The Invisible Ether and Michelson Morley

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The concept of the invisible ether or 'aether' is an old concept dating to the time of the ancient Greeks. They considered the ether as that medium which permeated all of the universe and even believed the ether to be another element. Along with Earth, Wind, Fire and Water Aristotle proposed that the ether should be treated as the fifth element or quintessence; this term which literally means 'fifth element' has even survived down to the present day to explain an exotic form of 'dark energy' which is crucial in some cosmological models. These ideas spread throughout the world until the advent of a new springtime in scientific thought. The first person in the modern era to conceive of the idea of an underlying ether to support the movement of light waves was seventeenth century dutch scientist Christiaan Huygens.

Many others followed in expressing their opinions on the ether concept. Whilst Isaac Newton disagreed with Huygens wave theory he also wrote about the 'aethereal medium' although he expressed his consternation in not knowing what the aether was. Newton later renounced the ether theory because in his mind the infinite stationary ether would interrupt the motions of the enormous masses (the stars and planets) as they moved in space. This rejection was reinforced by some other problematical wave properties which were not explicable at the time; most notably, the production of a double image when light passes through certain translucent materials. This property of matter known as 'birefringence' was an important hurdle to be overcome for a proper understanding of the wave nature of light.

Some time later (1720) whilst working on other astronomical issues related to light and the cosmos, English scientist James Bradley made observations in hopes of quantifying a parallax. This effect is an apparent motion of foreground objects in comparison to those in the background. Whilst he was unable to discern this parallax effect he happened to reveal another effect which is prevalent in cosmological observations; this other effect is known as stellar aberration. Bradley was able to easily describe this aberration in terms of Newton's particle theory of light. However, to do so in light of the wave or undulatory theory was difficult at best since to do so would have required a 'motionless' medium; the static nature of this ether concept was of course the property which had originally caused Newton's denial of the idea.

But Newton's acolytes would find themselves in a difficult position when it was shown that birefringence could be explained through another interpretation of the nature of light. If light was treated as being in a side to side action or 'transverse motion' then birefringence could be attributed to a light wave rather than the particle or corpuscular theory of Newton. This along with the detection of an interference effect for light by Thomas Young in 1801 renewed the ascendancy of the wave theory of light. These

findings however carried with them all of the preconceived notions prevalent in the scientific mind. Since it was assumed that waves like water and sound waves required a medium of propagation, it was similarly assumed that light still needed a medium or ether for its waves to be transmitted across the universe.

However, further problems would afflict the ether theory. Because of the unique properties of a transverse wave it became apparent that this hypothetical explanation required the ether to be a solid. In response, Cauchy, Green and Stokes contributed theoretical and mathematical observations to an 'entrainment' hypothesis which later came to be known as the 'ether drag' concept. But nothing would give more impetus to these ideas than when James Clerk Maxwell's equations (1870s) required the constancy of the speed of light (c). When the implications of Maxwell's equations are worked out by physicists, it was understood that as a result of the need for a constant speed of light only one reference frame could meet this requirement under the teachings of Galilean Newtonian relativity. Therefore, scientists expected that there existed a unique absolute reference frame which would comply with this need; as a result, the ether would again be stationary.

As a consequence, by the late nineteenth century the aether was assumed to be an immovable rigid medium. However, earlier previous theories existed as to the nature of the aether. One of the most famous of these is known as the 'aether drag' hypothesis. In this concept, the aether is a special environment within which light moves. Also, this aether would be connected to all material objects and would move along with them. Measuring the speed of light in such a system would render a constant velocity for light no matter where one tested for light's speed. This 'aether drag' idea originated in the aftermath of Francois Arago's experiment which appeared to show the constancy of the speed of light. Arago believed that refractive indexes would change when measured at different times of the day or year as a result of stellar and earthly motion. In spite of his efforts, he did not notice any change in the refractive indexes so measured.

Many other experiments would follow; these were performed in order to find evidence of the aether in its many different abstractions. However the most important of these was conducted by american scientists Michelson and Morley. Their experiment considered another alleged effect of a different aether theory which came to be known as the aether wind. Since the aether permeated the entire universe, the earth would move within the ether as it spun on its axis and moved within the solar system about the sun. This movement of the earth with respect to the aether gave rise rise to the idea that it would be possible to detect an 'ether wind' which would be sensed because of the aforementioned movement. Thus, their experiment was essentially an attempt to detect the so-called ether wind. This mysterious zephyr would be nearly impossible to detect because the aether only infinitesimally affected the surrounding material world. Michelson first experimented in 1881 with a primitive version of his interferometer; a mechanism designed to measure the wave like properties of light. He would follow this by combining forces with Morley in the most famous 'null' experiment of physics.

In this investigation, Michelson utilized an improved version of his interferometer device.

Michelson's apparatus would help him win the Nobel prize for his optical precision instruments and the investigations carried out with them. His most important study being what became known as the Michelson Morley experiment of 1887. Michelson and Morley used a beam splitter made of a partially transparent mirror and two other mirrors arranged horizontally and vertically from a light source. When a beam of light traveled from a source of coherent light to the half-silvered mirror (the semitransparent mirror) it is transmitted to either of the horizontal or vertical mirrors. When the light returned to the eyepiece of an observer the separately returning light waves would combine destructively or constructively. This phenomenon is known as the interference effect for light. It was hoped that a shifting of the interference fringes from that which was normally predicted would be able to ascertain the existence of the aether wind.

To detect this effect, the Michelson interferometer was prepared in such a manner as to minimize any and all extraneous sources of experimental error. It was located in a lower level of a stone edifice to eliminate heat and oscillatory effects which might comprise the experimental results. Additionally, the interferometer was mounted atop a marble slab that was floated in a basin of mercury. This was so that the apparatus could be moved through a variety of positions with respect to the invisible ether. But despite their many preparations the experiment did not yield the expected fringe patterns. Thus, Michelson and Morley concluded that there was no evidence for the existence of the ether. Others would replicate the experiment in different incarnations which modified the premise of the experiment. Each and every one returning a similar negative result. Modern theorists have taken these results and those of many other experiments as being indicative of the non-existence of the aether. However, even the negative result of Michelson Morley has come in to question as far back as 1933.

In that year, Dayton Miller demonstrated the fact that even though the duo's experiment had not specifically found the expected range of interference patterns, they had found an interesting little noticed effect. Miller then went on to suggest that Michelson Morley had found an experimental sine wave like set of data that correlated well with the predicted pattern of data. He also described how thermal and directional assumptions inherent in the experimental arrangement may have impacted badly on the fringe interference data. Thus, the test may have been performed in an imperfectly conceived experimental setup and with a built in mathematical bias against the detection of an appropriate outcome. Thus, in the future the aether theory in some form or another may still be sustainable as a foundational theory of physics.

Perhaps it is best to leave with these ideas as expressed in 1920 by Einstein who stated that he believed the ether theory to still be relevant to his ideas on space and time:

"More careful reflection teaches us, however, that the special theory of relativity does not compel us to deny ether. We may assume the existence of an ether"

he continued:

"Recapitulating, we may say that according to the general theory of relativity space is

endowed with physical qualities; in this sense, therefore, there exists an ether"

and finally:

"According to the general theory of relativity space without ether is unthinkable; for in such space there not only would be no propagation of light, but also no possibility of existence for standards of space and time (measuring-rods and clocks), nor therefore any space-time intervals in the physical sense. But this ether may not be thought of as endowed with the quality characteristic of ponderable media, as consisting of parts which may be tracked through time. The idea of motion may not be applied to it."