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# FOREST RAY MOULTON

*1872—1952*

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*A Biographical Memoir by*

CHARLES E. GASTEYER



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A R Moulton

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*April 29, 1872–December 7, 1952*

BY CHARLES E. GASTEYER*

FOREST RAY MOULTON was born April 29, 1872, in a log cabin near LeRoy, Michigan. His parents, Belah G. and Mary C. Moulton, and his grandparents were long-lived and of pioneer stock. They were, for the most part, farmers and teachers. Forest Ray's parents were active in church affairs and in establishing a local school. His mother wrote a charming book[1] about the lives of her ancestors, including stories of Indian attacks and a chase by a pack of wolves. The book also describes her early married life and some episodes in the boyhood of Forest Ray and her other children.

When he was born, his grandfathers disputed about a name for him, so his mother decided "that his name should be Forest Ray, for he was a perfect ray of light and happiness in that dense forest." He was the oldest of seven brothers and a sister. Five of the brothers were later listed in *Who's Who in America.*

F. R. Moulton became the first boy in his town to get a college education, at nearby Albion College. According to his mother's book, his example was an inspiration to many others. When he was a college sophomore, he solved by an original method

* Transmitted by G. M. Clemence.

[1] Mary C. Moulton, *True Stories of Pioneer Life* (Chicago: Press of James Watson and Co., 1924). A copy of this rare book is in the files of the National Academy of Sciences, Washington, D.C.

a mathematical problem which his professor had attempted unsuccessfully, whereupon the professor appointed him as an assistant in teaching astronomy. Although Moulton had a three-year preparatory deficiency to make up when he started college, he graduated in 1894 after only the usual four years of residency. Many years later Albion College awarded him an honorary Sc.D. degree in mathematics and astronomy.

In 1895 Moulton enrolled as a graduate student at the University of Chicago. He received a Ph.D. degree in mathematics and astronomy *summa cum laude* in 1899. For the next twenty-seven years he remained at that university in successive academic positions from instructor to full professor. During this time he carried out most of his scientific researches.

Moulton is probably best known as co-author of the planetesimal hypothesis with the geologist T. C. Chamberlin. This hypothesis was developed, during the years 1897 to 1900, to explain why the planets revolve around the sun in nearly circular, coplanar orbits and why nearly all of them revolve around the sun and rotate on their axes in the same direction. The earlier nebular hypothesis failed to explain the present form of the sun and the planets for reasons given by Moulton in an article written in 1900 (see the bibliography). The planetesimal hypothesis, described by Moulton in 1905, states that the planets owe their existence to another star which passed close to the sun. The passing star's gravitational force drew out of the sun matter which then began to revolve around it as a swarm of little planets or planetesimals. Later, the planetesimals coalesced into the large planets which now exist. A modified form of this hypothesis, called the tidal theory, was developed by Sir James Jeans and Harold Jeffreys in 1918;[2] a dispute about the authorship of the basic ideas of the theory arose between Jeffreys and

[2] Sir James Jeans, *Problems of Cosmogony and Stellar Dynamics* (Cambridge: Cambridge University Press, 1919), pp. 275-85.

Moulton in 1928 (see the bibliography). In 1930 F. Nölke showed that matter drawn out of the sun—a necessary part of both the planetesimal hypothesis and the tidal theory—will dissipate into space before it can condense into planets, because of solar gravitation.[3] These theories were later superseded by the hydrodynamical vortex theory of C. F. von Weizsäcker and G. P. Kuiper.[4]

Moulton was also interested in mathematics. He investigated periodic coefficients and the convergence of series expressions used in the solution of differential equations. Some of this work was published in his text *Differential Equations* (1930).

Moulton studied some special cases of the restricted three-body problem. With the help of his graduate students at the University of Chicago, he investigated the series of orbits for a particle without mass which revolves, first, around one of the two bodies having finite mass at a very small distance from it and, next, in successively larger orbits which finally embrace both bodies at a great distance from them. His classification of different kinds of orbits in the restricted three-body problem has been criticized. His researches are summarized in the book *Periodic Orbits* (1920).

During World War I Moulton was a major in the United States Army and was in charge of the Ballistics Branch of the Ordnance Department. He carried out an original theoretical and experimental study of projectile motion, for use in aiming the newly developed long-range guns. His work included the problem of projectile rotation during flight, about which very little was then known. His results are described in the book *Exterior Ballistics* (1926).

