Sci & Educ (2014) 23:707–710
DOI 10.1007/s11191-013-9662-x

BOOK REVIEW

Michael Eckert: *Arnold Sommerfeld: Science, Life and Turbulent Times 1868–1951*, Translated by Tom Artin

Springer, Berlin, 2013, 471 pp, Price: U.S. $ 49.99, ISBN: 978-1-4614-7460-9, DOI: 10.1007/978-1-4614-7461-6

Andre K. T. Assis

Published online: 24 November 2013

This book presents the first English-language biography of Arnold Sommerfeld (1868–1951). It was originally published in German (Eckert 2013).

The author is Michael Eckert of the Deutsches Museum in Munich. He studied physics at the Technical University of Munich, obtaining his Ph.D. in theoretical physics in 1979 from the University of Bayreuth. He is an expert in the history of modern physics and directed the edition of Sommerfeld's correspondence with other scientists, in two volumes (Eckert and Märker 2000 and 2004). He also published other books and papers on the history of modern physics.

The book has 15 Chapters and Eckert based his biography on the correspondence, books and papers of Sommerfeld, together with other original sources, many of which not yet published. In order to reach a large audience, he avoided mathematical formulas and specific technical details. But he was very careful in the discussion of the main physical topics related to Sommerfeld's life and the development of atomic and quantum physics during the first half of the twentieth century.

Sommerfeld's career developed in different cities like Königsberg, Göttingen, Claushal, Aachen and Munich. He was born in Königsberg and studied at its Albertus University, founded in 1544, which had many famous professors like Immanuel Kant (1724–1804), Carl Gustav Jacob Jacobi (1804–1851), Friedrich Wilhelm Bessel (1784–1846) and Franz Ernst Neumann (1798–1895). He matriculated at this University in 1886, studied mathematics and physics, obtaining his PhD in 1891. His supervisor was Ferdinand Lindemann (1852–1939), who worked out in 1882 the proof that the mathematical constant π (pi) is a transcendental number. Sommerfeld was assistant of the mathematician Felix Klein (1849–1925) and of the mineralogist Theodor Liebisch (1852–1922) in Göttingen, obtaining his habilitation there in 1895. He then was appointed professor in 1897 at the Clausthal School of Mining, moving later to the Royal Rhine-Westphalian Polytechnical School at Aachen. One major step of his career was to succeed Ludwig Boltzmann

A. K. T. Assis (✉)
Institute of Physics, University of Campinas-UNICAMP, Campinas, SP 13083-859, Brazil
e-mail: assis@ifi.unicamp.br
URL: http://www.ifi.unicamp.br/∼assis/

(1844–1906) as professor of theoretical physics at the University of Munich in 1906. He worked there for the rest of his life, creating a leading school of theoretical physics.

His collaboration with Klein led to the publication of a famous work on gyroscopes, in four volumes (Klein and Sommerfeld 1897–1910), which are being translated to English (Klein and Sommerfeld 2008–2013). Klein lectures on the theory of the top were developed by Sommerfeld leading to many applications in different areas of science, like gyroscopic applications for torpedo guidance and ship stabilization. The four volumes comprised almost 1.000 pages and soon became the standard reference on this subject. Section 4.5 of Eckert's biography presents many relevant details of this joint work and how it evolved over time.

He worked in many disciplines like mathematics, mineralogy, engineering and physics. In engineering, for instance, he worked with friction mediated by lubrication, published his classic hydrodynamic theory of bearing friction and introduced a dimensionless quantity which became known as the Sommerfeld number. Due to these researches he is counted as one of the so-called men of tribology. These and other researches in engineering are discussed at length in Section 5.3 of the book. Section 7.6 discusses many applied researches he performed in military physics during World War I. We can quote, for instance, streamlined telegraphy for the navy using alternating current, carried out in collaboration with Heinrich Barkhausen (1881–1956).

Sommerfeld is especially famous, however, for his elaboration of the atomic theory developed by the Danish physicist Niels Bohr (1885–1962). Bohr published his famous atomic model in three papers of 1913. During his study of this theory Sommerfeld developed what later became known as the Bohr-Sommerfeld atom. As discussed in Section 8.4 of the book, A New Quantum Number, already in 1920 Sommerfeld conjectured about the existence of an inner quantum number belonging to a hidden rotation in the interior of the atom, although there was not yet any concrete physical conception of this motion. Only in 1925 Georg Uhlenbeck (1900–1988) and Samuel Goudsmit (1902–1978) introduced the spin of the electron. Also the so-called Sommerfeld fine-structure constant, introduced in 1916, was based on these researches connecting the atomic structure with spectral lines. The spatial quantization of Otto Stern (1888–1969) and Walter Gerlach (1889–1979) is discussed in Section 9.1 of this biography, The Crisis of Models (see also Schmidt-Böcking and Reich 2011). Sommerfeld met Albert Einstein (1879–1955) personally in 1909 at the Natural Scientists Congress at Salzburg. They became some of the leading scientists developing the new atomic theory and modern theoretical physics.

During his life Sommerfeld published several editions of a famous book called *Atomic Structure and Spectral Lines*. The first edition appeared in 1919. Due to its influence it soon became known as the Bible of atomic physics, as discussed in detail in Section 8.6 of this biography.

