Dorothy Michelson Livingston

A personal recollection

Born in 1906, Dorothy Michelson Livingston was the daughter of celebrated physicist Albert A Michelson. The first American to receive a Nobel Prize in Physics, Albert Michelson was instrumental in disproving the long-standing theory of 'luminiferous ether', and his work paved the way for Einstein's theories of relativity. Over a period spanning 1978 to 1994, Barbara and Hans Haubold at the Vienna International Centre, Austria, talked with Dorothy about her father's research. In this paper, they aim to reconstruct Dorothy's contributions to our knowledge of Michelson's life.

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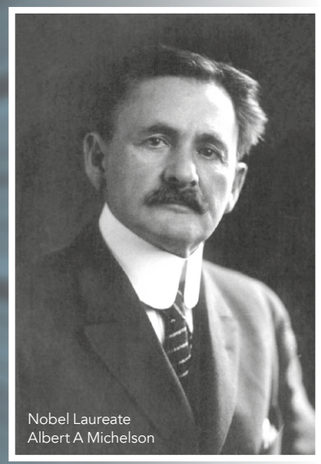
First thought up by Isaac Newton, 'luminiferous ether' was long believed to be an all-pervading, invisible fluid that engulfed the entire universe. At first, Newton used this seemingly magical medium as a crutch to lean on whenever his theory of light – he hypothesised that light is made up of tiny particles, also known as corpuscular theory – appeared to falter. As time passed by, Newton's theory of light eventually lost steam, especially when Thomas Young famously demonstrated the wave-like nature of light in 1801. However, this new theory only made the existence of the ether even more necessary: after all, waves need a medium to travel through.

Since light travels to Earth from distant stars and galaxies, scientists believed that the ether had to exist everywhere throughout space. Besides being a transporter of light, the ether had to be invisible, massless and, at the same time, extremely rigid. What was a desperate attempt by Newton to explain his faulty theory of light had gradually turned into a self-contradicting and yet totally indispensable idea.



Nobel Laureate Albert A Michelson

In the mid-19th century, James Maxwell, who had reinforced the wave-like nature of light in his theory of electromagnetism, suggested that the motion of the Earth through the ether must be detectable with optical experiments. Based on this idea, American experimenter Albert Abraham Michelson designed his interferometer experiment and, in 1881, revealed the non-existence of the ether for the first time.

BEGINNINGS IN BERLIN

Prior to his discovery, Michelson arrived in Berlin in September 1880. Here, he initially worked in the Physical Institute of what is now the Humboldt University of Berlin and in Hermann von Helmholtz's laboratory for optical research – both of which had the very best technical equipment for optical studies. Obtaining funds from Alexander Graham Bell, Michelson designed his interferometer: an instrument that split beams of light into two separate beams, which subsequently travelled along two 'arms' of equal length, positioned at right angles.

At the end of each arm, the beams were then reflected back to the beam splitter, where they were recombined. Michelson postulated that if luminiferous ether was present, the motion of the Earth through the stationary substance should cause the light in one arm to travel more slowly than the other, relative to an observer. When recombined, therefore, the beams should be slightly out of phase with each other and destructively interfere – causing the recombined beam to be dimmer than the original.

Figure 1. Dorothy Michelson Livingston and Barbara Haubold (right) enjoying their discussion of the Michelson biography and the Hudson River School (1991, Michelson Livingston's Wainscott estate).

To test this idea, Michelson built his original interferometer in the Physical Institute's basement. This instrument was so sensitive that even the slightest motion would disturb its measurements, and traffic on the street adjacent to the Physical Institute made reliable readings impossible. Fortunately, however, Helmholtz was acquainted with the director of the Royal Astrophysical Observatory at Potsdam and helped Michelson to move his apparatus there.

Figure 2. Albert Bierstadt: Hudson River School, Landscape with Cottage, 1859; Private Collection Haubold, Vienna and New York.

DISCOVERIES IN A POTSDAM CELLAR

In 1881, Michelson performed for the first time the ether experiment that carries his name today. The result was negative, in that the expected difference between the speed of light in the direction of movement through the presumed ether, and its speed at right angles, was found not to exist. Six years later, the experiment was repeated with greatly refined equipment at the Case Western Reserve University in Cleveland, Ohio. At last, the experiment showed that the ether idea could be laid to rest.

Along with the boldness of Einstein, who simply assumed that ether is not necessary for light to travel through, Michelson's elegant experimental evidence laid the foundation for the theory of special relativity. In a beautiful case of history repeating, the model of Michelson's interferometer was also used 100 years later to prove a result of Einstein's general theory of relativity – the existence of the gravitational waves.

