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Physics in Perspective

Richard Gans: The First Quantum Physicist in Latin America

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Richard Gans (1880–1954) was appointed Professor of Physics and Director of the Institute of Physics of the National University of La Plata, Argentina, in 1912 and published a series of papers on quantum physics between 1915 and 1918 that marked him as the first quantum physicist in Latin America. I set Gans's work within the context of his education and career in Germany prior to 1912 and his life and work in Argentina until 1925, as well as the foundation of the Institute of Physics of the National University of La Plata in 1906–1909 and its subsequent development by Emil Bose (1874–1911). I conclude by commenting on Gans's life after he returned to Germany in 1925 and then immigrated once again to Argentina in 1947.

Key words: Richard Gans: Friedrich Paschen; Emil Bose; Margrete Heiberg Bose; Joaquin V. González; Walther Nernst; University of Tübingen; University of Strassburg; National University of La Plata; magnetism; quantum physics; history of physics.

Education and Early Career

Richard Gans (figure 1) was born in Hamburg, Germany, on March 7, 1880, the oldest of five children of Martin Gans, a wealthy merchant of Jewish descent, and his wife Johanna née Behrens.[1] Their son matriculated in the humanistic Wilhelm Gymnasium in 1881 and passed the rigorous leaving examination (*Abitur*) at Easter 1898, obtaining marks of very good (*sehr gut*) in mathematics and science. He then studied electrical technology at the Technical University (*Technische Hochschule*) in Hannover until October 1899, where he met the Lecturer (*Privatdozent*) Friedrich Paschen. He remained there for a semester before transferring to the University of Strassburg to study physics under Emil Cohn and mathematics under Heinrich Weber. He received his Ph.D. degree *summa cum laude* in the fall of 1901 with a thesis entitled "On Induction in Rotating Conductors," after which he became an assistant to Georg Quincke at the University of Heidelberg.

Meanwhile, in February 1901, Paschen had been appointed Professor of Physics and Director of the Physical Institute at the University of Tübingen, and the following year he secured Gans as his assistant. Gans completed his second thesis (*Habilitations-*

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Fig. 1. Richard Gans (1880–1954) in 1948. *Credit*: Courtesy of the Museum of Physics, Department of Physics, National University of La Plata.

schrift), "On the Change in Volume of Gases by Dielectric Polarization," under Paschen in April 1903 which, Paschen recalled, embroiled him in huge fights (*grosse Kämpfe*) because of Gans's Jewish ancestry, since in Tübingen there was "an old tradition according to which no Jew should be admitted to the teaching faculty [*Lehrkörper*]."[2] Gans gave his *Habilitation* Lecture, "On Modern Theories of Electricity," on May 20, 1903, and received the right to teach (*venia legendi*) and became *Privatdozent* on July 6. He specialized on magnetism in his subsequent research, publishing a book on theories of magnetism in 1908.[3] That fall Paschen announced that Gans had been granted the title and position of Professor extraordinary (*ausserordentlicher Professor*) of Physics.[4]

Gans's promotion brought him into increasing conflict with Paschen, who as full Professor (*ordentlicher Professor*) took charge of the large introductory courses in experimental physics and assigned Gans as Professor extraordinary to the small advanced theoretical courses – a common practice in German universities at the time, since professorial incomes derived in part from the fees students paid to attend courses. By April 1911 their relationship had deteriorated to the point where Gans resigned as Paschen's assistant; by June he had resolved to leave Tübingen and had petitioned the Faculty of Mathematics and Science at the University of Strassburg for the right to teach (*venia legendi*) there. His petition was granted in December, and on January 3, 1912, he received the official approval (*Patent als Professor*). By then he had already moved to Strassburg and had begun teaching a course on the theory of magnetism during the winter semester of 1911–1912. At the end of that semester, on March 30, 1912, the Strassburg Dean of the Faculty of Mathematics and Science informed the provincial ministry that Gans had received a call to become Professor of Physics at the National University of La Plata in Argentina, and had requested a leave of absence for the summer semester of 1912 to explore the situation there. Gans retained the option of returning to Strassburg until October 4, 1912, when he relinquished the right to teach (*venia legendi*) there.[5]

