obvious that both reach the point A back at the same time.

Now let's look at the drawing on the right (1b). It is a schematic representation of the apparatus, a so-called 'interferometer', with which the M&M experiment was performed. Here, S ('S' of Source) is a light source, illuminating a beam splitter BS, a cube with in it diagonally a semi-transmissive mirror, of which A is the center. The figures m1 and m2 (twice the lowercase 'm' of mirror) are two plane mirrors. They are placed so that the distance AB is equal to the distance AC.



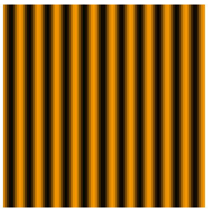
1a



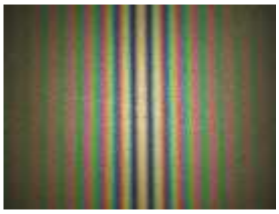
1b

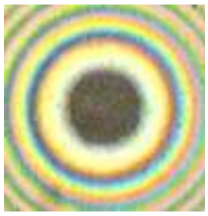
Light from S splits at the center of Bs, we call this point the point A. One partial beam goes to B, reflects back to A and reaches the observer in E. The other partial beam goes to C, reflects back to A and also reaches E. One can see the analogy between the two diagrams in 1a and 1b. Where (in 1b) the two partial beams travel a common path AE, one can expect an interference image to show up.

If one works here with monochromatic light, then one indeed sees a number of parallel light and dark stripes or circles. If one works with white light, then these have the colors of the rainbow. We searched the Internet and found images as shown in 2a to 2c, as results of the M&M experiment. Image 2d is not. It is an image of some Newton rings. Perhaps we searched poorly; however, we did not find colored circles as results of an M&M experiment. Perhaps they can be found. If so, they will be very similar to what Figure 2d depicts. We will return in detail to the formation of such lines and circles later in the text.

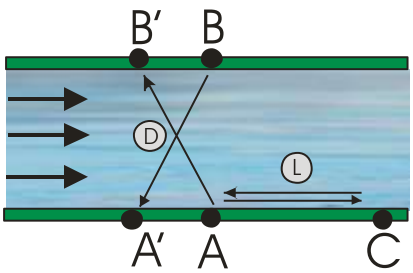

2a


2b

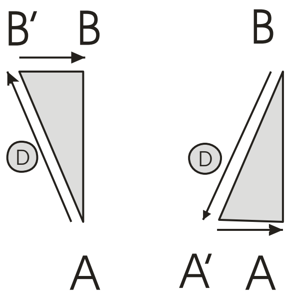

2c


2d

Back to the pool. We replace it with a river of flowing water (3a). Now it is far from certain that both swimmers D and L will still arrive together in A after their swim. For suppose that the water flows quite fast in the direction from A to C, swimmer L will make a stunning start, but once in C he will swim much more laboriously against the current. He will lose more time than swimmer D to get back into A.



3a



3b

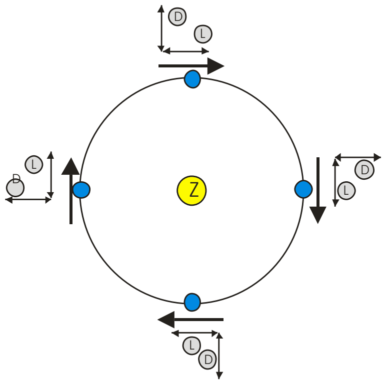
One can demonstrate this in a simple way using Pythagoras' Theorem (3b). If there is a current, then D must swim continuously from A to the direction B', to the left of B, to reach B. But then he will have traveled a distance equal to the hypotenuse (AB') of the right-angled triangle AB'B.

If D then wants to swim back to A from B, he will have to keep the direction to A', to the left of A. Then he will have covered a distance equal to the oblique side (BA') of the right triangle ABA'. In either case, that distance is greater than the direct crossing AB or BA.

In turn, swimmer L initially has the speed of the flowing water with him, but on his return from C to A, he has it against him. A numerical example shows that swimmer L then takes longer than swimmer D.

Consider this last fact, but now situated in the interferometer as represented in drawing 1b. Both light beams D and L cleave the static ether. But since the earth is never at rest, the interferometer, located somewhere on the earth, does not always maintain the same position with respect to that ether.

Let us look at drawing 4. If the whole space is indeed filled with such a static and evenly distributed ether, then the earth (the blue circle), among other things because of its movement around the sun (the yellow circle), will cleave this ether in the course of a year in an ever-changing direction.



4

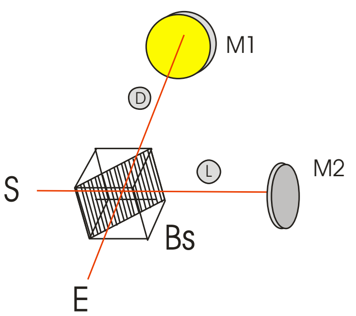
With the change of seasons, the earth moves through this substance sometimes in the transverse direction, sometimes in the longitudinal direction. But then the two light beams will not always arrive back together in A, just as our swimmers D and L do not.

In the M&M experiment, the expectation was that this difference in time would show itself by an altered interference image. However, when performed carefully and effectively, it turned out that the light rays D and L always arrived back together in A. And this regardless of the position of the interferometer relative to the assumed center substance. This result, the unchanged interference image observed repeatedly, led Einstein to conclude that it is not possible to establish a uniform motion relative to the ether. And if its existence cannot in itself be proved either, it also seems pointless to claim that the earth and the heavenly bodies move through it. So much for the description of this famous experiment and its scientific interpretation.

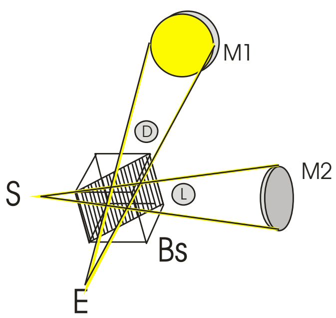
2. You look for something, and you find something else

Years ago, somewhat naively and overconfidently, we attempted to redo this M&M experiment - or rather, a self-conceived variation of it. We didn't use flat mirrors, we used two hollow mirrors M1 and M2 (the capital 'M' of Mirror). We aligned everything with a laser (5a) and carefully made sure that all the laser light was nicely in one plane.

Afterwards (drawing 5b) we replaced the laser with a white point light source, a fiber optic with a diameter of 0.3 mm. Here, both light beams diverge from S and Bs to both mirrors M1 and M2 to converge back to E after reflection.



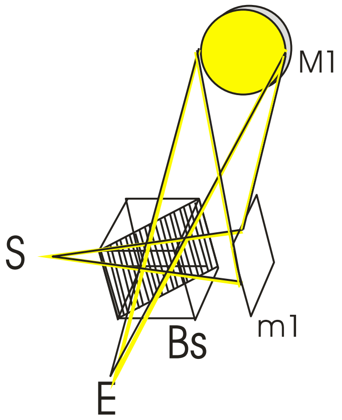
5a



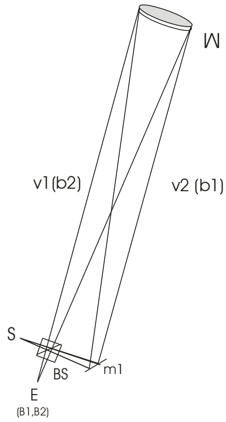
5b

Once the setup was ready, we searched somewhat impatiently in E for the interference image that should form. As it turned out, there was not the slightest trace of even incipient interference. Frustration all around. Reason? It is simply impossible for an amateur to put the mirrors M1 and M2 at an equal distance from Bs, and to within a component of a few light waves. But we didn't realize that at all at the time.

Then, out of a kind of dissatisfaction, just like that, simply because we did not want to assume that we had not achieved anything at all with our arrangement, we replaced the concave mirror M2 with the smaller plane mirror m1 (6a). But this one then, given the divergence of the beam, had to be much closer to Bs. In drawing 6b, the proportions are somewhat more realistic. The mirror M is indeed about 2500 mm (the curvature center distance k) away from the splitter Bs.



