Why Michelson and Morley expected the wrong result from their experiment

Cyrus Master-Khodabakhsh

School of Computing, Engineering and Mathematics – Western Sydney University

cyrs.master@westernsydney.edu.au; cyrusmasterkh@gmail.com

Abstract

This paper endeavours to explain why light and elementary particles have dual wave and particle characteristics, and proposes a physical interpretation of Huygens' principle. It also explains why the famous Michelson and Morley experiment did not give the expected result, and to show that it did, in fact, detect the ether but was not correctly interpreted.

Introduction

Before the advent of the special theory of relativity, physicists believed that space had a medium called ether. As any wave, like sound or water wave, requires a medium for its propagation, ether was assumed to be the medium for propagation of electromagnetic waves. In 1887 Michelson and Morley tried to detect the ether and measure the velocity of the earth through it by means of an interferometer[1]. They performed the experiment many times and under different conditions but did not get the expected result. Physicists tried to explain the null result of the experiments and proposed many different ad hoc theories, but none were accepted as they contradicted some already proven and accepted physical reality. Michelson and Morley's failed experiments thus provided the foundation for some theories of modern physics. In 1905 Einstein proposed his special theory of relativity[2] and apparently solved the mystery of the Michelson and Morley experiments. Ether was assumed by Einstein as "superfluous" and by physicists in general as non-existent. Although Einstein in his lecture at Leiden in 1921 said that "from the point of view of general relativity space without ether is unthinkable," [3] still many exponents of relativity refused to accept that ether exists. In this paper, I propose a hypothesis and use it to explain why the null result of the Michelson and Morley experiment is to be expected, and that the null result should not have been taken as a proof for the non-existence of ether, and hence not as the basis for many of the theories that followed.

Commented [CM1]:

Hypothesis

Light waves and light particles are not two aspects of the same thing as is generally believed. They are two different entities. *A light source emits streams of light particles called corpuscles. These corpuscles strike the ether particles at every point in their path in space and make them vibrate. Light waves are therefore local vibrations of the ether particles.*

The hypothesis is supported by Huygens' principle[4], which states that "every point on a wave front may be regarded as a new source of waves." Huygens' principle, which is a well-established fact in optics, can only have the following physical interpretation: that light particles (by striking ether particles) generate light waves at every point in their path. *This hypothesis explains why all elementary particles also exhibit wave characteristics.* These particles, when in motion, strike ether particles and generate waves in ether.

Michelson and Morley experiment

The detailed explanation of this experiment can be found in almost all physics text books. The reader is referred to them or to the original paper of Michelson and Morley[1] for more detailed experimental and mathematical analysis. Here only a brief explanation of the experiment is given. A beam of light from a source is split by a half-silvered mirror and sent through two perpendicular arms of the Michelson interferometer which is fixed on earth. The earth moves through the ether with a velocity v relative to the ether and therefore experiences an ether wind. One beam is sent in the direction of the motion of the earth and the other perpendicular to it. These beams are then reflected back by mirrors fixed at the end of each arm and after being reflected and transmitted by the half-silvered mirror, enter a region behind the half-silvered mirror where they interfere and produce an interference pattern. As the waves through the arm in the perpendicular direction to the motion of the earth travel through a longer path, they take longer to arrive than those that travel through the arm parallel to the motion of the earth. The interferometer is then rotated through 90^{o}. The direction of v is unchanged, but the two paths in the interferometer are interchanged. This will introduce a path difference in the opposite sense to that obtained before. A fringe shift therefore is expected to take place but in fact no shift was observed.

Let us examine the experiment from the point of view of the corpuscular theory of light and the above hypothesis. Consider only any two light corpuscles that are sent simultaneously in the two directions. Let us call the arm parallel to the motion of the earth arm 1, and the other arm 2. These light corpuscles arrive in the region behind the half- silvered mirror one after the other due to path difference. The one that has travelled through arm 1 arrives earlier. See Fig 1. These two corpuscles strike ether particles and *generate new light waves* ***locally*** *(according to the above hypothesis and Huygens'principle)*. The light waves interfere and create interference fringes.

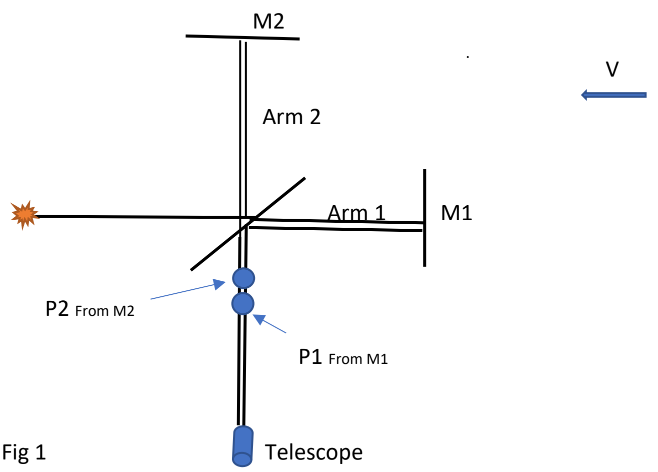

Fig 1

When the interferometer is turned through 90^o, the corpuscle that travels through arm 2, which is now parallel to the direction of the motion of the earth, arrives earlier than the one going through arm 1. See Fig 2.

