Chandler Greene

Mr. Kyle Smith

IB Physics 1

24 January 2015

Robert A. Millikan: A Biography

In 1868, a man was born that would live to succeed greatly in the sciences and advocate a philosophy of the compatibility of religion and the sciences. Robert A. Millikan was born on the 22nd of March this year to a family of 6 children in Morrison, Illinois. He lived what he called a "storybook Midwestern American boyhood, fishing, farming, fiddling, and learning next to nothing about science" (Millikan 1950). After high school, Millikan attended Oberlin College. He developed his intrinsic penchant for logical thinking and empirical observation, and self - studied subjects, notably physics. After the College staff found out that he had obtained a complex understanding of physics by himself, the offered to him the position of junior physics teacher, irrespective of the fact that he was an undergraduate.

Millikan remained at Oberlin College to continue in graduate studies, and received his master's degree. Following this, he was accepted a fellowship at Columbia University. He obtained his Ph.D. there after conducting significant research and experimentation on the polarization of light on incandescent surfaces. He then travelled to Europe and collaborated with the likes of Max Planck and Walter Nernst. While in Europe, Millikan was exposed to a newfangled concept of incorporating graduate students in the laboratory. In this way, teaching and research would coincide as a more hands-on and productive experience. He would use this methodology in working at Colleges in the US. He worked with Albert A. Michelson at the University of Chicago. Michelson would go on to win the Nobel Prize due to his exemplary findings primarily regarding light, the measurement of its velocity, and the Michelson-Morley experiment. Robert Millikan began as Michelson's assistant and thus was occupied with menial tasks. Michelson was busy researching and conducting experimentation, so the more tedious aspects of his job fell to Millikan. In the ten subsequent years, Millikan was heavily involved in teaching. He reformed the undergraduate physics program at the University of Chicago, integrating a greater amount of hands-on work and experimentation. In addition, Millikan wrote several textbooks, and his book "First Course in Physics" sold 1.6 million copies to provide him with a steady income. Robert Millikan married Greta Blanchard in 1902, and together they had three children (Frazee 2007).

Though Millikan was teaching at the time, he realized that in order to acquire recognition, it would be necessary for him to be more involved in research. In 1907, Millikan began exploring a recent subject of molecular physics. In the years before his foray into more intensive research, scientists hypothesized that an electron is a small part of an atom that has a specific charge of a constant value. Millikan formulated his "oil drop experiment" based on a previous similar method. This experiment focused on the movement of small oil drops suspended between electrically charged metal plates. The two metal plates were applied high voltage through a bank of batteries. Small drops of oil created by a perfume atomizer were injected into the chamber. A tiny hole in the top metal plate allowed an occasional drop through, and Millikan would observe it through the usage of a microscope. He was also measuring the internal pressure during the course of the experiment. The metal chamber (made out of brass) was surrounded in a container by motor oil to eliminate variations in temperature. An x-ray tube served to ionize the air surrounding the droplet. This apparatus in its entirety was a means for Millikan to view a drop that would rise according the activation of the electric field, with the only other movement of it due to gravity. Though he would time the rise of the fine oil droplets by hand, he did it with so much repetition that he was able to determine the charge on the drop with great precision. Millikan changed the charge on different drops, observing how they moved at integer multiples of the original rate of movement. This empirically confirmed that all electrons were indeed similar and carried a consistent electrical charge. In the years following this original experiment, he worked to refine different aspects of it and gather even more accurate results, later publishing the value of the electron's electrical charge in the year 1913.

When in Europe with his family in 1912, Millikan attended many of Max Planck's lectures. It was here that he learned of Planck's opposition to Einstein's views on the photoelectric effect (the emission of electrons from metals when they are hit by light). Einstein contended that light can be considered divisible into small packets called photons. Millikan grew to oppose Einstein's postulations on the matter in favor of Planck's view that light should be thought of as being composed of waves instead of photons or quanta. On account of these views, Millikan attempted to prove Einstein's view of light wrong through experimentation. Millikan's complex experimentation, however, showed the opposite: it explicitly confirmed how correct Einstein's theory was regarding the subject.  Millikan was the first to truly determine with a large degree of accuracy that the maximum kinetic energy of the electrons emitted when light strikes metal follows, in actuality, Einstein's equation $\frac{1}{2}mv^2 = hf - P$. In this equation, h is Planck's constant, f is the frequency of the light, and P is the work necessary for the metal to emit the the electron. Millikan also found h to be 6.57 x $10^{-27}$ $m^2$ kg $s^{-1}$ with a precision of ±0.5%. This value, though now refined more, was vastly more accurate than the approximations that preceded it.

During this time period on, Millikan received a great number of superlatives and promotions from various organizations. This included an appointment as a research consultant at

Western Electric in 1913 and an election to the National Academy of Sciences. He was also appointed as the director of the National Research Council in 1916. The National Research Council (NRC) was created in an effort to encourage the involvement of scientists in World War One. Millikan increased his involvement in the National Research council while decreasing his involvement in teaching and universities. He moved to Washington D.C. in order to be chairman of the National Research Council's anti-submarine committee. Millikan served as a lieutenant colonel in in the Army Signal Corps' (ASC) Science and Research Division.

Robert Millikan gained an incredible amount of experience and providence during this time. He returned in 1919 to the University of Chicago as a more prominent member of the scientific and academic communities, having stronger views on the roles of the government and universities on research after the war. In the next few years, he was recruited to what was, at the time, Norman Bridge Laboratory in California. Millikan taught there, and near the time when it was renamed to the California Institute of Technology, he was appointed as the president of it. It was here that he conducted much of his research. He was active in all aspects of the research. This included organizing the involvement of graduate students that would help him when in the laboratory, doing the laboratory work and research itself, and inquiring to various organizations about funding for his scientific endeavors.

Millikan was awarded the Nobel Prize in Physics in 1923 "for his work on the elementary charge of electricity and the photoelectric effect" (Nobel Foundation). Thus both his oil drop experiment and his experimental verification of Einstein's hypothesis on the photoelectric effect (and his refining of the value of Planck's constant) were key factors in his selection as a Nobel Prize winner. Some theorize that his experimentation and findings on the photoelectric effect were worthy of the Nobel Prize by themselves. His paper on the subject was an intense shock to the scientific community at the time, with Einstein's hypotheses and relating of new developments to quantum theory existing on the fringe, and even contrary to Millikan's preconceptions.

## Works Cited


Frazee, J. (2007, June 23). Robert Millikan. Retrieved January 22, 2015, from http://uudb.org/articles/robertmillikan.html

Millikan, R. (1950). The Autobiography of Robert A. Millikan. New York: Prentice Hall.

Robert A. Millikan - Biographical. (1965, January 1). Retrieved January 23, 2015, from http://www.nobelprize.org/nobel_prizes/physics/laureates/1923/millikan-bio.html

Robert Andrews Millikan. The Nobel Prize in Physics. (n.d.). Retrieved January 22, 2015, from http://millikan.nbaoh.com/1.htm