The Michelson and Morley Experiment *Once Again!*

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It is – to me – a fact that "mainstream science" has misused the 1887 Michelson-Morley experiment in order to "prove" that an ether or aether does not exist. However, it is *also* a fact, that a main reason for the misuse of this – in many ways – brilliantly conceived experiment, is, that the results of the experiment failed significantly in measuring up to the expectations. This astonishing discrepancy between the objectively obtained data sets and the theoretically expected levels of the drift readings, was then inadequately used to denounce the possible existence of an ether as a preferred frame of reference and as a wave transmitting medium for light and other electromagnetic waves. – But is there an explanation for this mismatch concerning data and expectations? I think so. The logic behind the experiment looks (mostly) deceptively fine, as long as you look at the details in a static view – But then, when the experiment is set into motion, a deviously buried and serious flaw springs into action. *This severe flaw is embedded in the very principles for the opto-mechanical function of the experimental setup inside the general instrument.*

1. Introduction

In 2008 I wrote a book (in Danish) [5] in which I, in detail, described the step by step process of the detection of the mechanisms behind an assumed flaw in Albert A. Michelson and Edward W. Morley's 1887 experiment [1] "*On the Relative Motion of the Earth and the Luminiferous Ether*".

In this paper I will try another, more direct approach.

This to some extend assumes, that the reader is a bit familiar with the general function and history of the Michelson-Morley experiment. Knowing the intended audience, I do not think that this is a too farfetched idea.

So: If you are not familiar with the experiment you might like to read Michelson's original paper. [1]

This said, let us plunge directly out into the meat of the drill.

2. Background

It is a well known circumstance that tradition has it, that Michelson's daughter has told that he used an analogy in order to explain the principles of his experiment to his children. This analogy might also have been used before an audience that was not familiar with the scientific approach and language needed to describe the experiment for a 'scientific Periodical.

As the title [1] of Michelson's paper says, the idea he pursued was to prove the existence the ether. (or, as is it is also spelled, aether). This ether was the medium that was thought to be that, in which all the waves of light and also all other, longer and shorter electromagnetic waves were traveling.

Although not proved – as it was thought, that the ether had not convincingly been detected in other previous experiments – the working hypothesis was that this aether might be fairly stationary with respect to the sun.

Therefore, as the planet Earth moves around the sun at a speed about 30 km pr. second, this would mean that light, coming from a source in this direction, would arrive faster to an observer on earth, than light coming from the opposite or perpendicular position.

If we now translate this assumed fact into the analogy that Michelson used, then his idea for a way to prove the existence of this speed difference, and thus the existence of the ether, can be quite easily understood.

Michelson exemplified the ether, flowing past the earth, with the slowly floating water in a long and wide river. In this river, he said, we will have a race between two swimmers, who will swim equally fast if swimming in the same directions.

These two swimmers will represent light beams, which we will want to see travel in different directions – out and back. The swimmers in the river will travel – swim – in lanes in the river that are exactly perpendicular to one another. They will also start at the exact same time and their starting position will be as close as possible to the same place. They will then have to swim two, exactly equally long distances. Therefore they will have to swim to a touchable turning point and then back to the same goal marker. These two directions – 90° apart from one another – are significant to the experiment, as will be explained below.

It is therefore also these principles that you [1] will see transferred into a laboratory experiment, where swimmers are substituted with light beams, and the bypassing ether is represented as analog in effect to the river's current, as it floats towards the sea.