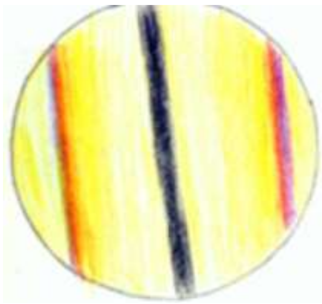
6a



6b

The image that then formed in E struck us with utter amazement. We saw two mirror surfaces - one mirror surface from each light path - that almost coincided, and interference lines began to form (7a). If we adjusted the mirror m1 slightly, the lines suddenly became much wider (7b). Changing the position of m1 again, we saw the mirror surface filled with some concentric circles, in the colors of the rainbow (7c). Comparing these quite wide lines and circles with the results (2a to 2d) of the M&M experiment, it may be clear that, almost by chance, we really stumbled upon something unusual.

7a



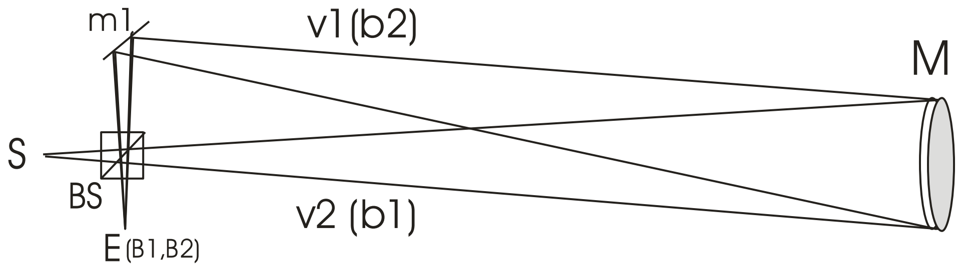
7b

7c

And we had no explanation for it. So it goes, when you don't know what you're looking for, you don't know what you'll find. So time to inform ourselves about all this seriously and in detail. And that became the beginning of a fascinating search, which eventually made us understand what was occurring. More than that, it allowed us to conceive and propose a number of other experiments, and some of them to be actually carried out ... and that is what this text is about.

3. Our basic setup: a type of radial interferometer

As already mentioned, in an interferometer the light is split into two sub-beams which subsequently reunite and, under well-defined conditions, can give rise to interference, to color shifts. We describe below a kind of radial interferometer. We get:



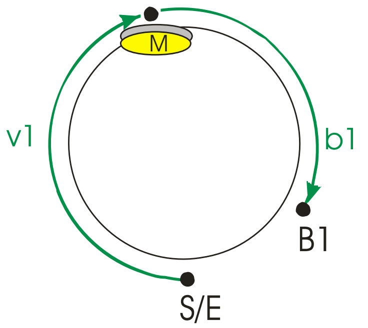
8

S = Source, point light source, white light.
M = Mirror, (capital letter) concave mirror, 155 mm diameter, f = +/- 1250 mm
m = mirror, (lowercase) small flat mirror, with reflective layer on top
Bs = beampslitter cube for visual light, 50/50, 20 mm^3.
E = Eye, eye, place of the observer
v = (lowercase) object distance
b = (lowercase) image distance
B = (capital letter) image point
K (capital letter) = curvature center point
k (lowercase) = curvature center point distance
Call this arrangement the "basic arrangement.

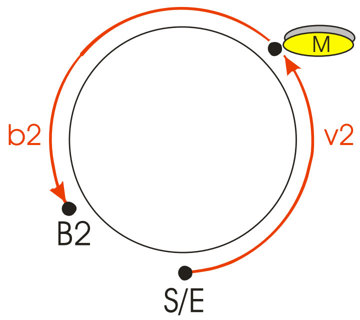
We have (drawing 8): v1, the object distance in the pointer sense. This goes diverging from S via BS and m1 to M, and reflects as the image distance b1, converging via Bs to the point B1, in front of the eye of the observer E. The part of the light that goes to S is lost.

We also have: v2, the counterclockwise object distance, this goes diverging from S via BS directly to M, and reflected as the image distance b2, converging via m1 and Bs to the point B2, in front of the eye of the observer E. Theoretically, the points B1 and B2 can coincide in E, but can also be just next to each other, or behind each other.

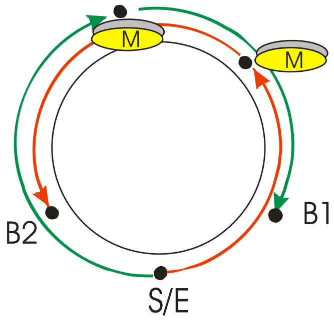
Let us try to explain this schematically as follows. In drawing 9a we see at the bottom the light source S, from where the light beam v1 leaves in clockwise direction to the mirror M, and which then reflects as b1 to the image point B1. However, we see that B1 does not reach the point E. The entire circular circumference was not completed. Drawing 9b shows us v2 reaching M in a counterclockwise direction, and then converging via b2 into the image point B2. Again, the image point B2 does not coincide with E. Finally, drawing 9c tries to summarize both drawings 9a and 9b. We see that both image points B1 and B2 do not coincide, nor do they reach the point E.



9a

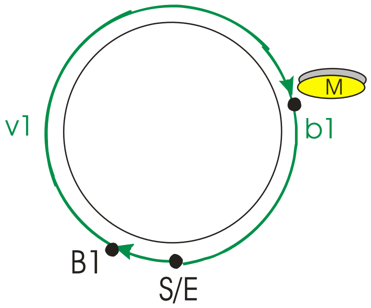


9b

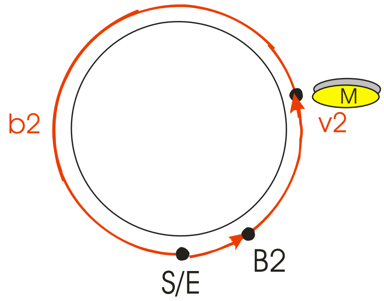


9c

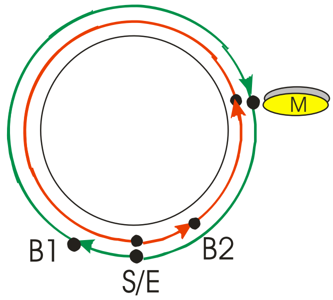
Now look at drawing 10a. The light starts from S in clockwise direction. After divergence and convergence, the image point B1 now falls beyond the point E. The traversed distance is more than the circle circumference. In drawing 10b the light starts from S in counterclockwise direction and the image point falls beyond E after the whole circumference. Drawing 10c unites drawing 10a and 10b. The image points B1 and B2 do not meet, and fall beyond E.



10a

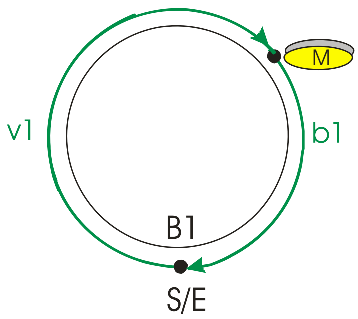


10b

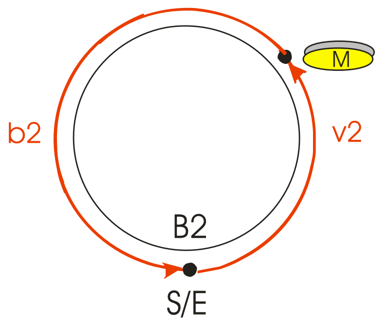


10c

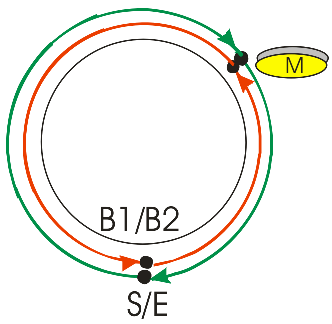
In drawing 11a, the light goes diverging in a clockwise direction to M, and converges in B1. This point converges to E. Drawing 11b shows us the light counterclockwise, with B2 also converging to E. Drawing 11c summarizes 11a and 11b. Both points, B1 and B2 coincide with each other, and this in E.