The Institute of Physics of the National University of La Plata

In 1880 the Argentine federal government relocated the capital of the province of Buenos Aires to the new city of La Plata, which it built some fifty kilometers southeast of Buenos Aires, and where in the next five years the provincial government established an observatory, museum, and public library.[6] Two years later it passed a law creating the Provincial University of La Plata, which opened in 1897 with the faculties of law, medicine, physics, mathematics, chemistry, and pharmacy. The university was nationalized in 1906, and its first president, Joaquin V. González, placed its new Institute of Physics under the administration of the observatory and secured for it the authority to grant the first doctoral degrees in physics and astronomy in Argentina. Tebaldo Ricaldoni directed the institute from 1906 to 1909, spending the "princely sum" of 99,000 pesos (178,200 marks) on equipment and installation expenses. González, however, then dismissed him, removed the institute from the observatory, and transformed it into a School of Physics in a new Faculty of Physical Sciences. Remarkably, these institutional innovations took place in a city still so new that one traveler in 1910 described La Plata as "a city of the dead.… Splendid public buildings, gleaming white gateways, magnificent avenues and groves – and no houses, no people!"[7]

Emil and Margrete Bose

Already in November 1908, González, anticipating his dismissal of Ricaldoni, had sent an emissary to Germany to locate a replacement for Ricaldoni as Professor of Physics and Director of the Institute of Physics. González soon settled on Emil Bose (figure 2). Born in Bremen, Germany, in 1874, Bose had passed the *Abitur* at the *Realgymnasium* in Nordhausen in 1895, then spent a semester in Geneva, Switzerland, and completed his Ph.D. degree at the University of Göttingen in 1898 with a thesis on the electrical

Fig. 2. Emil Bose (1874–1911). *Source*: H. Th. S. [Hermann Theodor Simon], "Emil Bose" (ref. 19), facing p. 464.

decomposition of gases, thereby becoming one of Walther Nernst's first students in his new Institute of Physical Chemistry. The following year Bose completed his *Habilitationsschrift* under chemist Oskar Emil Meyer at the University of Breslau, obtaining the *venia legendi* and becoming *Privatdozent*. In 1901 Bose returned to Göttingen as *Privatdozent* and Nernst's assistant.[8]

After the death of his wife in childbirth in 1902 and of their frail daughter in infancy, Bose fell in love with and married one of his students in Göttingen, the Dane Margrete Heiberg, nine years his senior, who in 1901 had become the first woman to receive the *Magistra Scientiarum i Kemi*, equivalent to a German doctoral degree in chemistry, from the University of Copenhagen.[9] In 1904 Bose became Woldemar Voigt's assistant in Göttingen and editor of the *Physikalische Zeitschrift*. In 1906 he was appointed Professor of Physics at the *Technische Hochschule* in Danzig. Then, in March

Fig. 3. The Bose family around 1908. *Back row, left*: Gustav Emil Hermann Bose standing behind his wife Gretchen Anna Gesche Bose holding their son Ludwig Gustav Adolf; *back row, right*: Emil Bose standing behind his wife Margrete Heiberg Bose holding their son Walter Bjorn Ludwig; *back row, center*: Gustav and Emil's father. *Credit*: Courtesy of Ingrid Bose.

1909, he was notified that he had been appointed Professor of Physics and Director of the Institute of Physics of the National University of La Plata; his wife Margrete received an adjunct professorship.[10] Their combined remuneration was 1,080 pesos (1,800 marks) per month. In addition, González promised Bose 24,000 pesos (40,000 marks) for purchasing apparatus.[11]

When Emil and Margrete Bose (figure 3) arrived in La Plata at the end of May 1909,[12] the Argentine press greeted them "as a research team rivaling Pierre and Marie Curie."[13] Bose organized the physics curriculum, purchased books, apparatus, and equipment, and furnished the Institute of Physics, which in March 1910 moved into new quarters, "a Grecian temple" (figure 4) that had been constructed originally to accom-

Fig. 4. The grand building into which the Institute of Physics of the National University of La Plata moved in March 1910. *Source: Universidad Nacional de La Plata Album* (1909).

modate the physics and chemistry classes offered by the *Colegio Nacional* that was attached to the university.[14] The huge building, around 65 meters in length, had a large basement whose floor was 2.3 meters below ground level and whose high walls had small windows in them. Above its central section was a large first-story lecture room, 12 meters high, which Bose equipped for lecture demonstrations.[15]