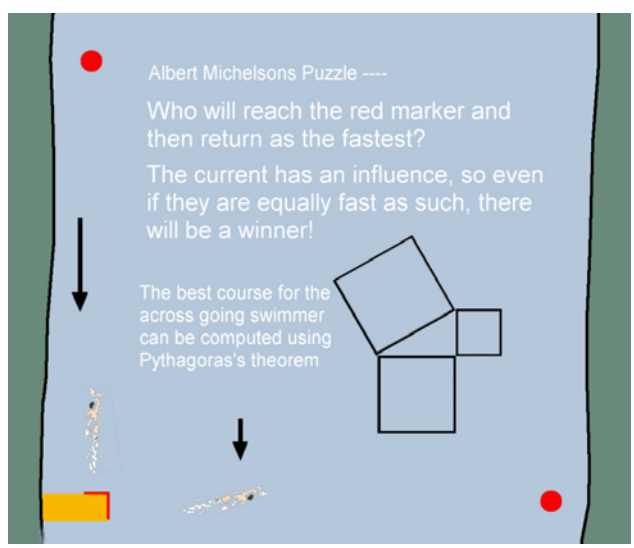

Fig. 1. The Pythagorean Theorem applied to two swimmers

3. Technical Explanation of the Two Set-ups

Below follows Michelson's ideas in two versions: 3.1 The river principle – and 3.2, the same principle as translated into the experiment using light beams instead of swimmers. (Note: The already informed interferometer- and Michelson connoisseur might of course like to skip to: 4. Comparing functionality in depth.)

3.1. The River Version

The crucial idea behind the experiment – and thus the perpendicular arrangement of the two lane directions – is, that the influence of a current upon the two swimmers (or by analogy on two light beams) will be, that although they are using the same effort to race through lanes of the same lengths respectively – the time used to travel the lane perpendicular to the direction of the current, will always be the shortest, while compared to the upstream-downstream direction.

Why? Well, generally spoken: The swimmer that goes across the river can direct more of his energy in such a way that it provides progress towards the goal, while he at the same time negotiates the drift factor. We can immediately see that both swimmers have to pass through more water than if they were swimming in a pond with no influencing currents. We can also immediately see that the swimmer going across the river has to compensate the forces of the current. He must do so by constantly swimming in a direction to the current that cannot be truly perpendicular. Instead he must direct his action towards an imaginary point somewhat upwards to the turning point and (on return) his goal point. Only by using this – by the way *intelligent* – behavior, he will be able to counteract the drift that the current will constantly impose on his body.

The effect on light beams in an equivalent experiment is of course not as mechanical as in the swimming example; but because the light waves are seen as propagating in the floating ether-current, then, accordingly, the traversing beam would be transported "downwards" within the assumed, earth-bypassing "ether-wind". The difference in time that it takes to negotiate the two lane directions respectively, can be calculated. If one of the lanes is oriented in a direct upstream-downstream direction it can be done immediately using simple adding and subtraction of the water speed and the swimmer speed. However, if a lane is not strictly parallel to the flow direction, we will have to figure out how much the increment in effectively used water distance amounts to, as the swimmer has to pass more water while counteracting the then induced, but unwanted drift.

Fortunately we have precise knowledge of both the water speed as well as of the direct lane length. This information is enough in order to let us calculate the real passed water distance with the help of Pythagoras's theorem for the relations of all the sides in a right-angled triangle. (The Pythagorean theorem: The sum of the areas of the two squares on the legs (*a* and *b*) in a right angled triangle equals the area of the square on the hypotenuse (*c*)). As an example, when the streaming water is perpendicular to the prescribed goal-course:

With 100 feet to the turning point, let the across going swimmer's speed be 5 feet per second, at an angle, relative to the river, and let him (if he just floated) be carried downstream at a rate of 3 feet per second. If the compensation angle is correctly chosen so that the swimmer moves directly across, then in one second the swimmer must have moved *four feet* across, because the *real* distance covered in one second will be the hypotenuse (the longest side) in a 3-4-5 triangle but the *effective* distance towards the goal will equal the 4 feet side. So, at an effective crossing rate of 4 feet per second, the swimmer gets across in (100/4)= 25 seconds, and back using the same time, which results in a total time of 50 seconds. In comparison, calculating the upstream downstream swimmer's time, it will add up to this:

He will use 50 seconds to just reach the turning point at 100 feet upstream, as his speed relative to the riverbank is only (5-3)=2 feet per second. Downstream back, the speed will be (3+5)= 8 feet per second, so this takes (100/8)=12.5 seconds, and the total time spent will be 62.5 seconds. In this case the race time difference will be 12.5 seconds in favor of the across river going swimmer.

