

Sommerfeld, Arnold (Johannes Wilhelm) | Encyclopedia.com

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(*b.* Königsberg, Prussia [now Kaliningrad U.S.S.R.], 5 December 1868; *d.* Munich, Germany, 26 April 1951)

theoretical physics.

Sommerfeld's father, Franz Sommerfeld (1820–1906), had been married to Cäcile Matthia (1839–1902) six years when his son Arnold Johannes Wilhelm was born. Franz Sommerfeld had himself been born and raised in Königsberg, where his father, Friedrich Wilhelm Sommerfeld (1782–1862), had been Hof-Post-Sekretär. The family was Protestant; and although Sommerfeld was no religious, he never renounced his faith. "My father the practicing physician...was a passionate collector of natural objects (amber, shells, minerals, beetles, etc) and a great friend of the natural sciences": he was also a member of the semipopular Physikalisch-Ökonomische Gesellschaft in Königsberg. "To my energetic and intellectually vigorous mother I owe an infinite debt," Sommerfeld also acknowledged in 1917 in his autobiographical sketch.¹ At the humanistic Altstädtisches Gymnasium (Collegium Fridericianum) in 1875–1886 where [Hermann Minkowski](#) and Max and Willy Wien were a few years ahead of Sommerfeld. "I was almost more interested in literature and history than in the exact sciences; I was equally good in all subjects including the classical languages."

Passing the *Abitur* at the end of September 1886, Sommerfeld matriculated immediately at the University of Königsberg. "After some irresolution" he opted for mathematics but heard lectures on philosophy and political economy, as well as natural sciences. Active participation in fraternity life (Burschenschaft Germania), with its compulsory drinking bouts and fencing duels, prevented systematic and concentrated study in his first few years at the university. His instructors in mathematics were [David Hilbert](#), *Privatdozent*: Adolf Hurwitz, *extraordinarius*, and Ferdinand Lindemann, *ordinarius*. To the latter Sommerfeld expressed particular and continuing thanks in his doctoral dissertation, "Die willkürlichen Funktionen in der mathematischen Physik,"² which "I conceived and wrote out in a few weeks" during the summer of 1891.

The dissertation was indeed but an exposition of the general mathematical foundation for a harmonic analyzer that Sommerfeld and Emil Wiehert, who in those years served Sommerfeld as the highest model of a deep mathematical-physical thinker,³ had conceived and constructed in 1890 at the institute of Paul Volkmann, professor of theoretical physics. Their mechanical instrument was, moreover, only part of a comprehensive attack on the problem of interpreting the earth-thermometer observations at the meteorological station in Königsberg, which had been set as a prize question by the Physikalisch-Ökonomische Gesellschaft. The analyzer would reduce the observed temperature curve (arbitrary function) to a trigonometric series; this same series and these same numerical coefficients must then be shown to result from a solution of the heat conduction equation with the appropriate boundary conditions. Sommerfeld tackled this latter problem alone; and although he was not entirely successful, he developed the methods that were to underlie his most important scientific work in the following decade — the application of the theory of functions of a complex variable to boundary-value problems, especially diffraction phenomena.

Although he hoped for a university career, Sommerfeld, as was customary, spent the following academic year preparing for examinations to qualify as a Gymnasium teacher of mathematics and physics. Then, in the autumn of 1892, not yet twenty-four, small in stature, and still very youthful in appearance — but with virility attested by a long fencing scar on the forehead — he entered upon his year of obligatory military service, choosing his reserve regiment in Königsberg. Discharged in September 1893, Sommerfeld, at his own option, participated in eight-week military exercises in 1894, 1896, 1898, 1901, and 1903, in the latter three as lieutenant. Despite his squat build, by middle age, with the aid of a turned-up waxed moustache, he managed to give the impression of a colonel of the hussars.

Drawn to Göttingen as "the seat of mathematical high culture," Sommerfeld first obtained through personal connections, an assistantship in the Mineralogical Institute from October 1 September 1893, to September 1894. During the following two years he was [Felix Klein](#)'s assistant, managing the mathematical reading room and writing out Klein's lectures for the use of (the students. "Consciously and systematically Klein sought to enthrall me with the problems of mathematical physics, and to win me over to his conception of these problems as developed it in lecture courses in previous years. I have always regarded Klein as my real teacher only in things mathematical, but also in mathematical physics and in my conception of mechanics." In particular, although continuing the line research in mathematical physics that he had at Königsberg, Sommerfeld recognized that Klein's program for applying analytical mechanics and higher mathematics generally, to engineering problems promised manifold mutual advantages.