11a



11b

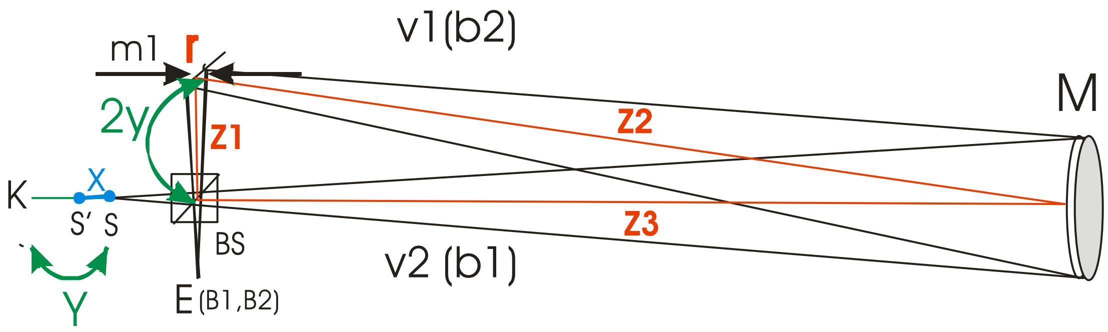


11c

The explanation that follows is an attempt to choose all the distances in the basic setup such that indeed the image points B1 and B2 coincide with each other in E, i.e., they lead to unusual interference images for the observer. The margin within which the interference shows itself is exceptionally small. For example, if B1 and B2 are only half a millimeter apart, they are a thousand (!) wavelengths apart, and in our setup there is no longer any interference at all.

In what follows, we will take a mathematical approach. We can't do it without calculations. Let's hope that the reader will leave these few lines behind him or her quickly, and that he or she can easily follow the thread of this text.

So we define more precisely. What we are axiomatically proposing here may seem somewhat unusual. However, they are very deliberate choices and the thoughtful result of a number of algebraic operations. We will skip those operations themselves here. We limit ourselves to the results. Those who are nevertheless interested in them will find them at the end of this text. However, their practical importance will become apparent fairly quickly. We illustrate this with drawing 12.



12

Notice the red triangle, formed by the center of Bs, m1, M and again with the center of BS. It is a right-angled triangle, with the right angle in BS. Z1 and Z3 are the rectangular sides, Z2 is the hypotenuse and is obviously longer than Z3.

The distance 2y, indicated by the green arc on the left, is the sum of the side z1, plus the difference of z2 and z3. Shorter; 2y = z1-(z2-z3).

The distance from the center of curvature K to S (the green arc at the bottom) is equal to one time y.

Finally, x, the distance from S' to S, is given by the formula $x = \text{sqr}(y^2 + f^2) - f$.

With all this data, try to define the object distances. We get:

v1 = 2*f - y + 2y + x or v1 = 2*f + y + x
v2 = 2*f - y + x

via the mirror formula 1/f = 1/v + 1/b we find :

b1 = v1*f/ v1-f b2 = v2*f/ v2-f

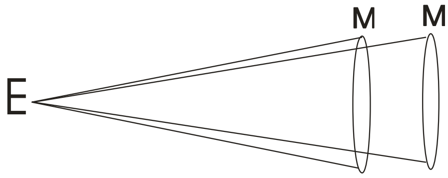
Illustrate we have the following values:
$f = 1250$, $y = 5$, $x = \text{sqr}(5^2 + 1250^2)-1250$ or 0.01. We get:

v1 = 2500 + 5 + 0.01 or 2505.01, b1 = 2505.01*1250/2505.01-1250 or 2495.01
v2 = 2500 - 5 + 0.01 or 2495.01, b2 = 2495.01*1250/2495.01-1250 or 2505.01

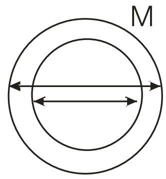
We see that with these values v1 = b2, and also that v2 = b1. The importance of this becomes immediately clear when we realize that v2 - b1 = 0, but also v1 - b2 = 0. This means that theoretically, for the observer in E, the image points B1 and B2 coincide exactly. It is the situation as it was explained in drawing 10c.

If we redo the calculation for another value, e.g. $y = 10$, and stick to the formula $x = sqr(y^2 + f^2) - f$, we always find that B1 and B2 coincide. In other words, our setup allows us to theoretically make two coherent points of light coincide exactly.

In our basic setup, the light path b2 is longer than the light path b1. The light from M reaching us via b2 has traveled a longer path than the light from M reaching us via b1. So that to the eye, the mirror M is farther in the first case than in the second case. This illustrates to us drawing 13a.



13a



13b

With the given values, this mutual difference in distance is 2505.01 - 2495.01 or 10 mm. It seems from E, that the mirror surface we see through one light path differs a little in size from mirror surface we observe through the other path. That is precisely why it is a radial interferometer. This shows us, greatly exaggerated, drawing 13b.

Do we build this interferometer and adjust it so finely that almost the entire mirror surface is filled with one interferometer color. Then we bring the hand into the light path. We see images as shown below (14a, 14b, 14c). The hand heats the surrounding air and this turbulence creates an obstacle for the light, causing it to diverge. The latter leads to color shifts. We see wisps of warm air continually rising upward. The whole thing is very dynamic and gives us a fascinating spectacle.


14a


14b


14c

We tried to capture these images digitally. However, our point light source has a diameter of only 0.3 mm, the diameter of an acupuncture needle, and is very dim. In some attempts to take pictures anyway, the images are so small and light weak that when digitally enlarged they show only a collection of overly blurred pixels. We therefore prefer to stick to a real-life representation in drawings in this text.

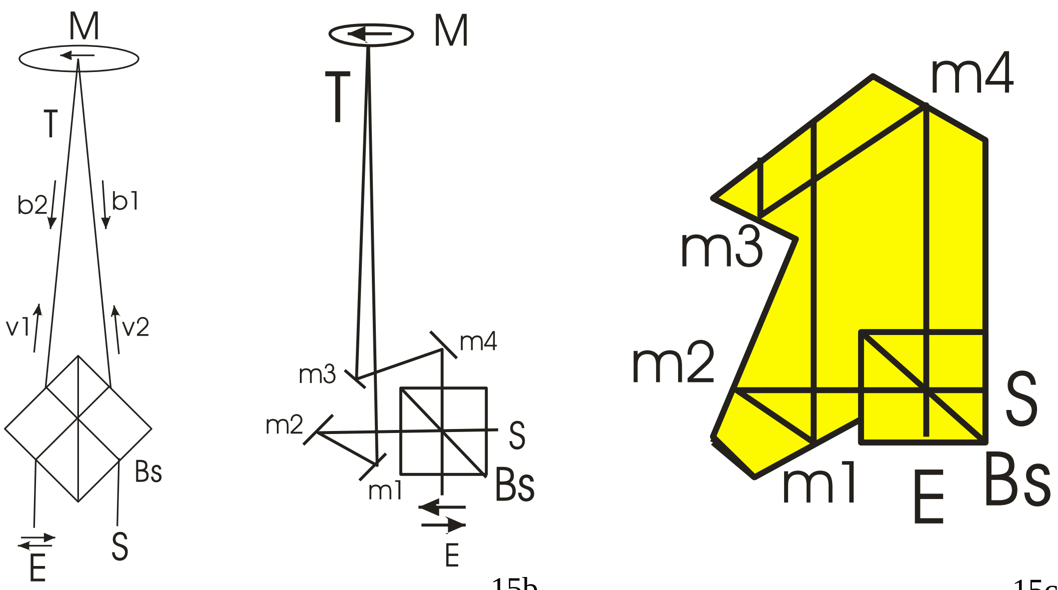
If we consider our interferometer, it becomes clear that the radiality decreases as the length difference between the two sub-beams decreases. This will allow us to make our interference bands wider. Our setup will then become even more sensitive. However, there is a limit. The plane mirror m1 (see Fig. 12) cannot be squeezed into Bs. The smallest distance we achieved for 2y was 7 mm. Nevertheless, this path difference can be eliminated in another way. We want to explain that in a moment.

In summary, we described and calculated a type of radial interferometer. This one is radial and because, seen from the observer E, the two images of M do not have the same size, not the same diameter. However, the image points B1 and B2 are much closer to each other than is thought possible, e.g., in Young's well-known two-slit experiment. Thus, much wider interference images can be obtained in a relatively simple manner. Our instrument is so sensitive that it shows the rising air caused by the heat of our hand in many changing interference colors.

