compact group possesses an invariant measure which assigns positive numbers to all open sets. An immediate consequence of this theorem was the analytic character of compact groups (J. Von Neumann). It was somewhat later applied to locally compact Abelian groups by Pontryagin. The theorem is now one of the cornerstones of those areas of mathematics where algebra and topology meet.

BIBLIOGRAPHY

See *Alfréd Haar: Gesammelte Arbeiten* (Budapest, 1959), B.S.-Nagy, ed.

H. FREUDENTHAL

HAAS, ARTHUR ERICH (*b.* Brünn, Moravia [now Brno, Czechoslovakia], 30 April 1884; *d.* Chicago, Illinois, 20 February 1941), *physics, history of physics.*

After studying physics at Vienna and Göttingen, Haas received his doctorate at Vienna in 1906 and then turned enthusiastically to the history of physics. In order to qualify as a lecturer he submitted to the Philosophy Faculty of the University of Vienna a dissertation on the history of the energy principle. His paper was the cause of considerable puzzlement to the physicists who were responsible for passing an initial judgment on it, and it was decided that he should prepare an additional work in pure physics.

In fulfilling the faculty's assignment, Haas followed the latest publications in physics and thereby came across the unsolved problem of black-body radiation toward the end of 1909. He studied J. J. Thomson's *Electricity and Matter,* the contents of which are reflections on atomic structure, while reading an essay by Wilhelm Wien in the *Encyclopädie der mathematischen Wissenschaften* in which the suggestion was put forth that the energy element "can be derived from a universal property of the atom." Seizing upon this idea, Haas became the first to apply a quantum formula to the clarification of atomic structure. In the process he substituted real atoms for the more formal than physical Planck oscillators in the radiation cavity.

Haas's quantum rule $E_{pot} = h\nu$ agrees, for the ground state, with the condition later stated by Niels Bohr; and thus Haas obtained the correct "Bohr" radius of the hydrogen atom. But, characteristically, he wrote down only the equation solved for the action quantum, i.e., $h = 2\pi e\sqrt{r \cdot m}$. Therefore, like Wien he considered the dimensions of the atom as fundamental, from which the action quantum can then be derived. Within a numerical factor of eight Haas also correctly derived the Rydberg constant from the action quantum h, the velocity of light c, and the fundamental magnitudes of the electron, e and m. He achieved this relation by a very formal second hypothesis, namely, that the frequency derived from his quantum rule corresponds with the constant of Balmer's equation.

Although Haas's theorem failed to take into account the excited states—and therefore the connection with spectroscopic data—it was nevertheless a remarkable forerunner of Bohr's atomic theory. Yet in February 1910 Haas's ideas were termed a "carnival joke" by Viennese physicists and only slowly found recognition.

In 1913, through the intervention of Karl Sudhoff, Haas became an associate professor of the history of science at the University of Leipzig. Sudhoff, then head of the German historians of science and medicine, had been favorably impressed by Haas's first address at Cologne in 1908 and also managed to get him the editorship of volume V of Poggendorff. At the end of World War I Haas returned to Vienna, where he gradually turned from the history of physics to physics. In 1920 he calculated—independently of F. Wheeler Loomis and Adolf Kratzer—the correct formulas for the isotope effect in rotational spectra. After several offers of guest lectureships he finally immigrated to the United States in 1935. From 1936 until his death he was professor of physics at the University of Notre Dame.

Haas's work in the history of physics was inspired by his interest in older as well as modern theories. (He was influenced by Mach's and Ostwald's interest in the history of science.) Haas possessed the "conviction that no other method is as suited as the historical for facilitating the understanding of physical principles and for clarifying and deepening the knowledge of their significance" (*Die Grundgleichungen der Mechanik . . .*, preface). His numerous books written from this point of view, often based on his lectures and addresses, are masterpieces of clear exposition which were widely disseminated and translated into many languages.

BIBLIOGRAPHY

I. ORIGINAL WORKS. Haas's writings include *Die Entwicklungsgeschichte des Satzes von der Erhaltung der Kraft* (Vienna, 1909), his *Habilitationsschrift; Die Grundgleichungen der Mechanik, dargestellt auf Grund der geschichtlichen Entwicklung* (Leipzig, 1914); *Einführung in die theoretische Physik,* 2 vols. (Leipzig, 1919–1921); and *Der erste Quantenansatz für das Atom* (Stuttgart, 1965), repr. of 1910 papers with extensive biography and bibliography by A. Hermann.

Among Haas's works in the history of physics are *Die Entwicklungsgeschichte des Satzes von der Erhaltung der Kraft* (Vienna, 1909); *Der Geist des Hellenentums in der modernen Physik* (Leipzig, 1914); and "Die ältesten Beobachtungen auf dem Gebiet der Dioptrik," in *Archiv für die Geschichte der Naturwissenschaften und der Technik*, **9** (1920–1922), 108–111.