When entering the building, at the end of the hall on the left was the office of the director's secretary (who also oversaw the library and apparatus collections), while on the right was the director's office with two large and two small cabinets in it to house the apparatus collection, whose catalog listed 2,671 items that had cost approximately 70,000 pesos (126,000 marks). The adjacent library (which also could be used as a small lecture room) contained mostly complete runs of 10 leading German, French, Italian, and American journals and around 600 books. As Margrete Bose remarked, "few physical institutes have such a library at their disposal; it certainly is the only one in South America."[16]

Adjacent also was Bose's personal research laboratory, on one of whose walls was an electrical clock that was synchronized with ones in the large lecture room, library, and basement. Nearby rooms housed dynamos, mercury vacuum pumps, and much else. All workrooms were equipped with gas, water, and electricity. The large basement was divided into twenty-five rooms of various sizes for various purposes, including four rooms for student laboratory exercises in optics, mechanics, and electricity, all completely equipped; a fully outfitted photographic darkroom; three rooms for advanced student laboratory exercises; a constant-temperature room; four rooms for scientific research; a wood workshop and two machine shops; a room equipped for electrotechnical exercises; a chemical-storage room; a large battery-storage room for supplying electricity, and another one housing a large motor, air compressor, and other machinery. Margrete Bose declared: "Argentina is not Europe. Within the space of a year, an empty building, one that was not built for this purpose, was furnished as a first-class, modern physical institute, which even in Europe would be an astonishing achievement; it is double so here."[17]

Bose's achievements served as a magnet to attract other outstanding scientists to the National University of La Plata. The mathematician Paul Franck, who had received his Ph.D. degree at the University of Leipzig in 1900, arrived in 1909. Foremost, however, were Jakob Johann Laub and Konrad Simons. Laub had studied briefly at the Universities of Cracow and Vienna, then at the University of Göttingen from 1902–1905, and had received his Ph.D. degree at the University of Würzburg under Wilhelm Wien in 1907. The following year he became Albert Einstein's first scientific collaborator in Bern, Switzerland, working with Einstein on his theory of special relativity. Then, in 1909, he became Philipp Lenard's assistant at the University of Heidelberg; the two soon became bitter enemies, so in October 1910 Laub wrote to Bose in La Plata, inquiring about the possibility of a position.[18] That same month, on Bose's recommendation, González extended an offer to Konrad Simons as Professor of Electrical Engineering. Simons had received his Ph.D. degree under Emil Warburg at the University of Berlin in 1903, became *Privatdozent* and Bose's colleague at the *Technische Hochschule* in Danzig in 1904, and was appointed as *ausserordentlicher Professor* and Director of the Institute of Technical Physics at the University of Jena in 1909. He arrived in La Plata in 1911, as did Laub as Professor of Theoretical Physics and Geophysics. Tragically, Bose did not live to enjoy the scientific collegiality of his new colleagues and the splendid facilities of his new Institute of Physics: he became ill and died of typhus on May 25, 1911, at the age of 36.[19]

Gans Arrives in La Plata

Gans, as the son of a Hamburg merchant, and imbued with the spirit of that independent commercial seaport (the motto of its merchants was "my field the world"[20]), knew that he could find success professionally not only in Germany but also overseas. He also knew that Emil Bose had established an outstanding, generously supported Institute of Physics at the National University of La Plata. Historian Lewis Pyenson has explained:

> The total budget of the school of physics rose from 24,000 pesos (43,200 M[arks]) in 1909 to 86,000 pesos (151,000 M) in 1912. Assuming that three-quarters of the budget went for professorial salaries, as seems to have been the case in 1916, the operating budget of the physics laboratory at La Plata in 1912 would have been around 36,000 M, or about the same as that of the physics laboratory of the University of Berlin in 1910. In 1913 … [the] budget of the school of physics rose to 108,000 pesos (194,000 M) and 95 students registered in the physical science faculty.[21]

By comparison, the annual salary of an *ordentlicher Professor* in a German university before 1914 was 3,000–4,000 marks.[22]