4. An inversion or "reversal" setup

A type of reversal interferometer was already mentioned in the first text. Here we go into further detail. The setup in the figure below on the left (15a) shows us a reversal with one Bs, as described in the literature. We did not succeed in generating wide interference with this. The beams already fall too obliquely on Bs, leading to vertical interference lines, not a mirror surface in a single interference color.

So we circumvented this problem with the setup shown in the middle image (15b). To make the distinct light paths equal to each other as much as possible, we used a map (15c), a detail of drawing 15b, where the two light paths could be made nearly equal in length, to within less than 1 mm path difference. Mirrors m1 to m4 could thus be placed very precisely in the right place.



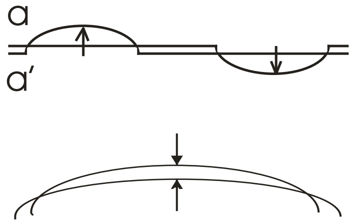
15a 15b 15c

Adjusting all the parts in 15b with the laser requires great precision. Indeed, all laser light must be in the same plane. With some flat auxiliary mirrors and a transparent piece of plastic, we checked whether the distinct laser beams effectively intersect, or whether they do not merely cross each other at a mutual distance.

In this reversal interferometer, one half of the image (16a) blends with the mirror image of the other half (16b). If we do not go beyond the centerline of the mirror by hand, a perturbed wave interferes with an undisturbed one. Imagine the perturbed wave by an arc and the undisturbed wave by a horizontal line (16c top). Their mutual difference, each indicated by the arrow, is much greater than in a radial interferometer The instrument is therefore much more sensitive. We see a much more intense color shift. One thus notices that in a radial interferometer (16c below), the difference between two curves, is smaller than the difference between a curve and a straight one.

16a

16b



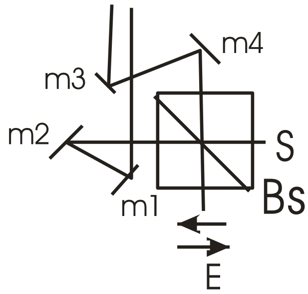
16c

If we place the finger in the light path, the result is surprising (17). We already described this in detail in the first text.

17

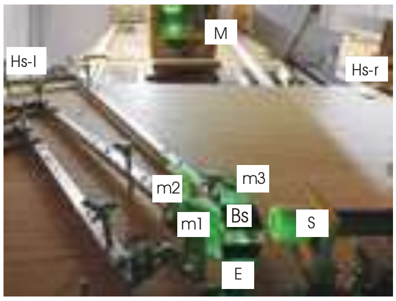
However, the image is never static. Any vibration of the optical bench, however minute, is such that one half of the image, reacts "opposite" to the other half. Clarify this as follows. We hold both hands with the fingertips together, without releasing them. If we move one hand forward or backward, the other follows simultaneously. This is how it is done with vibrations in an ordinary interferometer. Not so in a reversal interferometer. To stay with the example with the hands: when there is a shock, one hand moves forward, but the other backward by the same amount. And since our optical bench does constantly vibrate - we are talking about extremely minimal movements - the image constantly changes and it is not easy to quietly look at what is showing. They literally remain "snapshots" of an extremely dynamic event.

Drawing 18a gives us a detail of the arrangement from 15b. In picture 18b we pay attention to the raised mirror m4. In it we see the mirror image of the outlined lines on the card. If we adjust the mirror m4 so that we see the plotted line and its mirror image in line, we know that the adjustment is already quite accurate. We pay attention that all the laser light stays in the same plane. This obviously applies to the alignment of all mirrors. Photo 18c gives an impression of the optical bench. Mirror M is on a trolley, which can be accurately moved closer or further away, or should we say "driven," via a beam under the optical bench with adjustment screws.



18a

18b

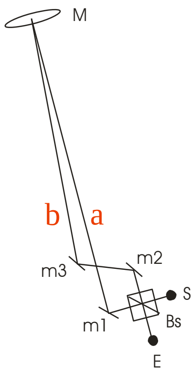


18c

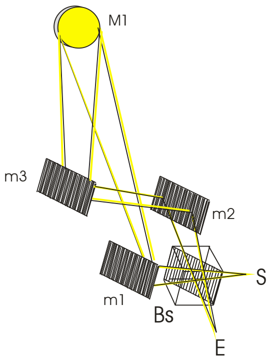
So much for the description of this reversal interferometer. Now let's move on to the next experiment.

5. A setup with radiality = 0

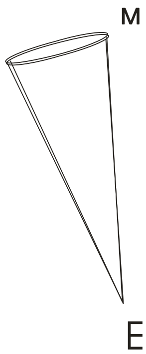
Let's try to make our basic setup more sensitive, by further reducing the path difference between the two partial beams. In other words, we make the light path a or v1 and the light path b or v2 equally long. We do this by adding the plane mirrors m2 and m3 to the basic setup. We see that in the drawing (19a)



19a



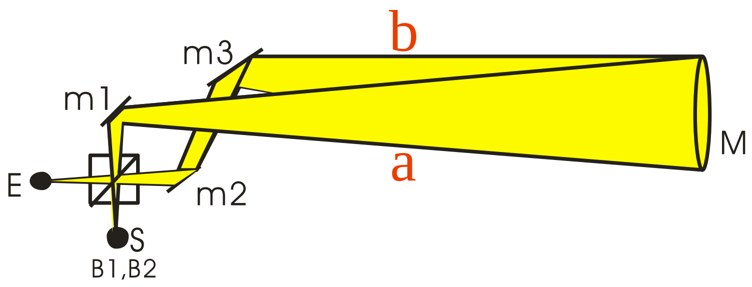
19b



19c

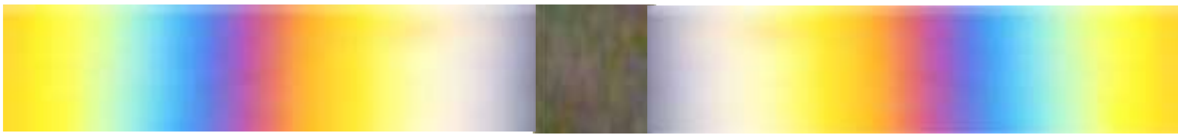
Figure 19b shows the diagram diverging and converging. Figure 19c illustrates that from E we see the mirror M at equal distances a and b. In other words, the mirror M is illuminated from its center of curvature K. Thus, v1, b1, v2 and b2 all become equally long. Put another way, in our formula $x = sqr\ (y^2 + f^2) - f$, x and y aim for 0 and the image points B1 and B2 in E coincide. As a result, our setup is no longer a radial interferometer. However, we do obtain an exceptionally sensitive instrument, which we expect will reproduce very small perturbations in the light path as color changes.

So we build the setup as shown in drawing 20 below.



20

A nice and wide interference band shows up fairly quickly upon alignment. (21).



21

In the end, when aligned with extreme precision, it becomes so wide that it exceeds the diameter of our mirror many times over. We can then adjust the mirror so that its entire surface is optionally filled with a single interference color each time. We see this presented below (22).

22

If we adjust to a background color and bring the hand into the light path just in front of the mirror, we see, depending on the color chosen, what is drawn and colored below (23a, 23b, 23c). We no longer notice violent turbulence as shown, for example, in the inverted interferometer (17), or even in the images in our basic setup (14a, 14b, 14c). No the image is now quite static. We can continue to watch quietly.

23a

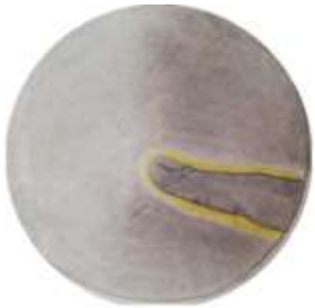
23b

23c

Finally, we gradually adjust the setup to destructive interference (24a), and bring the finger into the "light path (24b, 24c).