II. SECONDARY LITERATURE. See A. Hermann, "Arthur Erich Haas und der erste Quantenansatz für das Atom," in *Sudhoffs Archiv für Geschichte der Medizin und der Naturwissenschaften*, **49** (1965), 255–268; and *Genesis of Quantum Theory* (Cambridge, Mass., 1971), ch. 5.

A. HERMANN

HAAS, WANDER JOHANNES DE (*b.* Lisse, Netherlands, 2 March 1878; *d.* Bilthoven, Netherlands, 26 April 1960), *physics.*

De Haas was first educated to be a notary, but then studied physics at Leiden University where he was assistant to H. Kamerlingh Onnes. In 1912 he wrote his doctoral thesis, "On the Compressibility of Hydrogen Gas at Low Temperatures." After working in Berlin and at the Physikalische Reichsanstalt in Potsdam, de Haas was assistant to H. A. Lorentz, his father-in-law and at that time director of the physics division in the Teyler Institute at Haarlem. De Haas first became a professor of physics at the Technische Hogeschool, Delft, in 1917. He left for Groningen University in 1922, and from 1924 to 1948 was professor at Leiden University.

Together with W. H. Keesom, de Haas was director of the Kamerlingh Onnes Laboratory of Experimental Physics, initially one of the few laboratories in the world where low-temperature work was systematically carried out. In 1922 he became a member of the Royal Netherlands Academy of Science and Letters at Amsterdam. His health was never very good, but with the help of his wife (a theoretical physicist) he was able to maintain his international scientific contacts and to execute the duties of his laboratory directorate. Although he specialized in magnetism, de Haas found time to dabble in many different branches of physics.

The general trend of de Haas's work is shown by his early work at Berlin. There, in 1915, he performed an experiment suggested by Einstein, known as the Einstein-de Haas effect: the sudden magnetization of a suspended iron cylinder in a vertical solenoid causes a momentary torque in the cylinder. The theoretical foundation for this effect is that the unidirectional aligning of the spinning electrons in the magnetic field also aligns their mechanical moments, resulting in a torque pulse.

The experimental results of later scientists indicated that the ratio of the magnetic to the mechanical moment differed by a factor of two from the original classic expectation. This is the fundamental "half-integer quantization" for the spinning electron, as compared to the integer quantization for the orbital moment, a difference which runs through the whole development of modern atomic physics.

Pioneering with simple apparatus was de Haas's favorite conception of experimental physics. But he was also aware of the need for organization and routine techniques that had been introduced in the Leiden laboratory by Kamerlingh Onnes. Together with E. C. Wiersma, de Haas was a leader in the production of extremely low temperatures by adiabatic demagnetization of precooled magnetized material. Other lines of research led to the so-called Van Alphen-de Haas effect on the anomalous behavior of the resistance of a metal crystal in a magnetic field, and to magneto-optic researches on crystals, mainly done and published by Jean Becquerel. During World War II de Haas succeeded in preventing a large amount of uranium ore from being taken to Germany. After the war this uranium was useful in starting the Netherlands-Norway joint establishment for nuclear energy at Kjeller (Norway).

BIBLIOGRAPHY

For information on the Einstein-de Haas effect see "Experimenteller Nachweis der Ampèreschen Molekularströme," in *Verhandlungen der Deutschen physikalischen Gessellschaft*, **17** (1915), 152–170, written with Einstein. Also see E. Beck, *Annalen der Physik*, **60** (1919), 109. Other of de Haas's publications are in *Proceedings. K. Nederlandse akademie van wetenschappen* and in *Physica* (The Hague). A biography of de Haas may be found in *Jaarboek van de K. Akademie van wetenschappen gevestigd te Amsterdam* (1959–1960), 300; on the World War II period see also S. A. Goudsmit, *ALSOS* (Schuman, N.Y., 1947), where de Haas is called "Professor X."

J. A. PRINS

HAAST, JOHANN FRANZ JULIUS VON (*b.* Bonn, Germany, 1 May 1822; *d.* Christchurch, New Zealand, 16 August 1887), *geology.*

Haast was the only son of Mathias Haast and Anna Ruth. His father, a merchant, was elected burgomaster at Bonn. Haast studied geology and mineralogy at the University of Bonn, where, tradition says, he rescued the prince consort from drowning in the Rhine. Although he did not graduate, he worked for a time with August Krantz, a mineral dealer—leading a somewhat undistinguished life gripped by wanderlust and rendered more unsettled by the early death of his first wife, Antonia Schmitt.