In March 1895, Sommerfeld became a *privatdozent* in mathematics at Göttingen, presenting as his *Habilitationsschrift* the first exact solution of a diffraction problem, which he gave as a complex integral in closed form suitable for numerical evaluation. Henri Poincaré immediately adopted “my ‘méthode extrêmement ingénieuse.’” and in the following decades the reduction of a problem mathematical physics to the evaluation of complex integral became Sommerfeld’s hallmark. Sommerfeld gave an account of this work September at the Liibeck Naturforscher-Versammlung, where he had agile Wilhelm Ostwal charged by Ludwig Bokzmann; he sided W Bull.

Sommerfeld lectured on advanced topics at Göttingen for five terms before accepting professorship in mathematics at the Bergakademie in Clausthal in October 1897. Although teaching was elementary, the salary allowed him to marry. His bride, Johanna Höpfner, was the daughter the new *Kurator* of the University of Göttingen, Ernst Höpfner, a close associate of Friedrich Althoff and an enthusiast for Klein’s schemes³ The distance between Clausthal and Göttingen was short enough for Sommerfeld to remain in close contact with the university and Klein.

At Clausthal. Sommerfeld applied his extraordinary ingenuity in boundary-value problems to the propagation of electromagnetic waves along wires of finite diameter (obtaining the first rigorous solution) and to the diffraction of X rays by a wedged-shaped slit. Both calculations were of considerable interest to experimental physicists at that time, The collaboration with Klein on *Theorie des Kreisels* (1897–1910), which grew out of Klein’s lectures in 1895–1896 and became a thousand-page treatise, continued at Clausthal. Sommerfeld also undertook the editorship of the physics volume of the *Encyklopädie der mathematischen Wissenschaften* initiated and directed by Klein. The last part of this multivolume “volume” was not issued until 1926.

In April 1900, as the result of Klein’s energetic wire-pulling. Sommerfeld became full professor at the Technische Hochschule of Aachen— significantly, however, not in mathematics but in technical mechanics. Sommerfeld was expected to show his courses, as well as in his research, that evens classical engineering discipline could be developed on a consistent mathematical foundation: “Although my Aachen colleagues and students at first regarded the ‘pure mathematician’ with suspicion. I soon had the satisfaction of being accepted a useful member not merely in teaching but also engineering practice; thus I was requested to Her expert opinions and to participate in the Ingenieurverein.” There resulted fruitful collaborations with several theoretical engineers —with Agust Föppl on problems of resonance phenom in the vibration of bridges, with Otto Schlick the analogous phenomena in ships, and with August von Borries on problems of locomotive sirue lion. Of fundamental importance, how-ever, were Sommerfeld’s investigations of the hy dynamics of viscous fluids, aiming at an explanation of the onset of turbulence and a theory of lubrication of machines.

Recognition was not withheld by the engineers. Sommerfeld declined a highly complimentary offer of the chair of mathematics and technical mechanics at the Berlin mining academy. In 1903 the council of the the Gesellschaft Deutscher Natur-forscher und Ärzte invited him to deliver one of the plenary addresses at the Kassel congress. There he pointed to the felicitous collaboration between engineering and mathematics that he had done so much to initiate and that appeared — characteristically, but erroneously—destined to absorb not merely most of Sommerfeld’s future efforts but also much of the attention of physicists and mathematicians in general.

At the same time Sommerfeld, with his tremendous capacity for work, continued in mathematical physics and joined the advancing front of fundamental physical research with a series of extensive papers intended to provide a general dynamics of electrons, with special attention to motion faster than the speed of light. In this area his urgent need of discussion to clarify his thoughts could not be satisfied by technical colleagues; instead two bright engineering students, Peter Debye and Walter Rogowski, were invited to dinner two or three times a week and afterward were talked at for two or three hours in Sommerfeld’s study.⁴

Although the electron theory papers of 1904–1905 were soon rendered utterly passé by relativity (regaining some interest and currency only after the discovery of Čerenkov radiation), they made Sommerfeld a name among the most advanced theoretical physicists—Boftzmann, Lorentz, Wilhehn Wien. In the summer of 1906 this growing reputation brought a call to the chair of theoretical physics at the University of Munich. It was only under pressure from Roentgen, then professor of experimental physics at the university, that this chair, one of the very few in the field, had recently been funded after having been defunct for several years. Curiously, Sommerfeld’s appointment was opposed by Ferdinand Lindemann, now professor of mathematics at Munich, who was hostile to the electron theory in all its various forms and was disturbed by the want of mathematical rigor in its development.