24a

24b

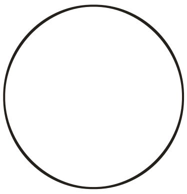


24c

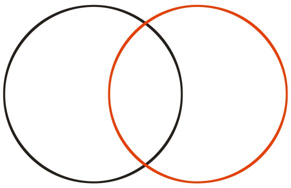
We see a white-yellow band just around the finger. Apparently, there is "something," a fine matter, disturbing the so sensitive destructive, and possibly in that place making the interference even constructive. The fact that that band is momentarily left behind when moving the finger back and forth indicates that this is a phenomenon other than diffraction.

6. Young and Newton: two sides of the same event.

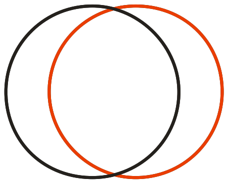
Gradually slide two transparencies on which a circle is printed over each other. We get (from 25b to 25d) :



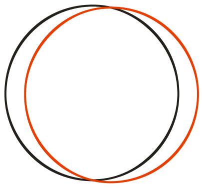
25a



25b

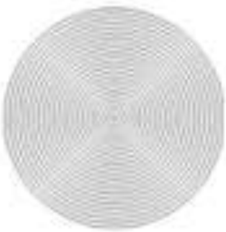


25c

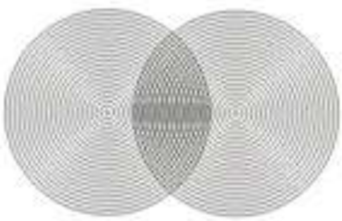


25d

Next, we gradually slide two transparencies, with a series of concentric circles printed on each transparency (26a), over each other. Well-defined patterns begin to form. We get (from 26b to 26d) :



26a



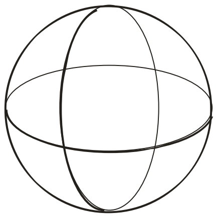
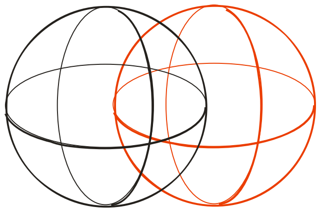
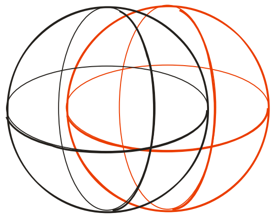
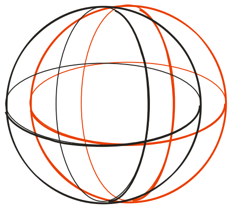
26b

26c

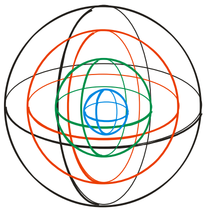
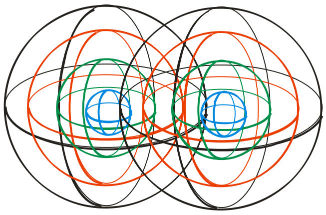
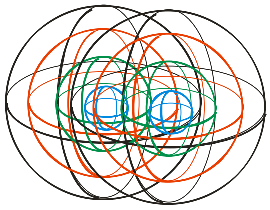
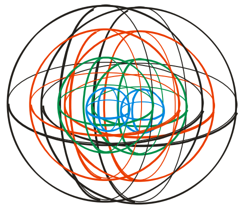
26d

The dark patterns, which form most clearly in drawing 26d, arise because two curves, each with slightly different curvatures, touch and even seem to flow into each other for a piece. This makes them appear to form a slightly thicker arc together.

Now imagine that they are not circles, situated in a flat plane, but spheres, which have a length and a width as well as a height (27a). Imagine that they gradually slide more and more into each other. We get (from 27b to 27d) :


27a

27b

27c

27d

Next, imagine that each is a set of four concentric spheres (28a). Such two sets gradually slide into each other. We get (from 28b to 28d) :

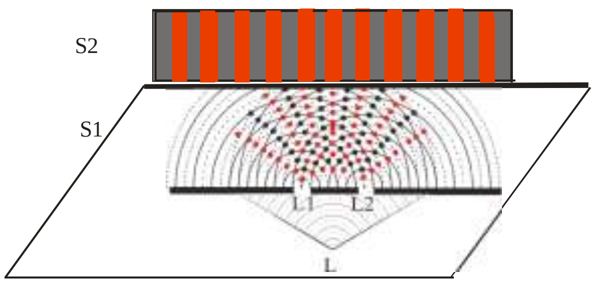

28a

28b

28c

28d

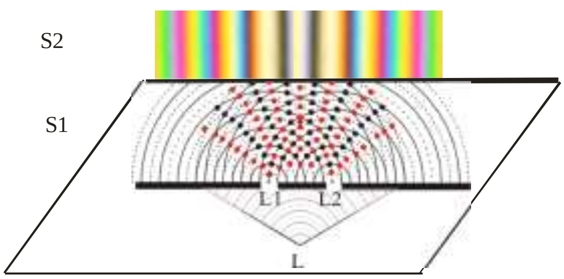
The paper or digital image gives a static representation of this. In drawings 28a to 28d we have used colors for clarity. However, in the case of light sources, imagine that they are one color: either monochromatic lazer light or white light. The latter is a collection of the colors of the rainbow.

Imagine that one such series of concentric spheres (28a) expands continuously and uniformly, obviously at the speed of light, and that from the center, new spheres are continually generated. Having that well in mind, one can imagine approximately what happens with a point light source, e.g., a fine fiber optic, emitting light in all directions.

Although in our drawings (28a to 28d) each point of light generates only 4 waves, the picture already becomes quite complicated.

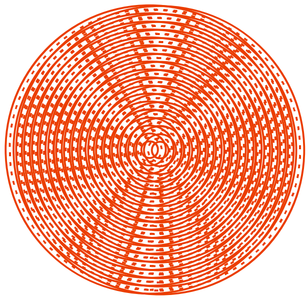
In the first text we discussed in detail Young's two-slit experiment, and this both for monochromatic light (e.g., red laser light), and for white light. Recall drawings 31 and 32 from the first text, which we reproduce here again. Now as drawings 29a and 29b.



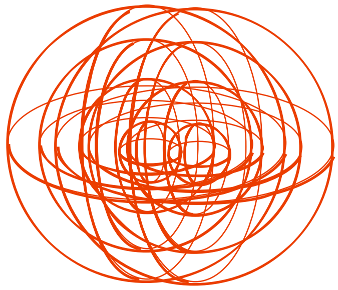
29a


29b

Giving below drawing 26d again, now as drawing 30a, next to it (in 30b) we find drawing 28d. Both, however, in red color.



30a



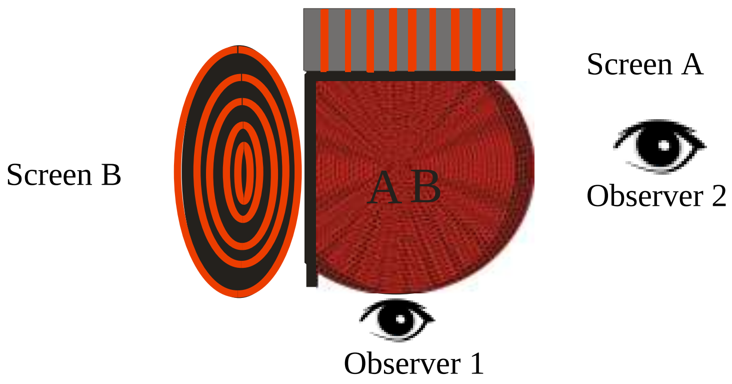
30b

Now, try to imagine that the drawing on the left (30a) is not a representation of circles in a flat plane, but a spatial representation of two sets of concentric spheres squeezed into each other. Were we to supplement drawing 30b with as many spheres as are represented in drawing 30a, drawing 30b would look just like 30a, the similar interference patterns included.

Recall: the eye does not see the individual light waves. It does see their interference. Just as in drawing 26d the patterns arise because parts of two circles, each of which has an almost similar curvature, touch each other and penetrate each other somewhat, so too here. Only now it does not concern circles, but spheres. Where two spheres, with almost equal curvature, touch and penetrate each other, we see at that place the common spherical shell.