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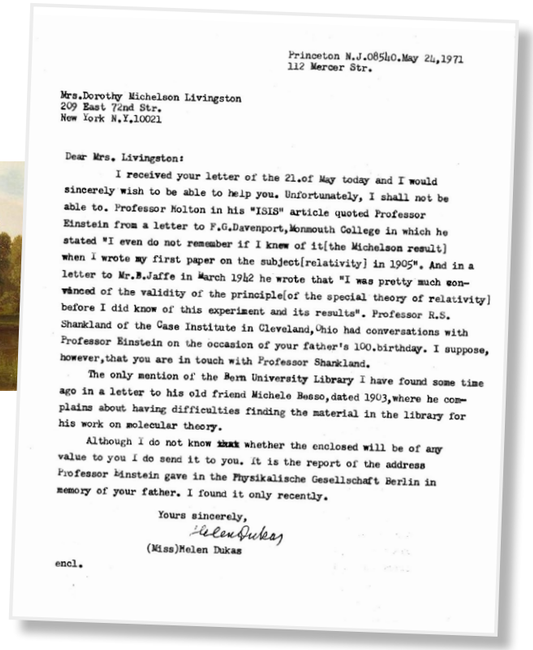

Princeton N.J.08540.May 24,1971
112 Mercer Str.

Mrs.Dorothy Michelson Livingston
209 East 72nd Str.
New York N.Y.10021

Dear Mrs. Livingston:

I received your letter of the 21.of May today and I would sincerely wish to be able to help you. Unfortunately, I shall not be able to. Professor Holton in his "ISIS" article quoted Professor Einstein from a letter to F.G.Davenport,Monmouth College in which he stated "I even do not remember if I knew of it[the Michelson result] when I wrote my first paper on the subject[relativity] in 1905". And in a letter to Mr.B.Jaffe in March 1942 he wrote that "I was pretty much convinced of the validity of the principle[of the special theory of relativity] before I did know of this experiment and its results". Professor R.S. Shankland of the Case Institute in Cleveland,Ohio had conversations with Professor Einstein on the occasion of your father's 100.birthday. I suppose, however,that you are in touch with Professor Shankland.

The only mention of the Bern University Library I have found some time ago in a letter to his old friend Michele Besso,dated 1903,where he complains about having difficulties finding the material in the library for his work on molecular theory.

Although I do not know ~~xxxx~~ whether the enclosed will be of any value to you I do send it to you. It is the report of the address Professor Einstein gave in the Physikalische Gesellschaft Berlin in memory of your father. I found it only recently.

Yours sincerely,
Helen Dukas
(Miss)Helen Dukas

encl.

Figure 3. 1971 Letter from Helen Dukas addressed to Dorothy Michelson Livingston, focusing on the role of the Michelson experiment in the discovery of special relativity by Einstein.

Until her death in 1994, Dorothy Michelson Livingston dedicated much of her life to documenting her father's remarkable contributions to physics.

DOROTHY MICHELSON: ENTREPRENEUR

Born in Chicago, a year before her father received the Nobel Prize in physics for his discovery, Dorothy recalls that her father was often not at home. When he was, however, it was a treat: he would show her how a single hair caused a sensitive scale to stagger under its weight and describe how a butterfly's wings refracted light to create fantastic colours. Among his hobbies, which included billiards, chess, and playing the violin, Dorothy recalled that he also enjoyed painting. Most of his creations were watercolours of California landscapes, many of which he hung on the walls of his house and office at the University of Chicago.

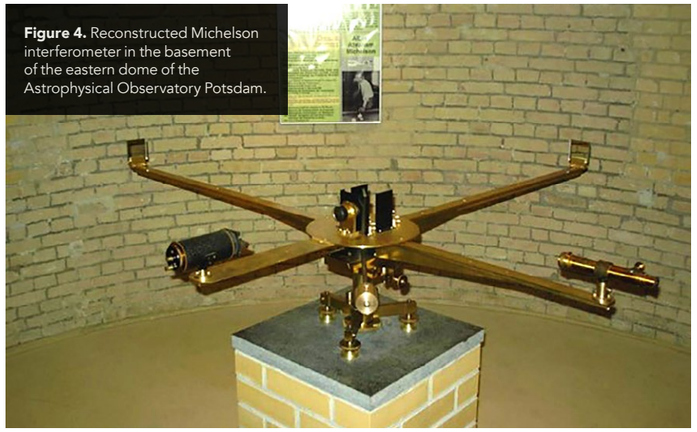

Figure 4. Reconstructed Michelson interferometer in the basement of the eastern dome of the Astrophysical Observatory Potsdam.

