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A Great American Scientist

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A GREAT AMERICAN SCIENTIST

Pasadena, Calif. — "Dr. Albert A. Michelson, 78, discoverer of the speed of light, and one of the greatest scientists of modern times, died here at 3:10 p.m. Saturday.

"Death came quietly to the man whose work made it possible to know the distance of the stars.

"It came on the eve of success of what he called his 'last experiment,' the most precise and extensive in physics—the exact determination of the speed of light."

So ran the opening paragraphs of a long and appreciative front page article in the Des Moines Sunday Register of May 10, 1931. And in a similar strain the press of the entire country told of the passing of this modest man of science, one of the greatest of modern times.

Professor Michelson was born in Strenlo, Poland, in December, 1852, and came to America with his parents when two years old. Little is known to the general public of his early life. Even Who's Who gives little information concerning these early years, perhaps because the available space is all required merely to list the many honors—medals prizes and memberships—that were bestowed upon him later by scientific societies in every scientifically in portant country in the world. It may be inferred that his educational advantages were adequate, otherwise he would have been unable to appeal successfully to President Grant in 1870 for an appointment to the U. S. Naval Academy, and to pursue successfully the rigid course of training administered there.

After graduating from the Naval Academy he was sent to sea for his first tour of duty as an officer. After a couple of years with the fleet he returned to the Naval Academy as an instructor in the department of physics and chemistry. He was already deeply interested in science, and consulted with professor N. M. Terry, then head of that department, concerning possible lines of research. Professor Terry suggested a more accurate determination of the speed of light, which had been cleaiming the attention of the French scientists, Fizeau and Foucault. This suggestion appealed to Michelson strongly. He undertook the work with such singleness of purpose that one of his superior officers in the Navy advised him to give more attention to duty and less to "this scientific stuff" if he ever expected to accomplish anything in the world. He also did it with such success that when his work was published in 1878 it was at once recognized as the most accurate that had yet been done. It continued to be so recognized until improved upon by Michelson himself nearly half a century later, in the remarkable series of experiments carried out on Mount Wilson, California, culminating in the one referred to above.

In determining the velocity of light, just as in the case of any other velocity, the problem is to measure the time consumed in traversing a measured distance. In Michelson's experiments a beam of light was reflected from a rotating mirror to a distant stationary one, and then back to the rotating one, from which, owing to the rotation, it was reflected along a different line from that originally followed. From the amount of divergence, and the measured speed of rotation of the mirror, the time required for the light to travel the double distance was computed.

The possible ways of improving on previous results were to measure more accurately either the time, or the distance. Michelson did both. To accomplish the former he increased the distance between mirrors from a few scores of feet to thousands of feet, in one instance to 22 miles. This increased the time interval to be measured from something like a millionth of a second to about one fifty thousandth of a second. Instead of a four sided mirror, such as was used in his first experiment, he substituted a mirror of eight, twelve, or sixteen sides. In these ways he enormously increased the possible accuracy in measuring the time.

To determine the distance he secured the help of the U. S. Coast and Geodetic Survey, who measured the 22 miles from Mount Wilson, on which the rotating mirror was located, to Mount San Antonio, where the stationary one was placed. It is believed that this measurement is accurate to half an inch.

All these factors gave Michelson confidence that this series of experiments, made in 1924, '25 and '26, would be the most accurate ever made. In this he was not disappointed. Still there was an uncertainty of eighteen or twenty miles per second, due in part to the unsteadiness of the air over the intervening valley. To Michelson this was intolerable. To meet the situation he decided to dispose of the air altogether. He constructed an enormous tube, a mile long and three feet in diameter, placed his instruments in a position to send the beam of light from one end to the other and back again, and evacuated the tube. He partially offset the shorter distance by using a mirror with 32 sides. The experiment was only partly finished when his last illness overtook him, but enough had been done to enable his assistants to assure him that it would be entirely successful, and to carry it on to completion.

The determination of the speed of light was only one of Michelson's many important experiments, every one of which dealt with a subject befitting his genius. Among his earlier ones was the determination of the length of the standard meter in terms of wave lengths of light of three different colors. This required the greater part of a year. When the work was finished it was at once conceded to be the most accurate measurement of a distance ever made. It is still so considered. How accurate it really was may be judged from the very close agreement in the results obtained by three different scientists, Michelson and two French physicists, working independently, and months apart, all, however, using Michelson's apparatus. The three results differed among each other by less than a single wave length.