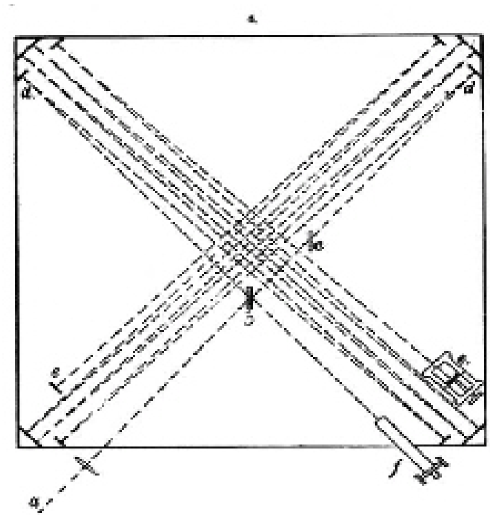

Fig. 2. Michelson's drawing: 1887 laboratory interferometer version

3.2. Michelson's Lab Set-up – Birds-eye View

Above: The actual lab-version set-up as Michelson has drawn it, seen from a top perspective. You have a light source, collimated by a lens system at *a* . Light is directed towards a half-silvered mirror (with the silvered face on the right hand side) at *b* – which at this side causes the beam of light to split into two perpendicular directions to one another. One part passes through the mirror and then through a piece of glass at *c* of same orientation, quality and thickness. This, in order to secure that the two beams of light passes through the same amount of glass. Then this beam goes on to be reflected at *d* to (after a series of round-trips) *e* . Here it arrives and is sent back through *c* – All-in-all it reflects in a total of eight mirrors (upper right , to lower left) until half of it again reflects at *c* and is merged in the telescope *f* with the other ¼ part of the ray, who took the similar, but perpendicular route (upper left – Lower right). The rectangular "box" at *e*' is used to fine-tune the reflective direction of this ray-part, so that a suitable interference pattern can be obtained. Each light-path round-trip amounts to a total of about eleven meters. The whole set-up rests on a massive stone-slab that in turn is fixed to a thick wooden ring, which floats on mercury in a iron cast trough, so that the whole, heavy system can be set into a circular, slow and (much needed) vibration free motion.

4. Comparing Functionality in Depth

Now, if we look at the differences of the two set-ups – *light beams* on one hand and *swimmers* on the other hand – we notice that measuring the speed difference of the two paired competitors cannot be conducted through the same measuring methods.

We can fairly easily measure the individual time of swimmers, while clocking them by a stopwatch. But due to the immensely fast travel times of light beams, this assumed difference cannot be measured quite so easily. Of course Michelson knew that, and his solution was to utilize the interference principle and an instrument of his own invention – the interferometer – in a set up as shown in Fig. 2, above.

It was known to Michelson, as an interesting fact, that if two narrow light beams of the same wavelengths slightly crosses one another while traveling in almost the same direction, you can see them produce a *steady* interference pattern if you look at them in an optical eyepiece with some enlarging, telescope like properties. This is due to constructive and destructive interference of the light waves at different meting points. At some places the light beams re-reinforce the effect of one another, and in some other places they out-cancel the effect of one another.

Now – If you – ever so slightly – alter the travelling length *or the traveling time* of one of the beams, and observe their interference patterns, you can see these patterns (fringes) move left or right accordingly as a function of which lane length you manipulate, and in which direction you do so.

So – as you cannot just "pop a gun" and then let a light race begin – (and thus hope to measure anything with success) – then, instead, a continuous comparison of the fringe patterns, produced by light from the two perpendicular directions, could be a work-around. This because, as mentioned, *also* a differential *shift in traveling time* for one (or, as used, simultaneously both) light beam(s) would create a small left – or right – drift of the observed, interference induced, fringes, as the set-up rotates relative to the expected direction of the ether-flow. And that is what Michelson had in mind to utilize.