After 1930, Moulton made a study of the size of the meteor-

[3] *Der Entwicklungsgang unseres Planetensystems,* pp. 187-91.

[4] G. P. Kuiper, "On the Origin of the Solar System," in J. A. Hynek, ed., *Astrophysics: A Topical Symposium* (New York: McGraw-Hill, 1951), ch. 8.

ite which produced Meteor Crater in Arizona. Assuming that the crater had once been a level plain, mining engineers estimated the amount of work necessary to transport enough material from the crater's center to make its surrounding walls. Moulton calculated the mass of a falling meteorite which could do this work, assuming reasonable values for the object's space velocity and angle of incidence and for the atmospheric retarding effect. For a nearly spherical meteorite composed mostly of iron and nickel and having the required mass, Moulton found that the diameter must be several hundred feet. He also suggested that the crater might be due to a swarm of meteorites, in which case the diameter of the whole swarm must have been considerably larger. His estimates of mass and size agree well with modern experimental studies.[5] Moulton's investigations of Meteor Crater were never published because he wished to avoid arguments with people who had published different opinions about the meteorite's size. His manuscripts are now kept by Dr. Lincoln LaPaz, Director of the Institute of Meteoritics at the University of New Mexico.[6]

Moulton had considerable influence on his contemporaries as a teacher and counselor. Students who worked on advanced degrees under his supervision included the astronomers E. P. Hubble and Walter Bartky and the mathematician T. H. Hildebrandt. It was Moulton who encouraged G. D. Birkhoff to start a study of Poincaré's works.[7] His qualities as a teacher are shown by the lucid style of his books *Introduction to Astronomy, Celestial Mechanics,* and *Differential Equations,* and by his many semitechnical articles published in the magazine *Popular Astronomy.*

[5] Norman Rostoker, "The Formation of Craters by High-Speed Particles," *Meteoritics,* 1 (1953):no. 1.

[6] Letter from Dr. LaPaz, March 11, 1956.

[7] Obituary of Birkhoff by Marston Morse, *Bulletin of the American Mathematical Society,* 52:357.

During his lifetime Moulton received wide recognition from scientific colleagues. While still a young man, he was a research associate of the Carnegie Institution of Washington. He became a member of many scientific societies: American Astronomical Society (1899), Royal Astronomical Society (1900), American Mathematical Society (1900), Circolo Matematico di Palermo (1905), National Academy of Sciences (1910), American Philosophical Society (1916), section on mathematics and astronomy of the American Academy of Arts and Sciences (1919), executive board of the National Research Council (1927). He was a member of the commission on dynamical astronomy and astronomical tables of the International Astronomical Union in 1922 and 1925. He held the offices of president and executive councilor in the Society of the Sigma Xi. He was an honorary member of the British Association for the Advancement of Science. Honorary degrees were awarded to him by Drake University (1939) and the Case Institute of Technology (1940). He assisted in the editing of the *Journal of Geography* in the early 1900s, the *Transactions of the American Mathematical Society* (1908-1925), and the *Astronomical Journal* (1914-1949). He was also a director of the Gould Fund of the National Academy of Sciences.

Almost as important as Moulton's purely scientific work was his deep interest in general education and in the organization of American science. He founded the first Parent-Teacher Association in Chicago. About 1920 he started a Society for the Promotion of Visual Education, the journal of which he edited for several years. He was active in the American Association for the Advancement of Science as secretary of its sections on mathematics and astronomy (1913-1924), member of the executive committee (1925-1929), permanent secretary (1937-1946), and administrative secretary (1946-1948). While he was permanent and administrative secretary, the A.A.A.S. acquired owner-

ship of the magazines *Science* and *Scientific Monthly,* purchased its own office building on a valuable site, and increased its membership from 18,000 to 43,000. According to an associate of Moulton at the University of Chicago and in the A.A.A.S., he deserves much credit for these achievements.[8] As permanent secretary, Moulton edited more than twenty A.A.A.S. symposia, mostly on medical subjects. He considered them suitable for publication both as scientific studies and as means for raising funds for the association. He edited the A.A.A.S. Bulletin (1942-1946), a vehicle for his personal essays about the philosophy of science and the application of science to human affairs. He helped organize support among A.A.A.S. members for establishment of the National Science Foundation.