This book includes in Sections 6.3 and 8.5 many important details of Sommerfeld's school, emphasizing the charismatic character of the founder. Some of his students include Peter Debye (1884–1966) who became the first of Sommerfeld's doctoral students, Frederick Grover (1876–1973), Ludwig Hopf (1884–1939), Demetrius Hondros (1882–1962), Rudolf Seeliger (1886–1965), Gregor Wentzel (1898–1978), Fritz Noether (1884–1941) who still a student in 1910 had edited the last volume of *The Theory of the Top*, Max von Laue (1879–1960), Linus Pauling (1901–1994) and Hans Bethe (1906–2005). Some of them made a deep impression on Sommerfeld while still students of the first few semesters, like Werner Heisenberg (1901–1976) and Wolfgang Pauli (1900–1958). The charismatic character of Sommerfeld as a teacher has been presented as follows by Einstein (pp. 253–4): "What I particularly admire in you, is that you seem to

have conjured such a large quantity of younger talent, as it were, out of the ground. That is something quite unique. You obviously have a gift for refining and stimulating the minds of your audience."

Sommerfeld is also the author of an excellent series of books, *Lectures on Theoretical Physics*, in 6 volumes, which has been reissued in new editions and translations after his death. Vol. 1: Mechanics, Vol. 2: Mechanics of Deformable Media, Vol. 3: Electrodynamics, Vol. 4: Optics, Vol. 5: Thermodynamics and Statistics, and Vol. 6: Partial Differential Equations of Physics. The volume on electrodynamics, for instance, is one of the rare textbooks mentioning the electric field existing between the internal and external cylindrical shells of a coaxial cable carrying a steady current (Sommerfeld 1964, pp. 125–130) and (Assis and Hernandes 2007, Chapter 7: Coaxial Cable).

It should also be remarked that Sommerfeld was the first German ever awarded the Oersted Medal (1949). It was awarded by the American Association of Physics Teachers, being the highest American award for achievement in the teaching of physics. They asked him for a report on his teaching activities, which was published that year (Sommerfeld 1949).

Despite the many honors he received during his life, there was a great regret that he never received the Nobel Prize, although some of his students were awarded this prize like Peter Debye, Max von Laue, Wolfgang Pauli, Werner Heisenberg, Linus Pauling and Hans Bethe. Sommerfeld himself was proposed 81 times to receive the prize, between 1917 and 1950. He holds the record of nominations without ever receiving this distinction. What he felt about this affair can be gathered from a letter he wrote in 1928 to his colleague in chemistry at Munich, Heinrich Wieland (1877–1957), who that year had received the Nobel Prize in chemistry (pp. 319 and 431): "But to dispel all suspicion of false modesty, I must simultaneously note that it is gradually becoming a public scandal that I have still not received the Prize."

Max von Laue, for instance, came to Sommerfeld's Munich Institute in 1909. In 1914 he was awarded the Nobel Prize for his interference experiments with X-rays passing through crystals. It is worth while quoting here a whole paragraph of Section 6.7 of this biography (p. 190), as it illustrates the clear exposition present in almost every page of this fascinating book:

> One year after the discovery of the X-ray interferences in crystals, though essential aspects of this phenomenon remained unknown, this much was clear: With this discovery, two new branches of physics had been christened. For one thing, it was possible to use crystals to scan the shower of impulses from an X-ray tube to find the waves it contains. As it is possible to make visible the different constituent colors contained in a white beam of light with a glass prism, it was now possible to employ crystals for spectral analysis of X-rays, and this would prove to be the key to the elucidation of the processes inside atoms. For another thing, X-rays of suitable wavelengths could be used to determine the unknown structure of crystals. It was not by chance that several years later Sommerfeld characterized "Laue's discovery" as the "most important scientific event" in the history of his institute.

The biography also describes in great detail his many trips abroad to countries like India, China, Japan and the USA. The politics of these difficult times with two world wars is also discussed at length.

Sommerfeld's final years are discussed in Chapter 11, Descent. They coincide with the period when Adolf Hitler (1889–1945) was named Chancellor of the Reich in 1933 and the period of World War II. Sommerfeld retired in 1935. He tried unsuccessfully to place Heisenberg or Debye to fill his position of academic chair. In the end he was succeeded in 1939 by Wilhelm Müller (1880–1968), a professor of mechanics from the Technical

University at Aachen. According to Sommerfeld (pp. 372–375), he was "the worst imaginable successor."

The book has many figures presenting beautiful old pictures of Sommerld, his family and colleagues. At the end of the work the author included 504 full references including first and last pages, titles etc.

This book should remain the definitive biography of Sommerfeld. Beyond presenting in depth his achievements in theoretical physics and its legacy, it includes the rich social and political environment surrounding his life and work.

References

Assis, A. K. T., & Hernandes, J. A. (2007). *The electric force of a current: Weber and the surface charges of resistive conductors carrying steady currents*. Montreal: Apeiron.

Eckert, M. (2013). *Arnold Sommerfeld: Atomphysiker und Kulturbote 1868–1951. Eine Biografie*. Göttingen: Wallstein Verlag.

Eckert, M., & Märker, K. (Eds.). (2000 and 2004). *Arnold Sommerfeld—Wissenschaftlicher Briefwechsel*. Vol. I: 1892–1918; Vol. II: 1919–1951. Diepholz.

Klein, F., & Sommerfeld, A. (1897–1910). *Über die Theorie des Kreisel*. Vol. 1–4. Leipzig.

Klein, F., & Sommerfeld, A. (2008–2012). *The Theory of the Top*. Vol. I: Introduction to the Kinematics and Kinetics of the Top. Vol. II: Development of the Theory in the Case of the Heavy Symmetric Top. Vol. III: Perturbations. Astronomical and Geophysical Applications. Birkhäuser.

Schmidt-Böcking, H., & Reich, K. (2011). *Otto Stern—Physiker, Querdenker, Nobelpreisträger*. Frankfurt am Main: Societäts Verlag.

Sommerfeld, A. (1949). Some reminiscences of my teaching career. *American Journal of Physics, 17*, 315–316.

Sommerfeld, A. (1964). *Electrodynamics*. New York: Academic Press.