In the river example there is no doubt about the direction of the water flow. However – when it comes to the ether and light relations, we do not exactly know the direction of the supposedly influential upstream-downstream ether-flow. And even if we did, we would just look at a non-moving pattern. But – as shown in the drawing above – Michelson had brilliantly realized, that *if* we mount the two light paths on a turntable, and *if* we put the system into motion – light source and all – *then* we should be able to obtain some dynamic shifts of the observed interference pattern.

This idea is easily understood if we manipulate our river set-up in just the same way:

After towing the whole system out into the center of river, we will swing it around with the starting platform in the middle and the lane markers in a 45° arc to each side. This means that both swimmers now will have to counteract the same (but mirrored) influence of the river current, in order to keep a needed course to the turning point marker – and likewise when they swim back to the goal marker.

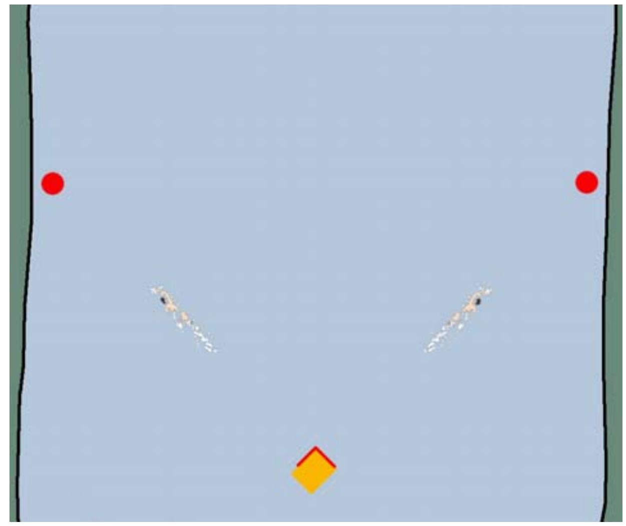

Fig. 3. Relocated and redirected lane system for the swimming contest

Therefore: – as the two swimmers now spend the same amount of energy to counteract the current – they will arrive at the goal point at the exact same time.

Also – when we return to the Michelson and Morley interferometer set-up – assuming the ether exists – we now know, that "Out there" there is a direction that at any given time will be one, that will let the two beams have the same relative velocities to the target place at the eye-piece. So, equivalently:

If you slowly spin the Michelson interferometer with its two lane set-up on the turntable, and thus equally alter the general directions of *both* the two light lanes, and – at some point – see the interference pattern move – And then after a very short stand-still – can see that the pattern begins to move in the opposite direction, *then* – as the hypothesis goes – you will have witnessed the effect of the ether moving relatively to the earth, and found the general direction of the ether-wind. If you complete a full circle you would see the directional shifts completed four times.

All in all: If you see motion of the fringes, as Michelson and Morley did, then something *must* have influenced the travel of light relative to our moving earth. And also, if you can repeat this phenomenon (and this has been done on several other occasions) [2] [3]), then you have proved the influence.

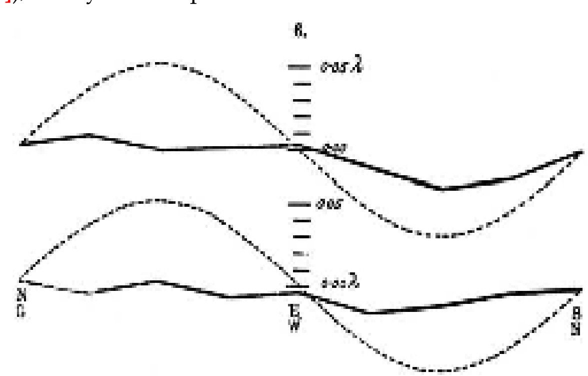

Fig. 4. Michelson's plot of a sample data set . Yes, it was a small effect, but it was not zero or within the experimental error-zone.