At Munich an institute was established for Sommerfeld for —a dozen rooms were fitted up for collections, seminars, assistants, and experimental work. Determined to check his own theories. Sommerfeld directed a considerable program of experimental research —even experimental doctoral dissertations. In the spring of 1912 his experimental assistant, Walter Friedrich, using covertly the facilities of the institute, discovered the diffraction of X rays by crystals.⁵

Sommerfeld always had a very ambitious conception of what he had to offer in his courses: the most recent results of research. Now, as a professor of theoretical physics, he felt obliged to work his way intensively into all the important problems of modern physics. At the September 1907 *Naturforscherversammlung* he defended Einstein’s relativity theory—thus placing himself, after Planck, among the earliest converts. In subsequent publications he cast the theory into vector form (1910) and applied it to various problems. One of the most striking applications was the prediction of a forward shift and narrowing of the

direction in which an electron decelerated from relativistic velocities emits the greatest amount of energy (distribution of *Bremsstrahlung*).

Sommerfeld met Einstein for the first time at the September 1909 *Naturforscherversammlung* in Salzburg. Despite the great difference in background and talents of the two men, they felt an immediate attraction—“a magnificent fellow” was Einstein’s reaction.⁶ At Salzburg the subject of the liveliest and most urgent interest was not, however, relativity but the [quantum theory](#). Einstein pressed his radical view of a radiation field containing discrete atoms of light while Planck and virtually all his colleagues resisted this revolutionary break with Maxwell’s electrodynamics, Sommerfeld, accepting Planck’s view that one must proceed as conservatively as possible, had in fact been led to his discovery of the forward shift of the *Bremsstrahlung* maximum while seeking an alternative explanation for a group of phenomena in which Johannes Stark, one of the very few advocates of light quanta, had seen strong evidence for the radical view.

During the year following the Salzburg *Naturforscherversammlung*, Sommerfeld gradually became convinced of the fundamental importance of the quantum and spent a full week with Einstein at Zurich “in order to parley over the problem of light and a few questions in the relativity theory. His presence was a real festival for me” Einstein reported, especially pleased at the extensive concessions that Sommerfeld made to his views on quantum statistics.⁷ Influential in this reorientation, as in so many other shifts of Sommerfeld’s scientific opinion, were the work and enthusiasms of his students and assistants—in this case especially Peter Debye and Ludwig Hopf.

It was, however, only after the announcement of the Compton effect in 1922–1923 that Sommerfeld, or his colleagues, accepted Einstein’s literally particulate structure of light even tentatively. Thus in 1910–1912, before the introduction of Bohr’s theory, Sommerfeld sought to add to the classical Maxwell-Lorentz theory a formal postulate regulating the interaction of atoms and [electromagnetic radiation](#)—a postulate that, although in no way demanded or suggested by the classical theory, was also, in contrast with Einstein’s and Bohr’s postulates, not inconsistent with it. This postulate, that the “action” (the integral of the energy respect to the time over the duration of the interaction) is always equal to Planck’s constant $h/2\pi$, Sommerfeld applied to the production of *Bremsstrahlung*, and to the inverse phenomenon, the [photoelectric effect](#).

Sommerfeld placed great importance upon this work, and his presentations at the first Solvay Congress (October 1911) and elsewhere attracted considerable attention. Although it led nowhere and had been abandoned by the end of 1913, it had nonetheless most effectively emphasized two points of view that were adopted in the more fruitful efforts of J. W. Nicholson and Bohr: it action primarily, and the energy only secondarily, that is quantized: the ubiquity of an h in the expression of the size, structure and internal energy of atoms, “but rather the existence of molecules [atoms] is to be regarded as a function and consequence of the existence elementary quantum of action.”⁸

The breakthrough came then in the summer 1913, with the appearance of Niels Bohr’s first paper on the “Constitution of Atoms and Molecules.” Sommerfeld studied the paper immediately and closely, for, as he wrote Bohr early in September 1913, “the problem of expressing the Rydberg-Ritz constant [in the exceedingly precise yet empirical formulas for the frequencies of the spectral lines] by means of Planck’s h has been with me for a long time. I discussed it with Debye a few years ago. Even though I remain for the present in principle somewhat skeptical toward atomic models still your calculation of that constant is undoubtedly great contribution.”⁹ And he closed by courteously announcing that he would like to try applying Bohr’s model to the [Zeeman effect](#) (the splitting of spectral lines emitted in a magnetic field).