Several business ventures occupied Moulton's interest and illustrate his versatility and industry. In 1906 he bought a farm in Michigan and managed it for a few years. In 1912 he was architect and contractor for a Chicago apartment building. He resigned his professorship at the University of Chicago to become a director of the Utilities Power and Light Company in that city (1926-1937). He was a personal counselor to the president of the company, advising him on business and financial policies and on the scientific problems of the power industry. Moulton became director of concessions and a trustee of the Chicago "Century of Progress" World's Fair (1933-1934). Although the Great Depression was then at its height, the concessions brought in much revenue, and the fair itself was a financial success.

The career of F. R. Moulton bears some similarity to that of the eighteenth-century French scientist, Jean-Sylvain Bailly.[9] Both men started their careers as astronomers and ended them in public service. Both were interested in medicine and in

[8] Obituary of Moulton by A. J. Carlson, *Science,* 117 (1953):545-46.

[9] Edwin B. Smith, "Jean-Sylvain Bailly—Astronomer, Mystic, Revolutionary—1736-1793," *Transactions of the American Philosophical Society,* 44 (1954):pt. 4.

philosophy. Both were prolific writers but not always critical thinkers.

Moulton married Estella L. Gillette in 1896; they were divorced in 1936. There were five children from this marriage. He married Alicia Pratt in 1939; they were divorced in 1951.

Moulton was a man of frugal habits. He did not smoke or drink. He enjoyed sports, playing football while in college and tennis afterward, until he suffered a coronary thrombosis at the age of sixty. He recovered from this attack after three or four years and then kept in physical trim by working at his son's farm on weekends. For many years he played billiards. He liked poetry, often quoting from Milton and Byron. He did not like card games, spectator sports, or the theater.

Moulton spent his last two years in Evanston, Illinois. He died December 7, 1952.

According to his close associates, he was outwardly a friendly man but inwardly quite reserved. He very seldom discussed his private life. "Dr. Moulton was apparently gentle, never showed annoyance even under extreme provocation, never raised his voice in anger or used profanity, but underneath he was the toughest, strongest character I have ever known."[10]

Moulton occasionally engaged in scientific and personal controversies with other astronomers, and he did not hesitate to use blunt language. This fact is borne out by his published scientific disputes with Percival Lowell (1909), his accusation of plagiarism against T. J. J. See (1912), and his dispute with Harold Jeffreys about the priority of formulation of the planetesimal hypothesis (1928).

Especially during his association with the A.A.A.S. Moulton wrote at length on social questions and the philosophy of science. From his writings his basic viewpoint seems to have been mainly optimistic and socially oriented. Before World War II he ex-

[10] Manuscript obituary of Moulton by F. L. Campbell.

pressed great faith in the probability of human progress through science.[11] During the war, this optimism was tempered by some moralizing about the social obligations which must accompany the pleasures and privileges of mankind.[12] Moulton never wrote much about formal religion. In his book *Consider the Heavens* (1935) he has a passionate account of the trial and persecution of Galileo by the Inquisition and warns against the careless use of scientific evidence to buttress theological beliefs.

Throughout his life, Moulton believed deeply in the humanistic value of scientific studies. A quotation about astronomy from his book *The Nature of the World and Man* (1926) illustrates his attitude: "To an astronomer the most remarkable and interesting thing about that part of the physical universe with which he has become acquainted is not its vast extent in space, nor the number and great masses of its stars, nor the violent forces that operate in the stars, nor the long periods of astronomical time, but that which holds him awestruck is the perfect orderliness of the universe and the majestic succession of the celestial phenomena."

The author gratefully acknowledges the help of several persons, mentioned in the footnotes, who supplied valuable details of Moulton's life and work. Especial thanks are due to the subject's brothers, Elton J. Moulton and Harold G. Moulton, for sending information which the author, who was not personally well acquainted with F. R. Moulton, could not have obtained otherwise.

11 Century of Progress Exposition, *Bulletin,* No. 2, 1933, and *Science,* 88 (1938):324-26.

12 *Social Science,* 16 (1941):356-64, and 17 (1942):5-19.

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*KEY TO ABBREVIATIONS*

Am. J. Math. = American Journal of Mathematics
Am. Math. Monthly = American Mathematical Monthly
Ann. Math. = Annals of Mathematics
Astron. J. = Astronomical Journal
Astrophys. J. = Astrophysical Journal
Bull. Am. Math. Soc. = Bulletin of the American Mathematical Society
Carnegie Inst. Wash. Publ. = Carnegie Institution of Washington Publication
Popular Astron. = Popular Astronomy
Soc. Sci. = Social Science
Trans. Am. Math. Soc. = Transactions of the American Mathematical Society

1895

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1896

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