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(*b*. Christiania [later Kristiania, now Oslo], Norway, 14 March 1862; *d*. Oslo, 9 April 1951)

physics, geophysics.

Bjerknes was the son of Carl Anton Bjerknes and Aletta Koren. His life and scientific activities were strongly influenced by his father; even in boyhood he became interested in the elder Bjerknes' hydrodynamic research, especially in the experimental verification of his father's discovery of the generation of forces between pulsating and rotating bodies in ideal (frictionless) fluids. His collaboration with his father was also necessary because the elder Bjerknes who had never received any formal training in experimental physics, was rather impractical. It should be noted, however, that at an early age Bjerknes was able to give an independent, even critical, evaluation of his father's research. On the other hand, he defended his father's memory with great devotion and gave a clearer and more general explanation of his theoretical thinking in *Vorlesungen über hydrodynamische Fernkräfte nach C. A. Bjerknes' Theorie* and in *Die Kraftfelder*.

Bjerknes began his scientific studies at the University of Kristiania in 1880 and in 1888 received the M.S. During the last years of his studies he decided to cease collaborating with his father, a decision that must certainly have been very diffcuilt to make but is a tribute to the maturity and independence with which Bjerknes regarded his possibilities for scientific research. In spite of his great devotion to his father, he was fully aware of the drawbacks to the elder Bjerknes' scientific isolation and one-sidedness, and feared that he himself could become a victim of the same circumstances. At this time he decided that after completing his education in mathematics and physics and obtaining a position that afforded him comparative peace and security, he would complete his father's work as far as possible.

After completing his studies, Bjerknes went to Paris on a state fellowship; there he attended Henri Poincaré's lectures on electrodynamics, during which Heinrich Hertz's studies on the diffusion of electrical waves were mentioned. He then went to Bonn, where he worked for nearly two years as Hertz's assistant and first scientific collaborator. For the rest of his life he remained a close friend of the Hertz family and helped Hertz's widow and daughter in 1933, when they had to flee the Nazis and seek refuge in England. This collaboration with Hertz resulted in some very important scientific publications on resonance in oscillatory circuits; and the theoretical and experimental resonance curves discovered by Bjerknes, along with a work by Poincaré, were of considerable importance for the understanding and final proof of Hertz's revolutionary experiments.

After his return to Norway, Bjerknes continued his studies, obtaining the Ph.D. in 1892 on the basis of the dissertation "Elektricitetsbevaegelsen i Hertz's primaere leder." It was his research in this field that especially qualified him for appointment as lecturer in applied mechanics at Stockholm's Högskola (School of Engineering) in 1893 and his appointment as professor of applied mechanics and mathematical physics at the University of Stockholm in 1895. Even though he abandoned experimental research in this field fairly soon, he retained a deep interest in the problems of electrodynamics for the rest of his life.

During the following years Bjerknes worked on his father's theories of hydrodynamic forces, which he succeeded in explaning in a simpler form than that based on his father's calculations of such specific examples as forces between pulsating balls in frictionless fluids. These investigations resulted in the two-volume work *Vorlesungen über hydrodynamische Fernkräfte nach* C. A. *Bjerknes's Theorie* (1900–1902). Later he often returned to the problem of force fields, which he treated in a simple, clear-cut fashion in two books published in 1906 and 1909.

During the period of his hydrodynamic studies, Bjerknes generalized on the well-known propositions of Lord Kelvin and Hermann Helmholtz concerning the so-called velocities of circulation and conservation of the circular vortex. He then applied this generalization to the movements in the atmosphere and the ocean.

Bjerknes' generalization depended on the introduction of a broader interpretation of the concept of fluids than that normally used in classical hydrodynamic theory, which assumes that a unique relationship exists between pressure and the specific volume (the volume of a unit mass). He perceived the fluids as thermodynamic systems, which made it necessary to renounce such an unambiguous relationship, and was led to the formulation of the theory of physical hydrodynamics.