That application, as Bohr himself discovered was not as simple as it appeared. Sommerfeld found himself obliged first to find a generalization; of the various quantization prescriptions that could be applied to mechanical systems with more than one degree of freedom. In the winter semester of 1914–1915 he was already lecturing to his students on the astonishing initial results of this investigation: a quantitative theory of the fine structure of the spectral lines of hydrogen and of the X spectra of the heavy elements, regarded as arising from the relativistic increase in mass of an electron by an amount depending upon the eccentricity of its orbit.¹⁰ It was only in the spring of 1916, however, that Sommerfeld found the definitive formulation of his quantization rules yielding a [quantum theory](#) of the normal [Zeeman effect](#) and, in the hands of his student Paul S. Epstein, of the Stark effect (the splitting of spectral lines emitted in an electric field).¹¹ In the course of this work Sommerfeld entered into (and afterward maintained) very close contact with experimental spectroscopists, especially Friedrich Paschen, with whom he exchanged some fifty letters within six months in 1916.

This extraordinary extension, enrichment, and precision of Bohr’s theory by Sommerfeld contributed decisively to its rapid and widespread acceptance. Only five years after Bohr’s first publication Sommerfeld, recognizing that the mathematical development of this quantum-theoretical atomic model had reached a conclusion of sorts, undertook a comprehensive exposition of the field. His *Atombau und Spektallinien*, of which the first edition appeared late in 1919, immediately became the bible of atomic physics and its successive editions, appearing almost annually in the early 1920’s, chronicled the progress of this field up to the eve of the introduction of quantum mechanics.

In these years, 1919–1926, Sommerfeld remained in the forefront of theoretical atomic physics; but he did so by largely reorienting his method and approach. Persuaded that the detailed structure of the spectra of atoms with more than one electron—and the close contact with current experimental work that he valued so highly—could not be obtained deductively by calculations from first principles, Sommerfeld pioneered a new style of theoretical spectroscopy. In this a posteriori approach, in contrast with the older a priori, the theorist began by immersing himself in the spectroscopic data, and worked back, by means of the combination principle, to the atomic energy levels. These levels he then tried to characterize by quantum

numbers and selection rules — on the basis of established mechanical and quantal laws if possible, or, if not, ad hoc. Thus where Sommerfeld had previously spoken of “numerical harmonies” in the bantum theory, he now began to speak of “number mysteries” (1919)—in the first instance, and most particularly, in the Zeeman effect. An adequate understanding of this phenomenon, and of the complex structure of spectral lines which was intimately connected with it, was then widely karded as the pecific content or contribution of a satisfactory atomic mechanics. Consequently the success of Sommerfeld and life students in the ordering of X-ray, atomic, and molecular spectra was followed with excitement and widely imitated. This approach did not, however, prove to be what it was then widely supposed to be, namely the highroad to quantum mechanics. Still, the results obtained were taken over with but slight alteration into the post-1925 quantum-mechanical theory of atomic structure.

Although not among the inventors of quantum mechanics, of quantum statistics, or of electron spin, Sommerfeld immediately became one of the most adept in the exploitation of these new concepts and prescriptions for the calculation of energies and rates of atomic processes, and the macroscopic properties of matter resulting from them. It was Schrödinger’s form, the wave mechanics, the partial differential equation, that Sommerfeld found most congenial. In 1929 he published one of the first textbooks of wave mechanics, the *wellenmechanischer Ergänzungsband to Atombau and Spektrallinien*. That favorite phenomenon, the relativistic forward shift of the *Bremsstrahlung* maximum, was recalculated with wave mechanics; and the reciprocal phenomenon, the distribution of photoelectrons, was given considerable attention. But in these years, and into the early 1930’s, the problem that drew most of Sommerfeld’s interest was the joint application of wave mechanics and Fermi statistics to the behavior of electrons in metals. With the aid of his students—especially Hans Bethe — Sommerfeld rehabilitated the electron theory of metals, which, after a promising beginning at the turn of the century, had languished under classical statistics and mechanics.