This gave rise to the red and black interference streaks in drawing 29a, which appeared on the screen S2. Notice that the point light sources L1 and L2 seen from the observer L, are next to each other.

However, that is not the only possible point of view. Light points can also be behind each other. Try to clarify that with the drawing 31 below. We see two red light points A and B, each generating a series of concentric spheres.



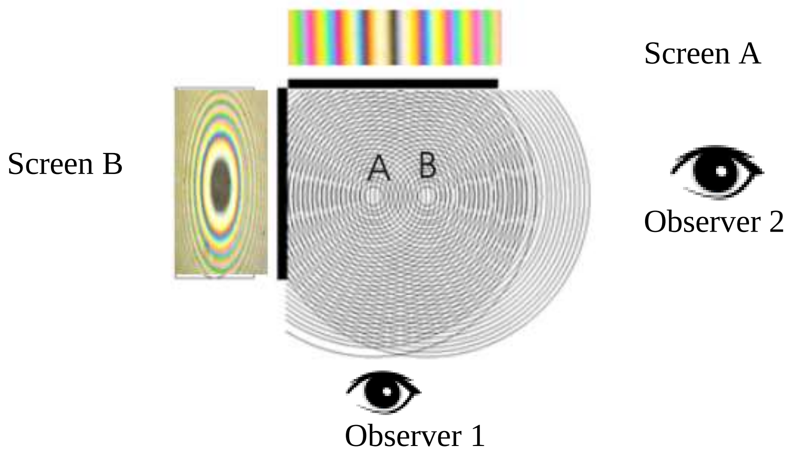
31

For observer 1 (bottom), points A and B are next to each other and generate on screen A (top) a number of parallel red and black lines, lines of constructive and destructive interference, as Young's experiment showed us.

For observer 2 (right), points A and B are not next to, but behind each other and generate on screen B (left) a number of concentric red and black circles, circles of constructive and destructive interference, the well-known Newtonian rings. Newton discovered them but could not explain them, because for him light consisted of particles, not waves.

Drawing 31 shows us the connection between Young's two-slit experiment and Newton's rings. They are like the two sides are of the same interference event. Even more, if we place the two points A and B not next to or below each other, but a little more diagonally, curves would appear on a screen, located between screens A and B, as a transition between circles and lines. We will return to this important distinction, the location of points A and B, next to or behind each other, further on in the text.

We talked above essentially about light of one color. However, we work with white light. On our screens we will therefore see colorful interference stripes or circles, as shown in drawing 32. This clarifies why at the very beginning of our experiments (drawings 7a, 7b and 7c) we were shown some circles and lines, whose meaning we did not initially understand.



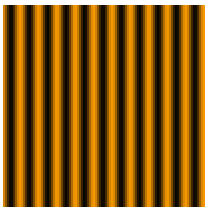
32

So much for a word on the connection between Young's and Newton's experiments, and this as the two sides of the same event.

7. And further?

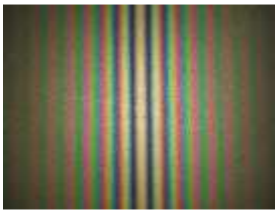
All this now leads to some fascinating reflections regarding the M&M experiment. We clarify. Recall pictures 2a to 2d. We repeat them here. As already mentioned, the M&M experiment conducted in 1887 showed, on the one hand, a number of vertical interference lines of constructive interference alternating with lines of destructive interference (drawings 2a and 2c). And on the other hand, a number of interference circles of constructive interference interspersed with circles of destructive interference (drawings 2b and 2d). Figures 2a and 2b involve light of one color. Figures 2c and 2d show us interference of white light.

Figure 2a shows us lines, not broad bands. In the center of Image 2c we see a black line, not a broad band. In Figures 2b and 2d we see centrally a circle of destructive interference. However, this does not fill the entire mirror surface.



2a

2b



2c

2d

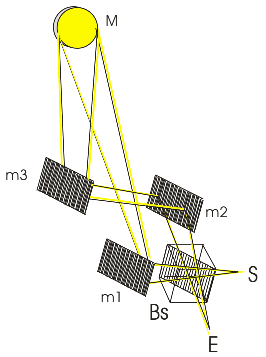
May we then suppose, observing drawing 32 which showed us the connection between Young's experiment and Newton's rings, that the two points B1 and B2, for the "observer" in E "*do not really coincide*," but on the contrary, as far as the lines are concerned, *lie side by side*? And where the circles are concerned (2b and 2d), the image points B1 and B2 do not coincide either, but lie *behind each other*. If not, the dark circle would fill the entire mirror surface.

Then one can ask the question whether the M&M experiment, with our current technique can be tuned so that the two image points in E do *not lie next to or behind each other*, but do (almost) coincide. This is at least evident from experiments with the so-called "Nulling interferometry" or it is also evident from the accuracy with which e.g. the 18 segments of the James Webb telescope are aligned. We clarify.

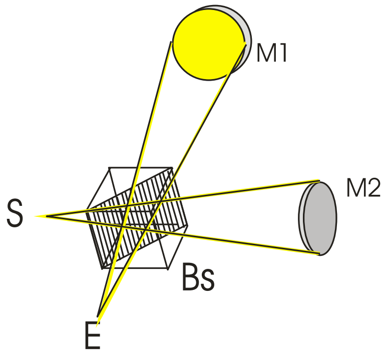
'Nulling interferometry'. Think of the stellar world. The question of whether other planets like our Earth exist elsewhere in the universe is very topical in our time. Finding such planets, however, is not so easy. If they are too far from a star, they are too faintly dim. If they are too close, the blinding light intensity of this celestial object prevents observation of the planet. That is why one uses, among other things, destructive interference: light beams can, under certain conditions, extinguish themselves. We have already explained this. The light from two closely spaced and equivalent telescopes aligned on the same star can be united, however, with a difference of half a wavelength or an unpaired multiple. Thus starlight is neutralized. But this does not necessarily apply to the light of the planet located near that star. In conclusion, the light of the star is attenuated or extinguished, but that of the planet, which is at a different distance from the telescopes, is not. Thus, the latter becomes visible.

We also find this far-reaching accuracy in adjustment at the *James Webb telescope*. The 18 individual hexagonal segments of the main mirror are adjusted so that the light from these segments can be aligned to the nearest nanometer (1×10-9 m, or one millionth of a millimeter (!)).

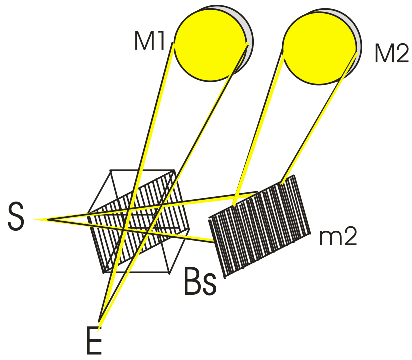
The question arises, however, who today needs a much more precisely performed M&M experiment? Probably no one, at least not in the arrangement with plane mirrors. But what if it is repeated with very high precision, not with laser light, but with white light, as shown in the setup with one hollow mirror and equal light path (33a), or with two hollow mirrors (33b or 33c).



33a



33b



33c

And what if one also achieves destructive interference here, and then brings the hand into the light path? Or do we think further. What, if one works with larger mirrors? What will then show itself of man? For now, these remain particularly fascinating questions.

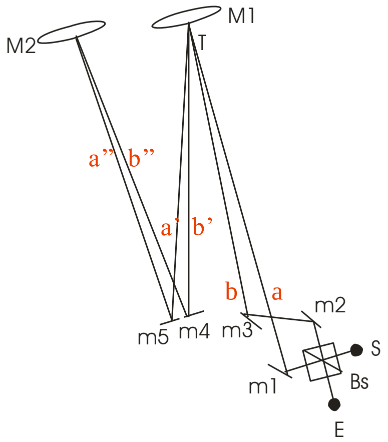
Let us look at drawing 33b. If, for example, the hand is brought in front of one of the mirrors M1 or M2, then in E a distorted and an undisturbed image mix. We ourselves achieved something analogous with the reversal arrangement (34) which we have already discussed in point 4 (and drawing 17).

