2. The M&M experiment and fine dust.

Content

2.1. A fixed point of orientation

Everyone has had the experience of being on a stationary train, standing next to a second train. If one of the two then departed gently, 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, once one turns one's gaze to infinite spaces, seems far from simple. The earth revolves around its axis, but also around the sun, which itself is part of a rotating galaxy. And this in turn belongs to an expanding universe. All this led to the probing question of whether a fixed point of reference could be found anywhere in space.

Waves in the sea have water as their medium. Sound travels via waves carried by air. And how does light travel? Perhaps a middle substance is also required here. And so physics welcomed a hypothetical and stationary medium, an extremely fine and invisible intermediate substance, the so-called “ether” that evenly fills all space. And the motion of earth, sun and stars, was relative to that ether. With this one would then have a fixed reference, an absolute standard for time and space measurements. But how to prove the effective existence of that ether?

2.2. An interference experiment

In 1887 Michelson and Morley investigated whether that supposed ether could indeed be scientifically established. For this purpose they designed and famous experiment that was based on interference of light. We will come back to this interference in more detail.

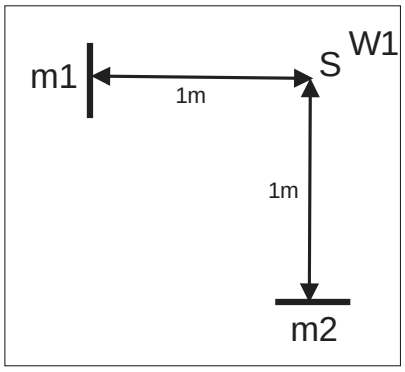
Michelson and Morley compared the speed of light parallel to the orbit of the Earth with the speed of light perpendicular to the same orbit. The result of this experiment showed invariably the same interference pattern, which meant that no difference in speed showed itself. Michelson and Morley initially thought their experiment had failed. If you step toward the locomotive in a moving train, your speed is slightly greater than that of the train. If you step backward, it is again somewhat smaller. But if you send a light signal from a particularly fast spacecraft in its direction of motion, or against its direction of motion, the two beams of light

always have the same speed. And that is a very surprising and seemingly contradictory conclusion that goes against Newton's laws. Einstein gave in 1905 in his special theory of relativity the theoretical explanation of this : the course of time in the universe is not an absolute, but changes with speed. A rapidly expanding galaxy has a different time course than a galaxy that does not move at the same speed.

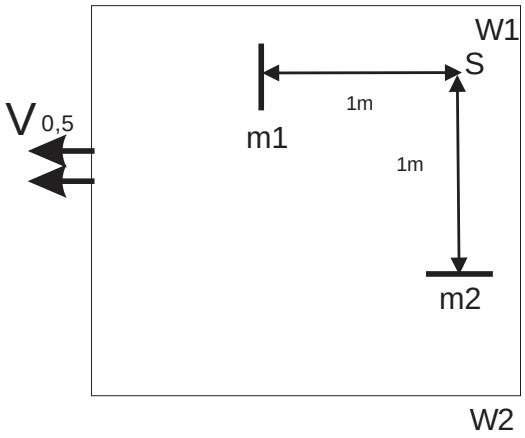
At first glance, it seems contradictory. But if one thinks about it for a moment, one quickly realizes that it cannot be otherwise. Clarify this in what follows.

2.3. A thought experiment.

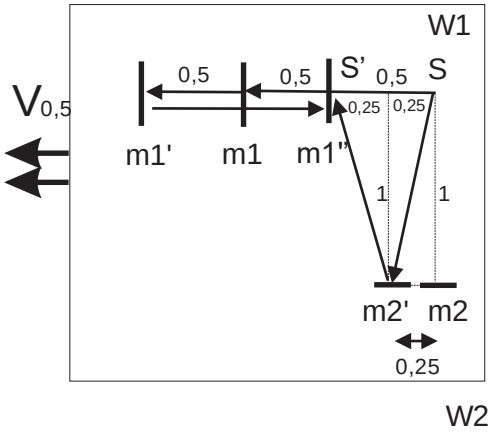
Situation 1 : In a train (the big square) there is a mirror m1 ('m' of mirror) in the middle of the corridor. Just 1 meter further back there is a child W1 (observer 1) holding two tennis balls in his hand and holding them at a height of 1 meter. On the ground there is also a mirror m2. The train is standing still. The child throws both balls simultaneously and with the same force, one to m1 in front of him, the second to m2 on the ground. Here we make abstraction of gravity. After rebounding, both balls come back to the child simultaneously. Each ball has traveled the same distance s (the lowercase letter) in the same time, namely 1 meter to the mirror m1 or m2, and after reflection also one meter, together 2 meters. This fact is confirmed by observer W1, the child in the train, but also by observer W2, his friend who is outside the train, watching everything happen through the window.



Situation 2 : The train travels at quite a high speed V (from Vitesse) and has traveled 0.5 m when the ball has been back and forth 1 time, i.e. goes from S to m1 and back to S. The child on the train (W1) again simultaneously throws both balls at the mirrors m1and m2. After reflection, the child (W1) on the train sees that both balls arrive in S simultaneously and have each traveled a going back (S-m1) and forth (m1-S) distance, each time of 1 meter, together thus 2 meters.