“What I especially admire about you,” Einstein wrote to Sommerfeld in January 1922. “is the way, at a stamp of your foot, a great number of talented young theorists spring up out of the ground.”¹² In the twenty-five years following his arrival in Munich—the period in which theoretical physics became a recognized, indeed glamorous, subdiscipline—Sommerfeld had more advanced students and turned out more doctorates than any other theorist. The near-monopoly that he held for the first fifteen of these years was seriously challenged only after [Max Born](#) arrived at Göttingen in 1921. The first, prewar, generation of doctorates included (in order of seniority) Peter Debye, Ludwig Hopf, Wilhelm Lenz, P. P. Ewald, Paul S. Epstein, Alfred Landé; the second, early postwar, generation included Erwin Fues, Gregor Wentzel, [Wolfgang Pauli](#) [Werner Heisenberg](#), Helmut Hönl, Otto Laporte; the third, postquantum-mechanical, generation included Hans Grimm, Albrecht Unsöld, Walter Heitler, Hans Bethe, Herbert Frisch. To this latter group must be added the American postdoctoral students then flocking to Germany. Partly in consequence of Sommerfeld’s visits to the [United States](#) (September 1922– April 1923; January–May 1929, as part of a trip around the world begun in October 1928; June–August 1931), the Americans made a point of spending some time in Munich; and several of them (Carl Eckart, William Houston, N. H. Frank) collaborated in Sommerfeld’s work on the electron theory of metals.

Sommerfeld took real pleasure in the company of his students, at least of those who had shown the requisite talent and *sitzfleisch*. With a disregard of social distance almost unheard of before the war, Sommerfeld took his students on strenuous outings in the Bavarian Alps. These occasions too were used for vigorous discussions of the physics that filled Sommerfeld’s life and that he insisted be the exclusive intellectual occupation of his students as well. With them he discussed not merely his own and their own work, but also the news that his extensive correspondence and travels brought him. His liberality and enthusiasm for new results were not always welcomed by Sommerfeld’s colleagues, who often saw their brain children nostrified and propagated in his conversations, lectures, and papers, or exploited by his protégés.

Although Sommerfeld never received a [Nobel Prize](#), from 1917 on, a steady stream of honors — prizes, memberships in foreign academies, honorary doctorates — flowed to him. The most valuable of these marks of recognition were the offers of the chairs of theoretical physics at the University of Vienna in 1917 (as successor to Hasenöhr) and at the University of Berlin in the spring of 1927 (to succeed Planck). The first brought the title *Gehelmrat* and a substantial increase in salary; the second brought a great deal of publicity, a doubling of his institute budget, and a far larger increase in personal income.

In return for the compliment Sommerfeld had paid his university by refusing the call to Berlin, it was anticipated that his colleagues would elect him rector of the university for 1927–1928. But grotesque as it may seem, this native of East Prussia, for whom the “Prussian virtues”— devotion to duty and love of the fatherland — had always been the norms of thought and action, was regarded by his colleagues as insufficiently “national” for this post. Properly patriotic as a Burschenschaftler, a member of the National Liberal Party while at Aachen, a (moderate) annexationist during war, disgusted and despairing at the revc Sommerfeld nonetheless compromised him irreparably in the Weimar period by his manfaest distaste for anti-Semitism, by openly siding with Einstein, by want of intransigence in international scientific relations, by accepting a visiting professorship at the [University of Wisconsin](#) in 1922–1923, and by favoring a [political party](#) (Deutsche Demokratische Partei) committed to parliamentary democracy. Right-wing groups put forward opposition candidate with “reliable national convictions”; and in the election, 16 July 1927, Somemerfeld was defeated 68–50.

Sommerfeld’s progress away from the antidemocratic chauvinism in which the great majority German academics were mired had begun at age fifty; at sixty-five, after fifteen months of Hitler’s regime, he noted in the draft of a letter of Einstein: “Moreover I can assure you that the misuse word ‘national’ by our rulers has thoroughly broken me of the habit of national feeling that was pronounced in my case. I would now be willing see Germany disappear as a power and merge a pacified Europe.”¹³