The results of Michelson's measurement were, for red cadmium radiation, 1,553,163.5 waves per meter; for the green, 1,966,249.7 waves, and for the blue, 2,083,372.1.

Other of his experiments were designed to disclose whether the earth in its movement around the sun carries the ether along with it, or whether it simply passes through, leaving the ether undisturbed. In the latter case the time required for a beam of light to travel a given distance and then return to the starting point would be slightly greater if the path of the beam lay along the line of movement of the earth than it would be if along a line transverse to that movement. Michelson found no difference. Since this was in direct contradiction to the well authenticated and easily reproducable results of Airy and others, a way had to be found for reconciling the inconsistency. This led to the theory of relativity. Michelson has therefore sometimes been said to have "started" Einstein.

In one of his experiments Michelson undertook the difficult problem of determining the elastic properties of the earth. This was done by observing the tilting of the earth's surface due to earth tides (similar to tides in the sea, but very minute in comparison). The observations were made by means of an interferometer, an instrument of great precision, invented by Michelson, and used in many of his other experiments. Strange as it may seem, the earth was found to be far more rigid than steel.

In none of Michelson's experiments is the tremendous sweep of his scientific imagination more apparent than in his determination of the diameters of stars. The distances of these objects are so great that even through the largest telescopes they appear as mere points, without measurable magnitude.

Many years ago Michelson suggested an interference method of measuring the diameters of Jupiter's moons. This proved to be more reliable than any other that had hitherto been tried. He then suggested that the same method could probably be adapted for measuring the diameters of stars. It was not until about ten years ago that he was enabled finally to make the trial.

The stellar measurements were carried out by mounting a twenty foot cross beam upon the end of the giant Hooker telescope at the Mount Wilson observatory, placing four small mirrors upon this beam, one near each end and two near the middle, all inclined at 45 degrees to the cross beam, and facing in such a way that a beam of light from the star was directed down the telescope tube from each end of the cross beam. After reflection from the telescope mirror these two beams of light were brought together again forming a series of interference fringes. These became gradually fainter as the two end mirrors were slowly moved toward the middle, and finally disappeared. The distance between the mirrors when this occurred made possible a computation of the diameter of the star.

The results obtained this way agreed remarkably well with those obtained by the English astronomer Eddington, and others, by a theoretical method — a fact that greatly strengthens confidence in the reliability of both.

Measurements were first made on Betelgeuse, which was thus shown to have a diameter of about 240,000,000 miles. The sun has a diameter of less than 1,000,000 miles (866,400). Thus we see what a tremendous object Betelgeuse really is. More than 275 suns the size of ours could be placed in line along its diameter. More than 1700 would be required to girdle it at the equator; and more than twenty millions of them would be required to make up the tremendous volume of this great luminary. Later measurements have disclosed that some of the stars are even greater in size than Betelgeuse. Antares, for example, has a diameter of about 400,000,000 miles, and a volume equal to that of ninety million suns. It is to Michelson that we are indebted for the method of determining experimentally the sizes of these tremendous and very distant objects.

Another of Michelson's achievements was the ruling of large and nearly perfect diffraction gratings. These are plates of metal, with one surface ground and polished until it nowhere differs from a true plane by more than a few millionths of an inch, and then, with a fine diamond point, ruling upon it a great number of parallel microscopic lines. Ruled surfaces of this kind about six by ten inches were made, with twenty to twenty-five thousand lines per inch. With such gratings spectroscopists have been able to analyze the light from different sources more effectively than ever before. Much of the recent progress in our knowledge of the structure of atoms has been the direct result of this more minute analysis of spectra.

It would be interesting to know what ones of his great contributions to science Michelson considered most important. In view of the fact that the accurate determination of the velocity of light held his attention throughout the long span of his scientific life, and was the last upon which he directed his energy, just as it was the first, perhaps it may be inferred that he placed this at the top of the list. However this may be, it certainly will be so placed by many scientists well qualified to judge—the astronomers and physicists who, in the language of the Sunday Register, say that "this great experiment will go down the ages like the work of Galileo and Newton."

W. H. Kadesch.

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VENEREAL DISEASES

Much has been said about what ought to be done about venereal diseases. Nearly everyone agrees that more education on the subject is needed, but that is about as far as it goes in at least ninety-nine cases out of a hundred. The result is that

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