In this connection, however, reference should be made to the contribution made in 1896 by L. Silberstein, at that time unknown to Bjerknes, who developed one of Bjerknes' two circulation theorems with out comprehending its far-reaching implications. The atmospheric movements that cause weather changes result from the radiation of heat from the sun, and the atmosphere thus works as a sort of thermodynamic heat engine that is constantly converting heat to mechanical energy; it also emits heat because of the friction resulting from atmospheric movements. It is therefore necessary, when atmospheric movements are described, to produce the synthesis of classical hydrodynamics and thermodynamics that results from the formulation of the theory of physical hydrodynamics.

Although he realized that it would not be completed in the future, Bjerknes planned an ambitious program as the final goal of this research: he hoped to be able, with the help of the hydrodynamic and thermodynamic theories, to use knowledge of the present conditions of the atmosphere and hydrosphere to calculate their future conditions. During a visit to the United States in 1905 he presented these plans, and received from the Carnegie Foundation an annual stipend to support his research in this field. The grant continued until 1941.

During his period as professor at the University of Stockholm, Bjerknes began collaboration with various scientists, for which he was eminently suited because of his stimulating intellect and deep understanding of his associates's need for independent development and research. Of special importance was his collaboration with J. W. Sandström, with whom he wrote the first volume of *Dynamic Meteorology and Hydrography* (1910). The second volume (1911), dealing with kinematics, was written with Th. Hesselberg and O. Devik. The projected third volume, dealing with dynamics, was completed by associates, but he lived to see its publication in 1951. In 1933 he co-authored a book with his son, Jack, and a friend of the son, H. Solberg, *Physikalische Hydrodynamik mit Anwendung auf die dynamische Meteorologie*.

After his return from Stockholm in 1907 Bjerknes became professor of applied mechanics and mathematical physics at the University of Kristiania, where he collaborated with Sandström, Hesselberg, Devik, and H. U. Sverdrup in developing dynamic meteorology. In 1912, when he was offered the professorship of geophysics at the University of Leipzig and the chairmanship of the newly organized geophysical institute, he decided to accept the offer, in the hope of better prospects. The new institute was stared under the best possible conditions: Hesselberg and Sverdrup followed him to Leipzig, and a few years later both his son and Solberg joined them.

A visit from Fridtjof Nansen resulted in an offer to Bjerknes to take over a professorship at the University of Bergen and to start a geophysical institute there. He decided to accept the offer after assuring himself that the institute in Leipzig would be carried on. Bjerknes was fifty-five when he started working in Bergen, and he remained there until 1926. His years in Bergen were perhaps the most productive of his life.

His main collaborators were again his son and Solberg; later they were joined by S. Rosseland, T. Bergeron, E. Bjørkdal, C. Rossby, and E. Palmén. Bjerknes himself continued to play an active role in both the practical implementation of extensive meteorological services and the work on theoretical meteorological problems. From this period came his now classic work *On the Dynamics of the Circular Vortex With Applications to the Atmosphere and to Atmospheric Vortex and Wave Motion*(1921). One of his finest books, it contains a clear explanation of the most important basic ideas in his research.

After his appointment as professor of applied mechanics and mathematical physics at the University of Oslo in 1926, Bjerknes continued his studies in dynamic meteorology in cooperation with Solberg, J. Holmboe, C. L. Godske, and E. Høiland. He became involved in the teaching of theoretical physics, but remained within the limits of classical physics, and in 1929 he published a small book on vector analysis and kinematics as the first part of a textbook in theoretical physics. The next volume planned, which was to include an explanation of the elder Bjerknes' "hydromagnetic" theory, was never completed. Despite intensive efforts, Bjerknes and Høiland never succeeded in finding a satisfactory formulation of this theory, which had occupied Bjerknes from his earliest years. This was a problem from which he could not, and would not, disengage himself.

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