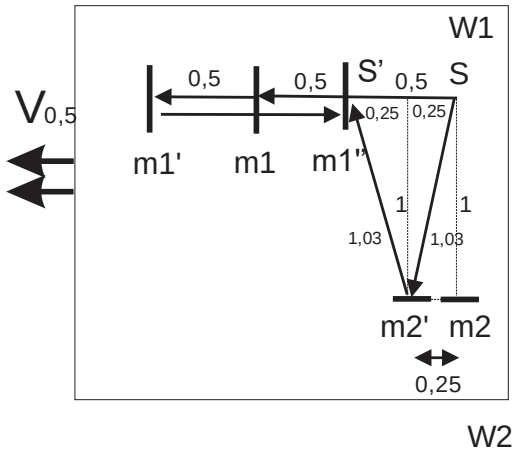
But the child W2, who is outside the train, does not agree at all. It does see both tennis balls leave, one horizontal to m1and the second to m2. However, because the train has a considerable speed, from W2's point of view the ball does not fall on m2, but somewhat diagonally to the left on m2', m2 has indeed moved to m2'.



After reflection on m2', the ball also goes up at an angle to the left and is caught by the child W1 in the train, which in the meantime has also moved 0.5 m to the left. The path s is no longer a vertical up-and-down movement, but rather has the form of a large letter V. The downward movement (S-m2') of this letter is like the hypotenuse of a right-angled triangle whose vertical rectangular side is equal to 1, and whose horizontal side is equal to 0.25.

The upward motion of this letter (m2'-S') is also as the hypotenuse of a right-angled triangle whose vertical right-angled side is equal to 1, and whose horizontal side is equal to 0.25.

Using the Pythagorean theorem, we know that the hypotenuse here is equal to the square root of $1^2 + 0.25^2$, a number rounded to 1.03. So for the child outside the train, the distance traveled is 1.03 * 2 or 2.06 m.



Next, look at the horizontal throw on the same drawing. The child W2 outside the train sees the ball leave for m1, but this mirror has meanwhile moved away from its original position in the moving train. Suppose the train has moved half a meter in the meantime, then the path to m1 has become not 1, but 1.5 meters. And after reflection, child W1, which was already moved half a meter to the left, has moved another half a meter to the left. The reflected ball then only has to travel 0.5 meters to the child. So for the child outside the train, the ball traveled 1.5 + 0.5 or 2 meters.

The ball to the ground traveled 2.06 meters; the horizontal distance was only 2 meters. But, and this is now the surprising and seemingly paradoxical thing, the child W2, outside the train saw that both balls reached their respective mirror simultaneously, and were also caught simultaneously by his friend W1 on the train. A movement with the train gives a different time for the child outside the train than a movement perpendicular to it

The child W1 on the train does not believe his friend W2's explanation, and says that his friend W2's situation remained unchanged, but that it was his friend W2 outside the train who moved away from him with great speed. Would the latter (W2) have hit a tennis ball vertically on the ground outside the train and caught it back, then his friend W1 on the train would claim that the ball had also made a 'V' like movement, but this time not to the left, but to the right. This fact can also be worked out somewhat analogously mathematically.

If we now replace the tennis balls with two coherent light beams, that is, light beams emitted by the same light source L, then we have a situation analogous to the M&M experiment. Michelson and Morley hypothesized that they would also observe a time difference - and thus a distorted interference image - in the two partial beams. But they didn't, and never did. And that surprised them. “The experiment failed,” they thought. Einstein, however, came up with a highly unusual solution : the measurement of time is not absolute. One second does not last the same time in systems moving away from each other at great speed. Should each observer in his own system, with his own experience of time and distance, calculate the speed of light, both would always arrive at the same constant : 300 000 km per second.

2.4. No ether wind was demonstrated.

This result, the repeatedly established unchanged interference picture, - we will come back to this interference later - 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 demonstrated either, it also seems pointless to claim that the earth and the heavenly bodies would move through a "uniform ether. Since then, the belief in the existence of a fine substance as a propagation medium for light has again been abandoned.

In some scientific circles, the latter leads rather easily to the conclusion that any form of 'fine' matter should be denied its existence. Some, however, will argue that this is an unproven generalization. Perhaps there are still types of fine dust that the M&M experiment failed to uncover? Or perhaps there are other than just uniform types of fine dust?

Still, the thought of it was quietly discredited. And if today you dare to bring up the subject again in astronomical circles, people sometimes look in your direction with a doubtful look: "You are not on board! Surely science left that topic long ago and definitively behind. What you are considering is not real science". Even in 1967 we still read from Van Heel in his quite well documented book : 'What is light' what follows : "Even if one can prove the existence of the ether, it remains a dubious matter, physics should concern itself with more tangible matters[1]".

[1] A.C.S. Van Heel en C.H.F Velzel, Wat is licht? Wereldacademie, De Haan/ Meulenhoff, 1967, p. 177.