34

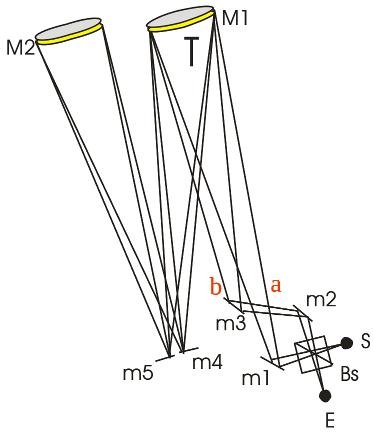
As mentioned, in that type of interferometer, one half of the image mixes with the mirror image of the other half. If we do not go beyond the centerline of the mirror by hand, a disturbed wave interferes with a non-disturbed one. This leads to very violent turbulence and an unstable image that vibrates continuously.

With current technology, it should be possible to eliminate the vibrations. If the arrangement as outlined in 33b (or in 33c), is built then one no longer has an image with the mirror image, but a single image interfering with an undisturbed image. Again, the question remains what will show itself if the hand is brought into the light path. And what if, in addition, one adjusts this interferometer for destructive interference?

In setup 36a, a second mirror M2 was added. One recognizes herein a derivative arrangement of 33a. We have only shown the laser lines. Drawing 36b shows the same setup, but now with diverging and converging beams. If one thinks them over for a moment, one notices that a disturbance (turbulence T, e.g. the hand in the light path of M1) is passed through once more, so that the disturbances become cumulative and the instrument becomes doubly sensitive. Mirrors m4 and m5 are in reality not next to, but just above m2 and m3, so the parallax becomes negligible. We built this setup, but could not get them adjusted vibration-free.

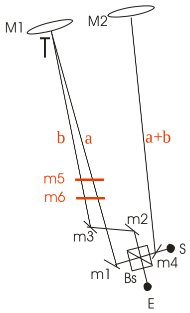


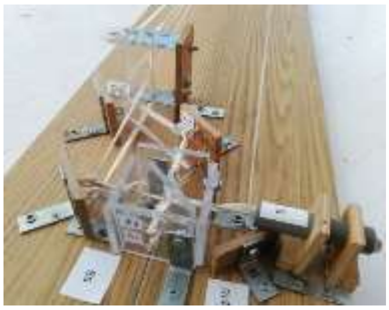
36a



36b

Finally, drawing 37a shows a top view of an arrangement that leads to an interference of two interferences. The red mirrors m5 and m6 aim to indicate that there are two levels. Figures 37b to 37d try to clarify all this with the help of some pictures of a model. The image E1, which shows itself at the bottom of Bs (37d) gives an initial interference of system M1. The image in E2, which shows in Bs just above E1, after the light passes through the system M1, M2 and back M1, gives us the image of this double interference. However, the image in E2 is slightly weaker than the image in E1 because it passed through Bs a second time on its light path. Were we not working in two levels, the points E1 and E2 would coincide in Bs, and the image of E2 would be overshadowed by the more intense light of E1. We will not discuss this arrangement further. Those who are somewhat familiar with such diagrams and ponder them for a while will certainly find their way. We also built this setup, but did not get it accurately adjusted..

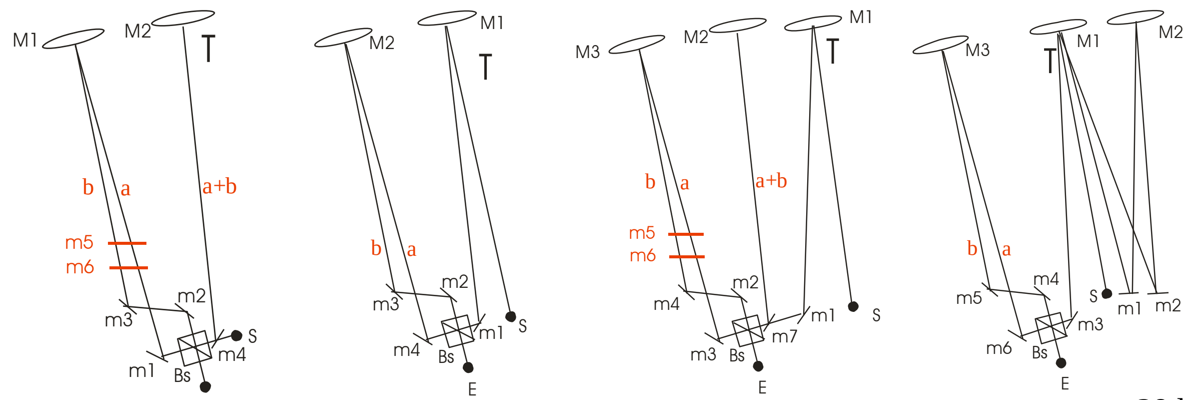




37a 37b 37c 37d

If a single interference already reveals so much color richness, what about the interference of two interferences described above? If this setup is ever successfully built, it will be an incredibly sensitive instrument that may show us a great deal that is otherwise hidden from the ordinary eye.

And beyond that, one can think of many variations. Notice in the diagrams below the location of the turbulence T, where the interference, the hand e.g., is brought into the light path.



38a 38b 38c 38d

Scheme 38 a is analogous to 37a, except that the interference takes place just before M2. An undisturbed interference image (in the system M1) is disturbed in the system M2, and again interferes in the system M1.

Scheme 38b is the derived basic setup, with equal light path. Since the interference takes place first for M1, there is no more parallax n system M2.

Scheme 38c is derived from 37a, but the perturbation T takes place outside the actual interferometer, so again there is no more parallax.

Scheme 38d is analogous to scheme 38b, except that the perturbation T is run through an extra time, making the instrument doubly sensitive.

One can apparently keep coming up with variations... These latter setups, however, far exceed the limits of what is possible for an amateur. Musing over all our tinkering, we have thought more than once that with white light interference, there is still a whole field of science to explore and so much to discover.

8. In conclusion.

The M&M experiment made Einstein decide not to consider an ether whose existence cannot be proven. After all our experiments, is this really the final word and the only possible decision? Would it be too bold a hypothesis to suppose that with a very much more carefully conducted M&M experiment, and with white light, something of the existence of a fine substance could yet be demonstrated? And if so, would this not be a curious twist of fate? The same experiment then provides first a denial, then a confirmation of what was assumed at the outset....

The opening paragraph of our text, Part I, reads: "In almost all times and in almost all non-Western cultures one hears and reads testimonies of people who claim that we not only have a biological body, but that we also have a set of subtle bodies, which together make up the so-called aura. This is said to be located in several rarefied layers around the biological body."

Although not uniformly distributed as assumed in the M&M experiment, the idea of the existence of a fine substance is peculiar to our entire cultural history.

This text intended to address the existence or non-existence of "fine dust" in a scientific manner. To reject any investigation on this subject in advance would not really show a scientific attitude. What is wrong with proposing a hypothesis, devising an experiment to investigate this hypothesis, carrying out the experiment and accepting the results: verification or falsification. It seems to us that in our experiments we have been faithful to this method.

Possibly in doing so, some of the results go against a current mindset. Do we want to see reality through the lenses of our prejudices? Or do we want to adjust our mentality to that which is true to reality? History teaches us that it is not bad to exercise caution when making judgments that go against a prevailing opinion. Refer for example to J. Margolis, *Ces savants excommuniés*, and limit ourselves to a sample from a translation of an article, published in the Sunday Times.

"Before their theory was accepted, L. Pasteur (1822/1895), the founder of microbiology, and A. Einstein (1879/1955), known for his theory of relativity, were dismissed as "dangerous deviants." When inventor Th. Edison (1847/1931) demonstrated his electric light bulb, he was accused of "mystification”. The brothers Wilbur (1867/1912) and Orville (1871/1948) Wright, who had made a motorized flight for the first time in history with a self-built airplane, were not even believed for two years "for science had determined that a machine, if it weighs more than air, cannot possibly fly." When the geologist Alfred Wegener (1880 /1930), recited the theory of the 'drift' of solid lands, the movement that the continents make in relation to each other, he was ridiculed." So much for The Sunday Times.