Therefore, ignoring the length-contraction idea with the same nonchalance as the "length-contractors" ignore the simple *fact* of definition, that waves *requires* a medium, I will opt for the ether as the better choice for this effect.

Note: *Not* a problem free one – Not at all. Just a better one... But (among other things) that then leave us with the mysterious question:

Why then, if something works, why is there such a huge gap between the expected values of fringe motion and the real world results in all Michelson-Morley type experiments? Also in the better working ones, as for instance Dayton C. Miller's? [4]

5. Hunting for a Possible Flaw

Let us examine the situation. And make a thought experiment. (Curtsy to our late professor Einstein...)

What if we placed a laser in the river set-up? What if we substituted one of the swimmers, and therefore also the adequate turning marker with a mirror, and then – for the sake of argument – imagined the laser to be just as slow as a swimmer and influenced by a slow world-ether current, which has the same direction and speed as the "real" river?

What happens if we now gently turn the complete river set-up from a three o'clock position to a ten to two position?

Well – as shown below in the ten to two positions: The laser heavily *overshoots* the mirror at the target marker! This happens, because it carries on with a *fixed* drift- counteracting direction that was fine in a three o'clock position, but which will overcompensate, when it is used in a ten to two position!

Therefore *the fixed position of the Laser* is the main culprit in our thought experiment.

Fig. 5. Overshooting: The swimmer knows his way. The ray doesn't.

So: *If* you cannot adjust the amount of compensation, but has adjusted your laser-calibration in a finalized way, when the setup was in the three o'clock position where the 5-4-3 compensation was the correct one to use, *then* this current-counteracting calibration will be much too much in the new, ten to two position. The overshoot will be inevitable.

Okay... But... What if we then re-calibrated in this position? Not good either. Because if we turned back to the three o'clock situation, then we would now be *under*shooting the target that we had just successfully reached before.

Now – as we have seen in our thought experiment:

Only if we mounted a multiple set of lasers sending rays out in multiple directions, we would have a hit and a returning ray in all orientations of the instrument, while turning it a full circle. But! It would also impair the intended function of the setup as each lasers position would be different, and successively, when turning the instrument, the successful one(s) would be paired with another new laser from another position. Not its own "twin".

Therefore, not knowing the relative, assumed ether flow direction, used for calibration by Michelson – (If he had any. It is at least not stated in his original paper) – we can now say this:

We suspect that the same type of fault is responsible for the strange mis-performance of the interferometer set-up.

6. Parallelism in Faults?

The question is: Are there flaws in the thought experiment that are close in similarity to the Michelson-Morley experiment, so that similar "mis-firings" can be expected to have an influence? The short version is: ...Yes.

When we look at the real, original Michelson interferometer we do not have light source compatibility. The thought experiment has a laser or multiple lasers with homogeneous monochromatic light. In Michelson's case, we have multi-colored light, combined to almost white light from an Argand Burner. But we *do* have a similar effect to the fixed calibration, as the mirror at *e* is only adjusted one, final time for each completed rotation of the total set-up. This one part of the fault-inducing elements is critical but it is not the whole story:

Because – What about the multiple number of lasers that ensured a hit? Is there a similar effect possible with collimated, almost white light as Michelson used? (From his Argand Burner [1])

The answer is: Possibly yes. But not fully proven. The cross-section of the smallest possible, sustained ray of light is not known. *Light is still not,* as far as the author is concerned, a very well understood phenomenon. But considering the function of the spectral analyzer, where one *very* small sample of rays from a *slit* is able to spread out and lit up several *meters*, it is a fair assumption to harbor, that there is an effect, due to the possibility of rays *coming from different locations of / on the face of the light source*.

Even a light source, measuring only a few millimeters in diameter, would have the potential to be substantially damaging to the minute detections needed in time-shifted waves as prescribed. When we work with such small differences – fractions of fractions of fractions of millimeters – it may well be, that even the possibility of a shift on the face of the light source of the successfully reflecting and interference making rays of – say – 0.05 millimeter, can almost nullify the sought-after speed difference.