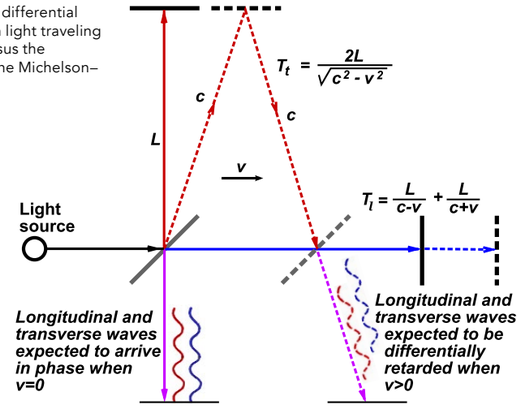

Figure 5. Expected differential phase shift between light traveling the longitudinal versus the transverse arms of the Michelson–Morley apparatus.

As an adult, Dorothy was active in New York society: hosting dinner parties with guests connected to Broadway theatre, upcoming writers and architects, and diplomats from the United Nations. When she decided to write a biography of her father, she was originally put off when told she had to cite every source of information – having never even written a term paper in high school. Yet after hiring a secretary and taking courses in creative writing and physics, she persisted for over 15 years to see the project through. Her efforts came to fruition in 1973, when the biography of Albert Michelson was completed and published.

THE BIOGRAPHY OF THE MASTER OF LIGHT

Dorothy's biography, *The Master of Light*, is the only one in existence about Michelson and is a unique source about his life. The work explains to the reader many details of Michelson's experiments and their social environment, as well as frequent repetitions by independent researchers. It details how Michelson not only invented a precision instrument for science and technology – the optical interferometer – but also performed precision measurements with this instrument, which formed the basis of Einstein's theory of relativity.

The biography draws from Dorothy's correspondence with many different celebrated physicists whom she and her father knew personally, and who discussed the physics of his experiments with them. Among the many figures consulted were Robert Oppenheimer, Niels Bohr, and Louise Alvarez, as well as Albert Einstein's secretary, Helen Dukas. As a result, her work provides a unique insight into both the professional and private environment of the world-renowned physicist Michelson.

RECOUNTING MEMORIES

Exactly a century after Michelson's original experiment, Dorothy recounted memories of her father at the 1981 Michelson Experiment Centenary Colloquium – which was centred on the Potsdam basement where Michelson placed his interferometer equipment. In addition, she spoke at the Einstein Centenary in 1979, and at a subsequent Centennial Symposium in Cleveland, which celebrated the repeat of Michelson's experiment, organised by the American Institute of Physics in 1987.

In 1989, Barbara and Hans Haubold moved to New York after Hans was appointed to the Office for Outer Space Affairs of the United Nations. Soon after, Dorothy and her husband, Goodhue Livingston, invited the Haubolds to their home at Wainscott on Long Island. Excitedly, they accepted the invitation and spent a weekend with the couple, where they listened to stories about their exciting lives.

Dorothy Michelson Livingston's work provides a unique insight into both the professional and private environment of the world-renowned physicist.

During this time, Dorothy provided the Haubolds with the opportunity to help to sort out and prepare the large collection of papers and documents which she possessed from her father. This was particularly exciting, as they came across correspondence between Michelson and many famous scientists. Based on this information and the memories conveyed by Dorothy at the three Centennial events between 1978 and 1987, Barbara and Hans Haubold have now pieced together Dorothy's memories of Michelson in unprecedented detail. Ultimately, their work highlights Dorothy's lifetime of dedication to promoting her father's world-changing legacy.

Behind the Research

Barbara & Hans J Haubold

E: bhaubold56@gmail.com **T:** +43 699 15014643

Research Objectives

Barbara and Hans Haubold worked closely with Dorothy Michelson Livingston and her husband Goodhue Livingston to explore the history of the 1881 Michelson experiment. Albert Abraham Michelson, Dorothy's father, conducted this experiment and was the first American to win the Nobel Prize in Physics.

Detail

Bio

Barbara Haubold is pursuing research on the Potsdam Michelson experiment and the Michelson Livingston family. She was pursuing economic projects in the Goethe House New York and International Atomic Energy Agency Vienna.

Collaborators

- Arak M Mathai (India/Canada)
- Reiner W John (Germany)
- Eiichi Yasui (Germany/Japan)
- Johann Wempe (Germany)
- D Michelson Livingston (US)
- Goodhue Livingston (US)

IAEA
International Atomic Energy Agency

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Personal Response

How did you first meet Dorothy, and what were your first impressions of her?

"We started correspondence with Dorothy in 1978 for the preparations of the Einstein Centenary 1979 and the Michelson Colloquium 1981. We invited Dorothy on behalf of the Berlin Academy of Sciences to participate at and contribute to the Michelson Colloquium 1981 in Potsdam. At the Colloquium, our first personal meeting with Dorothy happened. Since that meeting, we kept a personal contact by correspondence and by meeting Dorothy and Goodhue in New York and in Cleveland."