The thirty-two-year-old Gans arrived in La Plata in the middle of 1912 but left temporarily at the end of November to spend the holidays in Germany and to marry Leonie Buttmann, the daughter of a German officer, in Wiesbaden on February 14, 1913.[23] After Gans and his bride returned to La Plata (figure 5), he resumed his teach-

Fig. 5. Leonie Buttmann Gans tending flowers in the Observatory gardens, with the Grand Equatorial Building in the background. She and her husband Richard and their two sons, Eberhardt and Klaus-Dietrich, lived in one of the Observatory houses. *Credit*: Courtesy of the Museum of Astronomy and Geophysics, National University of La Plata.

ing and began new researches on magnetism and paramagnetism,[24] characteristically and uncommonly combining penetrating theoretical analyses with experimental precision, as also was the case for his researches in quantum physics, as we shall see. He established a pattern of first publishing his papers in a new journal, *Contribución al estudio de las ciencias físicas y matemáticas* (*Contribution to the study of the physical and mathematical sciences*), which he founded in 1914. That same year he also arranged for Walther Nernst, Bose's thesis advisor, to visit La Plata from late March to early May 1914.

Gans's Contributions to Quantum Physics

Gans made his first contribution to quantum physics at a meeting of the *Gesellschaft Deutscher Naturforscher und Ärzte* in Karlsruhe, Germany, September 24–30, 1911, just as he was leaving Tübingen for Strassburg. During the discussion following a lecture by Pierre Weiss, Professor of Physics at the Federal Institute of Technology (*Eidgenössische Technische Hochschule*) in Zurich, Switzerland, on the magnetic moments of molecules, Gans asked whether their constituent magnetons could be imagined as rotating rigid bodies in which electrons existed whose total angular momentum, according to "Planck's law," was $ph/2\pi$, where p is an integer and h Planck's constant.[25] Their total magnetic moment μ then would be $\mu = p(e/m)(h/2\pi)$, where e/m is the charge-to-mass ratio of an electron, so that $(e/m)(h/2\pi)$ is a "universal constant" and "the atomic structure of magnetism (μ) would be traced back to the atomic structure of electricity (e/m) and of energy (h)."[26] Unfortunately, substituting numbers yielded a value of μ ten times larger than Weiss had observed. Perhaps, however, Gans suggested, someone might see how to modify the mechanism and bring theory into agreement with experiment – a hope that would remain unfulfilled until after the discovery of electron spin in 1925. Nonetheless, historian Ulrich Hoyer has seen in Weiss's magneton and Gans's perceptive analysis of it one of the roots of Niels Bohr's 1913 quantum theory of the hydrogen atom.[27]

Gans carried out no further research in quantum physics until the fall of 1915, three years after he had arrived in La Plata, when he showed that the specific susceptibility of a diamagnetic material is proportional to the moment of inertia of its constituent magnetons. Based upon Kotaro Honda's measurements of the specific susceptibilities of various diamagnetic materials, he determined an average value for the moments of inertia of their constituent magnetons, finding that almost all are of the same order of magnitude.[28]

Gans then enlisted the practical help of a colleague, the engineer Adrián Pereyra Míguez, and at the end of 1915 reported the first of a series of experiments designed to test Planck quantum hypothesis.[29] His interest here quite likely was stimulated by Walther Nernst's visit to La Plata from the end of March to early May 1914, during which period, in April, he gave a series of lectures in French and German on thermodynamics that was attended by more Argentine professors than students,[30] and that dealt in part with the specific heat of solids, whose quantum theory had been developed by Albert Einstein and Peter Debye.[31] The notes of Nernst's lectures were translated into Spanish and published in Gans's new journal, *Contribución al estudio de las ciencies fisicas y matemáticas*, in May 1915.[32] Gans had relished the opportunity to talk once again about quantum physics with such a distinguished German scientist, now remarking that "even if this [quantum] hypothesis is in absolute contradiction to classical mechanics, the successes derived from its consequences have surprised physicists."[33]