As early as 1915 Johannes Stark had Sommerfeld the “energetic executive secretary” of the “Jewish and philo-Semitic circle” of mathematicians and theoretical physicists.¹⁴ and Stark’s enmity grew more intense and more open in the Weimar period as Sommerfeld continued to protect the interests of these circles and to frustrate Stark’s ambitions. At the Nazi take-over, immediately attained positions of power and influence: and he sought to use them to extirpate and branch, the “Jewish” spirit in German physics. A tug-of-war now developed over Sommerfeld’s chair, for in the spring of 1935 he passed the obligatory retirement age and continued to function as professor only provisionally, from semester to semester, pending appointment of a successor faculty took the position that only a theorist of rank, if possible from Sommerfeld’s own school could maintain the tradition and placed [Werner Heisenberg](#) at the top of its list. This choice resisted strenuously by the advocates of a “German” physics. In July 1937 an article in the magazine of the SS labeled Sommerfeld and Heisenberg, among others, “white Jews of science” and “agents of Judaism in German intellectual life” who will have to “disappear just like the themselves.”¹⁵

Stark himself added an unreserved endorsement of the article, although he was more discreet in his rhetoric and charges. Sommerfeld, and other physicists as well, entered official protests; and as Stark went into eclipse, Heisenberg’s appointment seemed assured. But the “German physics” faction won the final round; in 1940 Sommerfeld received, as he himself said, “the worst conceivable successor,” Wilhelm Müller, one of the stalwarts of the movement.

Through the war Sommerfeld occupied himself with the preparation for publication of his six-semester cycle of lectures on theoretical physics. At its end, now approaching eighty, he resumed the directorship of the Institute of Theoretical Physics—but not his lectures—for several years. Early in April 1951, while strolling with his grandchildren, he was struck by an automobile and died a few weeks later.

NOTES

1. “Autobiographische Skizze.” in *Gesammelte Schriften*, **IV**, 673–682; unless otherwise indicated, all first-person quotations are from this sketch.
2. *Gesammelte Schriften*, **I**, 1–76; henceforth, where a bibliographic citation is not given for a piece of scientific work, the publication in question has been reprinted in Sommerfeld’s *Gesammelte Schriften*.
3. Karl-Heinz Manegold, *Universität, technische Hochschule und Industrie...*, Schriften zur Wirtschafts- und Sozialgeschichte, **XVI** (Berlin, 1970), 164–165.
4. P. Debye, interviews, 3 and 4 May 1962, at Archive for History of [Quantum Physics](#).
5. Paul Forman, “The Discovery of the Diffraction of X-Rays by Crystals; a Critique of the Myths,” in *Archive for History of Exact Sciences*, **6** (1969), 38–71.
6. Einstein to J. J. Laub. 31 Dec. 1909, as quoted by Carl Seelig in [Albert Einstein](#), *Leben und Werk eines Genies unserer Zeit* (Zurich, 1960), 145.
7. Einstein to Laub, Sept. [?] 1910, as quoted *ibid.*, 197.,
8. “Das Plancksche Wirkungsquantum und seine allgemeine Bedeutung für die Molekularphysik,” address at the Karlsruhe *Naturforscherversammlung*, Sept. 1911 in *Gesammelte Schriften*. **III**, 19.
9. German original published by L. Rosenfeld in his ed. of Niels Bohr, *On the Constitution of Atoms and Molecules* (Copenhagen–[New York](#), 19693), lii.
10. John L. Heilbron, “The Kossel-Sommerfeld Theory and the Ring Atom” in *Isis*, **58** (1967), 451–485.
11. A. Hermann, ed., *Der Stark Effekt*. Dokumente der Naturwissenschaft, Abt. Physik, **VI** (Stuttgart, 1965).
12. [Albert Einstein](#) and Arnold Sommerfeld. *Briefwechsel...*(1968), 98.
13. *Ibid.*, 114–115.
14. Quoted from the draft of a letter to the Prussian Education Ministry by A. Hermann, in *Sudhoffs Archiv...*, **50** (1966), 280.
15. *Das Schwarze Korps* (15 July 1937), **6**.

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Sommerfeld's literary remains—some 2,000 pages of lecture notes and some 1,000 letters, almost all to Sommerfeld — are at the Bibliothek des Deutschen Museums Munich. Microfilms are available at the Archive For History of [Quantum Physics](#), for which see T. S. Kuhn *et al.*, *Sources for History of Quantum Physics* (Philadelphia, 1967), 87–89, where about 200 letters by Sommerfeld' in various other collections are also listed Sommerfeld's correspondence with Albert Einstein and with Johannes Stark, not listed by Kuhn *et al.*, has now been published: A. Einstein and A. Sommerfeld. *Briefwechsel. Sechzig Briefe aus den goldenen Zeitalter der modernen Physik*, edited and annotated by A. Hermann (Basel-Stuttgart, 1968): and A. Hermann, “Die früum;l;he Diskussion zwischen Stark und Sommeifeld üuml;ber die Quantenhypothese,” in *Centauras*, **12** (1967), 38–59. Letters from Sommerfeld to Lé on Brillouin an and W. F. Meggers are included in the collections of the Niels Bohr Library, American Institute of Physics, [New York](#): letters to [Felix Klein](#) are in the Klein-Nachlass Niedersäehsische Staats- und Universitätsbibliothek,Göttingen.