It may be added, among other things, that G. Cantor (1845/1918), the founder of modern set theory, suffered the same fate and died in a mental institution, half mad with incomprehension. His work is now widely accepted and appreciated. Copernicus (1473/1543) had his findings published only at the end of his life for fear of sanctions. Galilei (1564/1642) was convicted in 1633 for claiming that it was the sun that revolved around the earth, not the other way around. His request to test his claims in his viewer was ignored. Only in 1978 (!) was he rehabilitated by the religious authorities. Anyone who informs himself a little further can add to such erroneous assessments and will find that it is not always easy to hold an opinion that goes against a prevailing mentality.

What led us in all experimentation is the strong belief that there is such a thing as an aura and thus a fine substance. As already mentioned, sensitives believe they can sense something of this substance, seers claim to see it, and a number of magicians additionally claim to be able to manipulate it, e.g., to achieve healings with it. It is all too easily forgotten, but a critically educated person finds responsible uses in addition to the numerous abuses. A number of illnesses (cancer, sciatica...) show themselves, according to those who can perceive this clairvoyantly, as a dark spot in the aura, a spot that gradually continues its repercussion, its pathogenic effect, in the biological body.

Those who, in addition, can mantically perceive the energetic force effect of a prayer, as a stream of myriads of extremely fine points of light, claim that it is an influx of a fine material healing energy that threatens and - at least in part - destroys the dark, pathogenic, energies. The belief, the profound conviction that there is reality involved in these hypotheses, may well be a power idea not to neglect any physical research in this vast field. Let us leave it to advancing science and to time to bring clarity to this.

May we conclude all this with the concluding paragraph from our first text? "Possibly all our experiments and reflections may well spur further research at a higher, professional level. The question remains: what would show itself if larger telescopes, with mirrors of, say, 2 meters diameter or more, and with an accuracy incomparably better than ours, were to literally put the whole of man in the spotlight. Will other, possibly unprecedented perspectives about us humans then come to light - literally? And if so, will such might enrich our view of ourselves and of life, scientifically, philosophically and religiously? Surely these remain extremely fascinating and intriguing questions"

November 2022

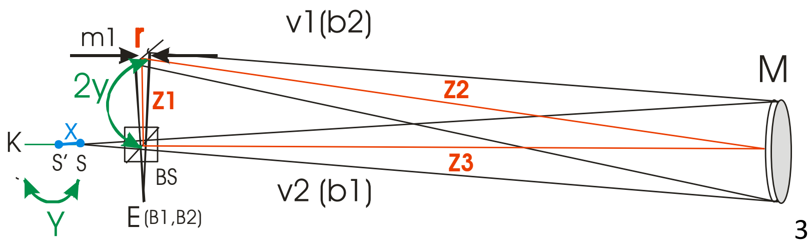
References

2a: https://demonstrations.wolfram.com/MichelsonInterferometerWithEquallySpacedFringes/
2b: https://commons.wikimedia.org/wiki/File:Michelson-Morley_experiment_conducted _with_white_light.png
2c: https://en.wikipedia.org/wiki/Michelson%E2%80%93Morley_experiment
2d: https://sites.google.com/site/puenggphysics/home/Unit-II/newtons-ring

After an initial orientation text, this was the second part, which sought to focus mainly on the M&M experiment. In a third part, the emphasis is not so much on the scientific content, but we go more into the philosophical and religious aspects of the existence or non-existence of "fine matter.

Finally: we give below, as announced, the algebraic elaboration leading to the formula: x = sqr (y² + f²) - f

9. The algebraic elaboration..



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Thinking the point light source in S', we try to define algebraically the two object distances. We get:

v1, the object distance in clockwise direction, is equal to the distance from S' to S, then to B, m1 and M, or: v1 = 2*f - (y - x) + 2*y = 2*f + y + x. (1)

v2, the anticlockwise distance, is equal to the distance from S' to S and on through B to M or: v2 = 2*f - (y - x) = 2*f - y + x (2)

Via the mirror formula 1/f= 1/b+1/v we find: b=(v*f) /(v-f), so that b1, the first image distance, belonging to v1, and going from M via B in the direction of E, is equal to

b1 = (2*f-y+x)*f / (2*f-y-x-f) (3)

For b2, the second image distance, belonging to v2, and going from M via m1 and B in the direction of E we find:

$$b2 = (2*f+y+x)*f / (2*f+y+x-f) \quad (4)$$

Next, seeing on the drawing where b1 is located, we find that the available path for b1 is equal to v2. So the image point B1 (the uppercase letter to distinguish the lowercase b1, the image distance) will be at b1-v2 away from E, or:

$$B1 = b1 - v2$$

Seeing entirely analogously where b2 is located, we find that the available path is equal to v1. Thus, the point B2 will lie at b2-v1 from E away.

$$B2 = b2 - v1$$

We find the mutual distance D between the two image points B1 and B2 by making the difference between the latter two values. We get:

$$D = B2 - B1 =(b2-v1)-(b1-v2) = (b2-b1) - (v1-v2) \quad (5)$$

From (1) and (2) we find:

$$(v1-v2)= 2*f-y+x-2*f-y-x= -2*y \quad (6)$$

So that we can rewrite (5) as: $D = (b2-b1)+2*y$ (7)

Now substitute in (7) for b2 and b1 the values obtained in (3) and (4):

$$D = ((2*f-y+x)*f/(f-y+x)) - ((2*f+y+x)*f/(f+y+x)) + 2*y$$

Now we work out this equation further.

$$=(((2f^2-fy+fx)*(f+y+x)-(2f^2+fy+fx)*(f-y+x))/(f-y+x)*(f+y+x)) +2y$$

$$= (2f^3+2f^2y+2f^2x-f^2y+fyx+f^2x+fyx+fx^2)/(f+y+x)*(f-y+x) -$$

$$(2f^3-2f^2y+2f^2x+f^2y-fy^2+fyx-f^2x-fyx+fx^2)/(f+y+x)*(f-y-x) -2*y$$

$$= (2f^2y/(f+y+x)*(f-y-x)) -2y$$

$$= (2f^2y/(f^2-fy+fx+fy-y^2+yx+fx-yx+x^2)) -2y$$

$$= (2f^2y/(f^2+2fx+x^2-y^2)) - 2y$$

or $D = (2f^2y/((f+x)^2 - y^2)) - 2y$ (8)

With this last expression, we now have a formula that tells us at what distance the two image points B1 and B2 are apart in our setup, and this as a function of the focal length f of our mirror M, of the value for y and of the radial shift x of our point light source.

In this expression, let x aspire to 0, and working out further we obtain:
$D = (2f^2y/(f^2 - y^2)) - 2y$ $D = (2f^2y - 2y (f^2-y^2)) / (f^2 - y^2)$

$$D = (2f^2y - 2yf^2 +2y^3) / ((f^2 - y^2) \quad D = 2y^3/(f^2-y^2)$$

We thus see that the value of D becomes smaller as the value of y decreases and /or the value of f increases. Thus, if we want to bring the image points B1 and B2 closer together at x

= 0, we will have to equalize the object distances v1 and v2 as much as possible and work with mirrors with long focal points.

The importance of a small D-value will become clear in the next chapter, where it will be shown that we then have a larger mechanical tolerance when adjusting our setup.

The obvious question now is when the two image points really coincide, or when the value for D becomes 0. We will calculate this as a function of the distance x, since this value can be most easily changed in a setup by moving the light source forwards or backwards. Working this out, starting from the equation given in (8), we find:

$D = (2f^2y / ((f+x)^2 - y^2)) - 2y$, or: $(2f^2y / ((f+x)^2 - y^2)) - 2y = 0$

and work out further:

$2f^2y/ ((f+x)^2 - y^2) = 2y$, or $(f+x)^2 - y^2 = 2f^2y/2y$

$(f+x)^2 = f^2 + y^2$ $f + x = sqr(y^2 + f^2)$, or

$x = (sqr(y^2 + f^2)) - f$

With this last formula, we have the requested; a zero value for D as a function of x. Thus, if x satisfies the condition described above, then the two image points B1 and B2 should practically coincide. Still, note that it is not so much coincidence that we are aiming at. If they cover each other completely, there is no interference at all. We want to see if they can come very close to each other and what should be done to that end, in the belief that practice is not an exact reflection of these theoretical results after all.