Max Planck had recently proposed his second quantum theory, in which he assumed that atoms absorb energy continuously but emit energy in quanta.[34] Gans now sought to determine, similarly, if an atomic oscillator that had been excited by an external force would oscillate even if its energy was less than an entire quantum.[35] To do so, he and Pereyra Míguez built a device to measure the refractive power of a lens when light of extremely low intensity passed through it. This was a most difficult experimental challenge, made even more so by the interruption of supplies owing to the outbreak of the Great War in August 1914, which required them to improvise by using the carbon arc, filters, photographic plates, and instruments on hand, for example by adapting an Adam Hilger collimator and telescope to a camera. They found that the refractive power of a lens for both very weak and very intense light was the same, indicating that an atomic oscillator can absorb much less than a quantum of energy. Theoretically, Gans considered a system of oscillators of one degree of freedom, calculated the energy of the system, and compared it to that of a quantum system, making the problematic assumption that all of the oscillators absorbed the same amount of energy simultaneously. He concluded that "the hypothesis of 'quanta' is only applicable to thermal oscillations."[36] This work, which Niels Bohr cited approvingly in 1924,[37] was the first Latin American contribution to quantum physics.[38]

Later in 1916, Gans calculated the energy of an oscillator of three degrees of freedom and compared it to that obtained by assuming that the oscillator was equivalent to three linear oscillators, finding that the two energies were not the same.[39] He went on to calculate the free energy and internal energy of monatomic and diatomic gases as a function of their temperature and density, showing that for an ideal gas quantum theory and classical thermodynamics predicted equivalent results at high temperatures and large volumes, but not at low temperatures and high densities, in agreement with later quantum-statistical results.[40]

In 1916 Planck published a new paper on the structure of phase space,[41] which prompted Gans in the spring of 1917 to correct the results he had found earlier for oscillators of three degrees of freedom.[42] He now proved that an oscillator of two degrees of freedom and of frequency ν is equivalent energetically to two linear resonators, one of frequency ν, the other of frequency 2ν,[20] a result that Nernst and his student F.A. Lindemann had found empirically in 1911.[43] Gans then went on to prove that an oscillator of three degrees of freedom and of frequency ν can be replaced energetically by three linear oscillators, one of frequency 2ν, the other two of frequency $(2/3)\nu$. Reflecting on all developments to date, Gans concluded:

> The theory of "quanta" is at the peak of its evolution. The truths of yesterday are no longer the truths of today, and today's hypotheses may be refuted tomorrow.
>
> However, all of these uncertain studies, comparable in their uncertainty to the essays on electromagnetic theory in the pre-Maxwell-Hertz time are not useless, because each result, although negative, is a step forward and the collaboration of theory and experiment demands a broad road from which many paths and branches spread out, all converging to the same place: the mechanics of the microcosm of "quanta," so different from the classical mechanics of the macrocosm.[44]

In 1918, in his last work on quantum physics, Gans extended the theory of paramagnetism to the low-temperature region.[45] His goal was to distinguish between Planck's first and second quantum hypotheses, according to which an atomic oscillator both absorbs and emits energy in quanta, or absorbs energy continuously but emits energy in quanta. These two hypotheses are very different, but many of their consequences are practically identical, so it is difficult to distinguish between the two experimentally. Gans calculated, according to both hypotheses, the magnetic susceptibility of a paramagnetic substance at low temperatures, where its elementary magnets oscillate about their equilibrium positions in the presence of an external magnetic field and thus have two degrees of freedom. For the former, he used the results of his previous analysis of two-dimensional oscillators and obtained an expression involving three constants. For the latter, he used the same results, but he assumed that the oscillators absorb energy continuously, obtaining an analogous expression involving other constants. He then compared these two expressions at higher temperatures and found that the former constants remained valid, thus showing that the magnetic susceptibility of paramagnetic substances could be explained theoretically by Planck's first quantum hypothesis, that an oscillator both absorbs and emits energy in quanta. Gans added that the magnetic susceptibility of paramagnetic substances therefore could be explained by the interaction of its elementary magnets with the external magnetic field, and hence did not mean, as some people had suggested, that classical statistical mechanics was invalid. Thus, physicists should continue to use the classical equipartition theorem as long as possible, "mainly because" quantum theory "still is not well developed," while classical statistical mechanics is "based upon the solid grounds created by Boltzmann and Gibbs."[46]

With those words, Gans left research in quantum physics and returned to research in classical physics. Indeed, throughout his life Gans viewed himself as a classical physicist;[47] in a review of his work that he prepared at the age of 70 he did not even mention his above papers on quantum physics.[48] Nonetheless, they were, in fact, the first papers on quantum physics that were published in Latin America.[49]