Sommerfeld's “Autobiographische Skizze,” prepared in 1917 and supplemented in 1950, has been edited and amplified by Fritz Bopp: “Arnold Sommerfeld.” in *Geist und Gesralt. Biograohische Beiträge zur Geschichte der Bayerischen Akademie...*, **II** (Munich, 1959), 100–109. repr. in Sommerfeld's *Gesammelte Schriften*, **IV** 673–682. Sommerfeld also supplied the biographica data for his entry in the *Reichshandbuch der Deutschen Gesellschaft* (Berlin, 1931), 1802. Much additional biographical information has been drawn from the UniversitäUsitrchiv, Munich (Akten des Rektorats, Pers. Akt, **EII-N** , “Sommeifeld, 1905 bis–”) and from the Baycrisches Häitpstaatsarchiv, Munich (Abt. I. MK 35736, “sommerfeld, Dr. Arnold”).

II. Secondary Literature. Numerous commemorative and obituary notices are cited in *Gesammelte Schriften*, IV. 723–727, of which the most detailed and reliable is [Max Born](#), “[Arnold Johannes Wilhelm Sommerfeld](#).” in *Obituary Notices of Fellows of the [Royal Society](#) of London*, **8** (1952), 275–296, repr. in Born's *Ausgewahlte AbhandlungenII* (Cöttingen, 1963), 647– 659. Publications omitted from or issued subsequent to the listing in the *Gesammelte Schriften* are “Arnold Sommerfeld Recipient of the 1948 Oersted Medal.” in *American Journalof Physics*. **17** (1949). 312–314; Linus Pautting, “Arnold Sommerfeld: 1868–1951,” in *Science*, **114** (1951). 383–384; Helmut Hönl. “Memoirs of Research on Zeeman Effect in Munich in Early 1920s,” unpublished typescript at the Archive for History of Quantum Physics: P. P. Ewald, “Erinnerungen an die Anfänge des Münchener physikaJischen Kolloquiums.” in *Physikalische Blätter*, **24** (1968). 538–542; and A. Hermann. “Sommerfeld und die Technik.” in *Technik‘ in Tecgbukgeschichte*, **34** (1967), 311–322: *Friihgeschichte der Qtiantenihearie* (Mosbach, 1969). esp. ch. 6: and “Arnold Sommerfeld,” in *Die Grossen der Weltgeschichte*, IX (Munich-Zurich, 1970). 702–715.

The addresses at the Sommerfeld Centennial Memorial Meeting, Munich. [10–14 Sept. 1968. have been published in F. Bopp and H. Kleinpoppen., eds.. *Physics of One- and Two-Electron Atoms* (Amsterdam–New York, 1693); F. A. Bopp, “Opening Address.” 1–7: P. P. Ewald, “Arnold Sommerfeld als Mensch, Lehrer und Freund,” 8– 16: A. Hermann, “Sommerfeld Role in the Development of Early Quantum Theory.” 17–20: B. L van der Waerden. “The History of Quantum Theory in the Light of the Successive Editions of Sommerfeld's *Atombau und Spektrallinien*” 21–31: H. Welder. “Impact of Sommerfeld's Work on Solid State Research and Technology,” 32–43: and W. Heisenberg. “Significance of Sommerfeld's Work Today.” 44–52.

P. Forman, “Alfred Landé and the Anomalous Zeeman Effect. 1919– 1921.” in *Historical Studies in the Physical Science*,**2** (1970). 153–261, discusses Sommerfied's work on the Zeeman effect and includes several letters: and Roger H. Stuewer, “William H. Bragg's Corpuscular Theory of X-Rays and y-Rays” in *British Journal for the History of Science*, **5** (1971). 258–281. publishes correspondence between Bragg and Sommerfeld.

Paul Forman
Armin Hermann