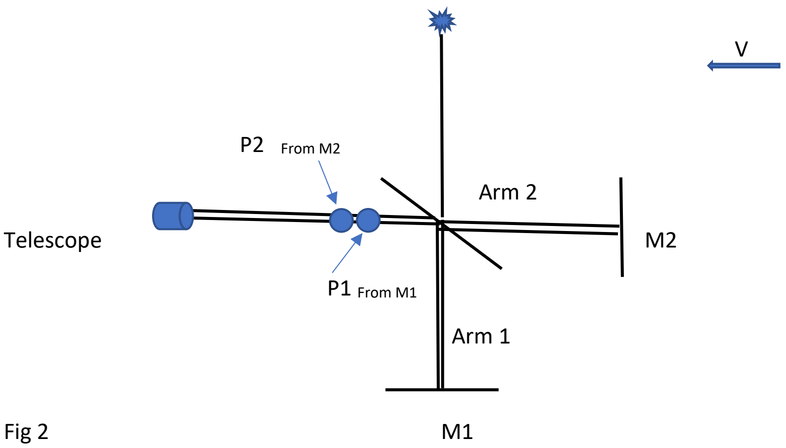

Fig 2

Again, these particles strike the ether particles and generate light waves *locally*. The waves interfere and produce interference fringes. These corpuscles cannot in any way be distinguished from one another as far as their effect on producing the interference pattern is concerned. To understand this statement better, let us label the corpuscle that arrives from arm 1 particle P1 and the corpuscle from arm 2 particle P2. **The time difference between the arrival of these two particles in the rotated orientation is the same as in the original unturned orientation.** In the first orientation P1 arrives first and in the second orientation P2 arrives first. And since these particles carry no distinguishing information, it makes no difference which particle has come from which arm, and we may simply say that in both orientations P1 arrives first and hence **the two orientations are equivalent and no shift of the fringes should be expected.**

The waves that interfere and create the fringes are not the ones that Michelson assumed to have come all the way from the source, rather, they are generated locally. That is why it makes no difference how long the arms of the interferometer are or whether the arms are of equal length or not.

However, looking at the interference pattern as the interferometer is gradually turned, a slight change should be observed as the angle of rotation changes and approaches 45^o. This is because as the interferometer is rotated, the transit time difference between the two corpuscles is gradually reduced as the effect of the ether wind on one arm increases and on the other decreases. At the 45^o angle, the ether wind affects the corpuscles in both arms equally and hence the two corpuscles should arrive in the said region simultaneously. When the angle is further increased towards 90°, the change in the interference pattern should ***reverse*** until the angle becomes 90°, where the fringes are at the same position as when the interferometer was in the original orientation. *The change in the interference pattern, no matter how slight, is a sign of the existence of the ether, otherwise no change at all should be observed when the interferometer is rotated.* In fact, Michelson and Morley did observe a slight change.

Conclusion

The above hypothesis explains the null result of the Michelson and Morley experiment. It also explains the wave and particle characteristics of elementary particles and the logic behind Huygens' principle. The null result of the experiment in turn proves the correctness of the hypothesis.

The hypothesis, that is, the assumption that light particles generate light waves locally in their path, can be used to explain some other light phenomena. For example, in Fizeau's experiment, it makes more sense to assume that the water drags the light corpuscles, rather than dragging the ether. As the water cannot fully grip the corpuscles, only part of the velocity of the water is added to them. The waves are therefore generated in a different region than expected, giving the impression that the ether has been dragged.

The null result of the Michelson and Morley experiment in the late 19th century became a major turning point in the progress of physics. It provided a great stimulus to theoretical and experimental investigations. Looking back at the historical development of physics that followed, one wonders, had the experiment not been performed, or had it been interpreted differently, would Lorentz have written his transformation equations and would Einstein have invented his theory of relativity? Or would classical mechanics have been extended to cover some aspects of physics in relation to the motion of light and elementary particles in ether, as for example the recent derivation of mass energy equivalence, without the use of Einstein's relativity. [5]

Acknowledgement

The author would like to express his sincere appreciation to professor Bijan Samali, Centre Director, School of Computing, Engineering and Mathematics at Western Sydney University for his encouragement, valuable advice and help in publishing this paper. He would also like to thank James Evans for proofreading.

References

1. A. A. Michelson and E. Morley, *Am. J. Sci.,* 134, 333 (1887)
2. A. Einstein, "On the Electromagnetics of Moving Bodies," *Ann. Physik,* 17, 891 (1905)
3. A. Einstein, Lecture at Leiden May 4, 1920
4. Chr. Huygens, Treaties on Light (London: Macmillan 1920; Project Gutenberg edition, 2005), P. 19

5. Cyrus Master Khodabakhsh, Derivation of mass-energy equivalence using Newtonian Mechanics as an alternative to Einstein's relativity postulates, Physics Essays 29, 3 (2016)