Return to Germany

During and after the Great War, Gans gave a number of popular lectures in La Plata, including ones on German universities (1917), Einstein's theory of relativity (1920), and the microscopic and ultramicroscopic observation of small particles (1924).[50] In 1920 he also offered a course that dealt with statistical mechanics and the quantum hypothesis, including Bohr's use of it in his theory of the hydrogen atom, and in 1924 aspects of quantum theory were included in the curriculum under "Special Physics."[51] Further, in 1923 Gans made arrangements for a visit of Fritz Haber to La Plata, for whom he demonstrated the Tyndall effect, the depolarization of light, by benzene molecules.[52]

Einstein praised Gans in a letter of August 22, 1922, to the mathematician Gerhard Kowalewski, declaring that Gans is

> one of the most prominent and multiply-talented physicists. Under difficult circumstances and in completely unlearned surroundings he has worked theoretically and experimentally, mainly in the field of magnetism.[53]

Gans felt the isolation that Einstein's words reflected.[54] For example, in a letter of December 18, 1921, to Walther Gerlach he wrote: "I am very thankful to you that you have suffered so long without complaining, because otherwise I hardly would be in a position to publish anything in German journals…."[55]

Still, Gans's papers were much delayed in publication in the *Annalen der Physik*. Thus, Gans's paper on oscillators of three degrees of freedom was received by the *Contribución al estudio de las ciencias físicas y matemáticas* on April 12, 1917, and published in October 1917, but was not received by the *Annalen der Physik* until August 23, 1919, over two years later, and published in 1920,[56] the same year in which three other papers of his were published that had been received by the La Plata journal as long ago as between May 17, 1916, and November 9, 1917.[57]

Meanwhile, behind the scenes, in a Germany just beginning to recover from the devastating postwar inflation of 1919–1922, moves were being made to bring Gans back to his homeland. Thus, in view of the impending retirement of Paul Volkmann, Professor of Theoretical Physics at the University of Königsberg, its Philosophical Faculty drew up a list of his potential successors on January 16, 1924, placing Gans at the top of the list.[58] As justification, the Faculty noted that by then Gans had published, in addition to two books, one on vector analysis (1906), the other on the theory of magnetism (1908),[59] and several major review articles, the exceptionally large number of around 160 papers, divided into four major categories: (1) the application of Maxwell's theory to special problems, for example, to magneto and electrostriction, to the fundamental equations of electrodynamics, and to the electrodynamics of moving bodies; (2) the general and molecular theory of magnetism; (3) the molecular theory of dielectrics; and (4) the molecular theory of the depolarization of light (Tyndall effect).[60] However, when Gans was informed of the Faculty's recommendation, he sent a telegram declining to be a candidate for the position.[61] By November 1924 the position still had not been filled, and Gans, who just happened to be in Göttingen then, agreed to visit Königsberg from January 6–8, 1925. Once there, he immediately signed a statement of understanding, agreeing to accept the position of Professor of Physics and Director of the Second Physical Institute of the University of Königsberg beginning September 1, 1925.[62] After thirteen years, Gans resigned from the National University of La Plata, where its Institute of Physics now faced a difficult period of retrenchment,[63] and returned home to Germany.

Less than a decade later, Gans's personal and professional life changed dramatically. His wife Leonie died in 1932, probably as a result of illnesses she had contracted in Argentina,[64] leaving him to care for their two sons, both born in Argentina, Eberhardt in 1917, Klaus-Dietrich in 1922.[65] Then, following the promulgation of the Nazi Civil Service Law on April 7, 1933, Gans lost the authority to conduct student examinations at Königsberg in 1934, and on October 14, 1935, he was placed on leave and forbidden to enter his institute and hence use its library and even his own collection of reprints of scientific papers.[66] Throughout this difficult and humiliating time, however, Gans retained the support and friendship of colleagues, especially Walther Gerlach, who had been one of his students in Tübingin during the winter semester of 1909–1910 and who had come to know Gans well during 1910–1911.[67] Gans and Gerlach now exchanged letters regularly and also met personally in January 1936 in Berlin, where Gans, knowing that his dismissal from Königsberg was inevitable, obtained a position as a theoretical physicist and consultant to the Research Institute of the *Allgemeine Elektrizitäts-Gesellschaft*.