7. Conclusion

There are two facts here that to my knowledge has not been considered before I wrote about them [5] – Which are:

1. The light source has a fixed calibration, which means a directionally fixed compensation for what ether-drift that existed at the moment the used position of the axis were in play while fine tuning the calibration. This establishes a drift counter-balance to the ether wind that is *only* adequate in this same position. When the axes moves away from this position, as prescribed through the rotation of the whole set-up, then the effect will be, that this fixed compensation caus-

es the individual ray-parts in the beam to move in a way that will make them either overshoot or under shoot so that they do not participate in any (visible) interference pattern, or pairing up in interference producing patterns, with a part of the beam whose origin were their own split self.

2. The face of the light source is most certainly so big, that it – during the instruments rotation – can supply split- and mirrored rays that – though not meeting their own quarter-part – successfully can reach and merge with one another – In what in the present situation resembles what would be a hefty give-away in position – and thus a time head-start for the upstream downstream going participant.

It is then a fact that – paired with the above mentioned "misfiring" we will have the effect of substantially reducing the sensitivity and thus the measuring capacity of the whole setup – which is just what we have seen in the various versions of supposed ether-tests in many Michelson-Morley type experiments.

And – as a piece of eventually useful information for those that might want to try to calculate and "ray-trace" the very complex interdependencies:

A not fulfilled study gives me some reason to believe, that the more *modern* a version of the M&M experiment is, the less prone it will be to yield any differences at all.

This is eventually due to the (in modern versions) often very small distances from the light source to the beam splitter and the mirrors. The time difference of the ether's influence on the immediately reflected ray(s) versus the – in the first encounter – through-passing ray(s), may be the key to understand this phenomenon.

All in all: This means that the optical behavior of the opto-dynamic system in a Michelson Morley type of experiment does not comply with the general behavior that the researchers expected; a behavior which was the very one they calculated from. Therefore the translation from the swimmer-river paradigm to the actual interferometer setup will – and cannot – work as presumed.

8. Discussion

Although there will still be a moving interference pattern to look at, the impression is, I think, that the whole idea of the experiment is severely compromised.

It is *not* – as assumed – the same parts of the general beam of light which splits up and later re-unite to form the interference patterns. It is *different* and continuously *changing* parts of the beam that mingle and create the final interference patterns.

This means, in a Michelson-Morley type experiment, that the light source – during the successive rotation of the turntable – *sort of auto-adjust,* and that it therefore – from the general beam – do secretly *select* the rays that interfere. This is the *rays* that at – and from – any given position are able to make it through and pass the various reflections and thus follow a path that allows them to come back to interfere with *another* ray-part of the general light beam – Which likewise has been selected on the basis of the needed, angular drift and reflective demands that ensures the arrival and then the interference forming that are finally watched in the telescope.

It is – as already mentioned in the conclusion – *not* a trivial task to figure out what *really* goes on at chosen rotations of a given Michelson-Morley type of experiment. This depends upon multiple related factors involving the distance of the light-source to the beam splitter and the distances to the reflecting mirrors and the number of round-trips performed and the angle used to provide these multiple reflections and how all these factors correlate. Also the *diameter* of the collimated beam and its quality may play a role. The same goes for in which direction the apparatus was oriented when calibrated. And furthermore the question of other reflective characteristics (in moving mirrors) as proposed by Michelson in [1, pp 344-355] – has not been addressed.

The figures produced by me are moderately to immensely exaggerated, and therefore not intended to be anything near what would be true representations of actual ray-paths, but just produced in order to highlight and visualize the involved dynamics and the roles of the participating parts.

References

[1] Albert A. Michelson, Edward W. Morley, "On the Relative Motion of the Earth and the Luminiferous Ether". *American Journal of Science* **203**:333-345 (Nov 1887).

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[3] James DeMeo, "Dayton Miller's Ether-Drift Experiments: A Fresh Look", *Pulse of the Planet* **5** (2002).

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