Biographical Encyclopedia of Astronomers

Jeffreys, Harold

Born Fatfield, Durham, England, 22 April 1891

Died Cambridge, England, 18 March 1989

Geoscientist Harold Jeffreys is most happily remembered today as the J of the WKB-J (Wentzel-Kramers-Brillouin) method for obtaining solutions of certain classes of differential equations of great importance in quantum mechanics and other branches of modern physics. He is less happily remembered as one of the last opponents of the concept of mantle convection, plate tectonics, and continental drift, the best current understanding of the evolution and behavior of the Earth's outer layers.

Jeffreys had a head start in his early education as he was born in the village school of Fatfield where his father, Robert Hall, was headmaster and his mother, Elizabeth Mary Sharpe, was a teacher. As a teenager, Harold had interests in photography and botany. In 1907, he went to Armstrong College in Newcastle upon Tyne, then part of the University of Durham, which is now the University of Newcastle upon Tyne. He graduated from there with distinction in mathematics and, in 1910, was admitted to Saint John's College, Cambridge. There he earned bachelor's and master's degrees and was elected a fellow in 1914. The association would last a lifetime.

An essay on nutation and precession, topics Jeffreys would return to, won him the Adams Memorial Prize at Saint John's College in 1912. Thus, at the start of his career, he was showing an interest in research in the field of dynamical astronomy. A particular interest would be the theory of tidal evolution of the Solar System

The period from 1915 to 1917 found Jeffreys working in Cambridge's famous Cavendish Laboratory on war-related projects that led him to study fluid dynamics. In 1917 he was awarded a D.Sc. from Durham. Over the next 5 years, Jeffreys was engaged by the Meteorological Office where he studied atmospheric circulation, including the roles of cyclones.

From 1922 to 1931, Jeffreys served as a fellow and lecturer at Saint John's College. He was appointed University Reader in Geophysics in 1931 and remained in that position for 15 years, until elected Plumian Professor of Astronomy and Experimental Physics, a position he held until his retirement in 1958.

During his life, Jeffreys worked in and made significant contributions to a number of interrelated areas: hydrodynamics, celestial mechanics, seismology (especially the physics of the Earth's interior), probability, and pure mathematics. He was also one of the first to explore the influence of radioactivity on the Earth's cooling.

Seismology was Jeffreys' lifelong passion. Of particular interest to him was how earthquake waves could aid in investigating the interior of the Earth. In 1921, he deduced from seismic records associated with an explosion in the Rhineland that the Earth's crust has at least two layers above the mantle. Some six years later, he demonstrated that the Earth must have a dense, liquid core, a result that has been amply confirmed subsequently. His third major discovery was the division between the upper and lower mantle, which he attributed to a change in the crystal structure of olivine

Jeffreys spent many years calculating the travel times of seismic waves through the Earth. (His calculator is on display at Cambridge University's library.) These data would not only provide more precise locations of remote earthquake sources but also allow a better understanding of seismic-velocity structure within the Earth's interior. The work was started in 1931, and he was joined by K. E. Bullen as a research student. By the end of the decade, the Jeffreys-Bullen tables were published, and a reliable velocity model for the Earth was complete.

Jeffreys wrote extensively on the dynamics of the Earth and the Solar System, using materials derived from his own studies and those of graduate students. Among his investigations was a study of the variations in the Earth's rotation, including the effects of a liquid core. In particular, he showed that slowing down of the Earth's rotation, derived from astronomical observations, was most likely due to eddy viscosity in shallow seas. Subsequently, this result has been largely confirmed

Jeffreys' book *The Earth: Its Origin, History and Physical Constitution*, first published in 1924, presented the first systematic account of the physical state of the Earth as a whole and influenced the study of geophysics for many years as it went through successive editions. However, it was not without controversy. In later editions, Jeffreys continued to oppose the ideas of mantle convection, continental drift, and plate tectonics, which were generally accepted after about 1965

Most of Jeffreys' significant work in geophysics was completed before the advent of such new research tools as artificial satellites or deep drilling in the ocean floor. But often his results were the basis for later developments. Jeffreys' work on the theory of the Earth's gravitational field, as an example, showed gravity highs over the North Atlantic and the Pacific, and gravity lows over the Caribbean and Indian Ocean. These results were met with skepticism but subsequently vindicated by data obtained from the perturbations of artificial satellite orbits.

Again, as a pioneer in planetology, Jeffreys argued in 1923 that Uranus and Neptune would have surface temperatures (controlled mainly by the Sun's radiation) of about -120 °C. This view was contrary to the generally accepted beliefs at the time but proved correct, as did his suggestion that the densities of these two planets indicated that their primary constituents must have molecular weights similar to methane and ammonia

Jeffreys's *The Theory of Probability*, first published in 1939, was based on Bayesian methods that were not then popular but are now widespread in such areas as risk assessment and astronomy.

Throughout his long career, Jeffreys played an instrumental role in many organizations: He was elected a Fellow of the Royal Society in 1925, he was President of the Royal Astronomical Society from 1955 to 1957, and he served on the council for over three separate terms: 1919-

1928, 1929-1931, 1955-1960. From 1946 to 1957 Jeffreys was honorary director of the International Seismological Summary; in 1964 he served as president of the International Association of Seismology of the Earth's Interior.

Jeffreys won many awards, including the Gold Medal of the Royal Astronomical Society (1937), the medal of the Royal Society of London (1948), the Bakerian Lecturer of the Royal Society (1952), the Bowie Medal of the American Geophysical Union (1952), the Royal Society's Copley Medal (1960), Columbia University's Vethesen Prize (1962), the Royal Statistical Society's Guy Medal (1963), the medal of the Seismological Society of America (1978), and the Wollaston Medal of the Geographical Society. He was a recipient of the Victoria Medal of the Royal Geographical Society and was awarded honorary degrees by the universities of Liverpool and Dublin. Moreover, he was made a Knight Bachelor in 1953

During 1940, Jeffreys married Bertha Swirles. They had no children. Lady Jeffreys was a mathematician and vice mistress of Girton College, Cambridge, from 1966 to 1969. With him, she co-authored *Methods of Mathematical Physics* (1946), which incorporated much of his original work in mathematics, including studies of operational methods for the solution of differential equations and asymptotic methods. She outlived him by a decade.

Following the end of World War II, Jeffreys travelled extensively, spending five months at Columbia University's Lamont Geological Observatory and a similar period of time at Southern Methodist University. In addition to his research, he lectured on a range of topics in mathematics, statistics, and geophysics to both students and research groups

According to those who knew him, Sir Harold Jeffreys was somewhat over medium height and usually dressed informally. Although very difficult to talk to, he was sociable and dined regularly at Saint John's College. For many years he sang tenor in the Cambridge Philharmonic Choir. He had wide interests both in science and beyond. His writings include papers on physics and psychology; he was also an expert photographer.

George S. Mumford

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