Gans held this position until the outbreak of war in September 1939, after which he worked at *Telefunken* and other Berlin firms until, in the spring of 1943, he was ordered, at age 63, and never before having had to do any physical work, to clean up streets after Allied bombing raids.[68] Earlier, between 1936 and 1942, he had had a private telephone, which enabled him to remain in contact verbally with his friends, above all Gerlach, but also with Max von Laue, Paul Rosbaud, and others. Gans's biographer, Edgar Swinne, has concluded that Gans was not murdered in the Holocaust not only because his friends in Berlin protected him, but also because he was deeply respected

Fig. 6. Richard Gans (1880–1954) in old age. *Credit*: Courtesy of the Museum of Physics, Department of Physics, National University of La Plata.

by many people for the extraordinary humanity with which he had treated them.[69] Three of them, the physicists Hans Jensen, Fritz Houtermans, and Heinz Schmellenmeier, devised a plan that succeeded in getting Gans released from his work detail in the spring of 1943 and transferred to a scientific research laboratory, which was evacuated to Oberoderwitz in the fall of 1944, and which was liberated by American troops on April 14, 1945.[70]

Gans's two sons, both of whom had Argentine passports, survived in Berlin until the end of the war but were captured by Russian troops in June 1945 and imprisoned in a camp near Moscow for four months before they were released and found their way by a circuitous route to Vienna, where the French Occupation Authorities sent them on to Argentina.[71]

Gans (figure 6), with the support of Arnold Sommerfeld, was appointed Professor of Theoretical Physics at the University of Munich in 1946, but became unhappy there and in less than a year resigned his position, desiring to join his sons in Argentina.[72] Since he was a German citizen, however, the American Occupation Authorities forbade him to leave Germany. He therefore decided to leave Germany secretly and illegally, entering France without a passport. He lived in Paris for four months before Enrique Gaviola and another old Argentine friend were able to secure an Argentine visa for him, which Gaviola sent to him by airmail on April 8, 1947.[73] One month later, he, his older son Eberhardt, his wife, and their infant son, and his younger son Klaus-Dietrich were living together in a beautiful country house in a villa development between La Plata and Buenos Aires. Gans remained on the faculty of the National University of La Plata until 1951 and then transferred to the University of Buenos Aires. He died on June 27, 1954, at the age of 74 and is buried in La Plata.

Acknowledgement

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32 Walther Nernst, "Evolución de la termodinámica especialmente en su aplicación a los cuerpos sólidos y a las transformaciones químicas," *Contrib. estud. cien.* **1** (1915), 97–157 [translated by Edwin Rotlin; received August 1914; published May 1915].
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37 Niels Bohr, "On the Application of the Quantum Theory to Atomic Structure. I. The Fundamental Postulates," *Proceedings of the Cambridge Philosophical Society (Supplement)*, (1924), 1–42; on 40, note; reprinted in J. Rud Nielsen, *Niels Bohr Collected Works*. Vol. 3. *The Correspondence Principle (1918–1923)* (Amsterdam, New York, Oxford: North-Holland, 1976), pp. 458–499; on 497, note.
38 P. Kittl, "Cien años de mecánica cuántica," website http://cabierta.uchile.cl/revista/13/articulos/13_2/index.html> [28 pp.], p. 6.
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44 Gans, "Contribución a la teoría de los 'quanta.' Tercera parte" (ref. 42), p. 89; *idem*, "Oszillatoren von zwei und drei Freiheitsgraden" (ref. 42), in which these paragraphs are not included.
45 Richard Gans, "Teoría de los quanta y magnetismo," *Contrib. estud. cien*. **2** (1918), 193–205 [received January 21, 1918; published July 1918].
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47 Frau Damián Canals, Gans's former student, personal communication, October 20, 2005.
48 E. Gaviola, "Introducción" [Homenaje a Ricardo Gans en su 70o aniversario], *Revista de la Unión Matemática Argentina* **14**, No. 3 (1950), 101–108.
49 On the early history of quantum physics in two Latin American countries, see María de la Paz Ramos Lara, ed., *La mecánica cuántica en México: Una visión interdisciplinaria a cien años de su nacimiento* (Delegación Coyoacán, México, D.F.: Siglo veintiuno editores, s.a. de c.v., 2003) and Regino Martínez-Chavanz, "La recepción de la física moderna en Colombia," *Saber y tiempo; publicación de la Asociación Biblioteca José Babini* **18**, No. 5 (2004), 41–71. Gans is rarely cited as one of the early contributors to quantum physics, but he is by Kittl, "Cien años de mecánica cuántica" (ref. 38), p. 6.

50 Swinne, *Richard Gans* (ref. 1), p. 53.
51 Ramón Loyarte, "La evolución de la Física," in Sociedad Científica Argentina, ed., *Evolución de las Ciencias en la República Argentina* (Buenos Aires: Coni, 1924), p. 78. Quantum physics was largely ignored in courses in La Plata until the 1940s; see Damián Canals-Frau, "Recuerdos de mi profesor y amigo "Tata" Beck," *Revista de Enseñanza de la Física* **14**, No. 1 (2001), p. 67.
52 Swinne, *Richard Gans* (ref. 1), p. 59.
53 Quotaed in Pyenson, *Cultural Imperialism* (ref. 6), p. 231.
54 E. Gaviola, "Richard Gans (1880–1954)," *Ciencia e Investigación. Revista patrocinada por la Asociación Argentina para el progreso de las Ciencias* **10**, No. 8 (1954), 381–384; on 382–383.
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57 Richard Gans, "La permeabilidad reversible en la curva ideal de imanación," *Contrib. estud. cien.* **2** (1918), 145–172 [received November 9, 1917; published July 1918]; *idem*, "Die reversible Permeabilität auf der idealen Magnetisierungskurve," *Ann. d. Phys.* **61** (1920), 379–395; *idem*, "Los momentos de inercia de los magnetones," *Contrib. estud. cien.* **1** (1916), 381–384 [received May 17, 1916; published August 1916]; *idem*, "Die Trägheitsmomente der Magnetonen," *Ann. d. Phys*. **61** (1920), 396–397; *idem*, "El comportamiento de redes hertzianas," *Contrib. estud. cien.* **2** (1917), 7–27 [received December 10, 1916; published July 1917]; *idem*, "Das Verhalten Hertzscher Gitter," *Ann. d. Phys*. **61** (1920), 447–464 [received August 23, 1919].
58 Swinne, *Richard Gans* (ref. 1), p. 65.
59 Richard Gans, *Vektoranalysis mit Anwendungen auf Physik und Technik* (Leipzig and Berlin: B.G. Teubner, 1906; sixth edition 1929); *idem*, *Theorie des Magnetismus* (ref. 3).
60 Swinne, *Richard Gans* (ref. 1), pp. 66–67. For another account of Gans's life and work at the National University of La Plata, see Carlos D. Galles, "Semblanza de Ricardo Gans," in Videira and Bibiloni, *Encontro de Históri*a (ref. 12), pp. 62–71. Gans's works eventually were cited by many leading physicists; see Pablo Kittl and Gerardo Díaz, "La universidad, lugar ineludible de creación, y por lo tanto de investigación y crítica," website http://cabierta.uchile.cl/revista/25/articulos/pdf/edu7.pdf>.
61 Swinne, *Richard Gans* (ref. 1), p. 173, n. 4.
62 *Ibid*., p. 73.
63 O. Civitarese, "Sobre la investigación en física en los primeros años del Instituto de Física de la Universidad de La Plata," in Videira and Bibiloni, *Encontro de História* (ref. 12), pp. 210–211, especially pp. 194–211.
64 Swinne, *Richard Gans* (ref. 1), p. 90.
65 *Ibid*., p. 168, notes 63, 64.
66 *Ibid*., p. 97.
67 *Ibid*., p. 18.
68 *Ibid*., p. 108.
69 *Ibid*., p. 109.
70 Heinz Schmellenmeier, "Die 'Affäre Prof. Dr. Richard Gans'," in Swinne, *Richard Gans* (ref. 1), pp. 112–122.
71 Swinne, *Richard Gans* (ref. 1), pp. 123, 133.
72 *Ibid*., pp. 138, 140.
73 Gaviola, "Richard Gans" (ref. 54), p. 384; Swinne, *Richard Gans* (ref. 1), p. 144.

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