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Max Born

Max Born FRS, FRSE (German pronunciation: ['maks 'bɔʁn] (listen);[2][3] 11 December 1882 – 5 January 1970) was a German physicist and mathematician who was instrumental in the development of quantum mechanics. He also made contributions to solid-state physics and optics and supervised the work of a number of notable physicists in the 1920s and 1930s. Born won the 1954 Nobel Prize in Physics for his "fundamental research in quantum mechanics, especially in the statistical interpretation of the wave function".[4][5][6][7]

Born entered the University of Göttingen in 1904, where he met the three renowned mathematicians Felix Klein, David Hilbert, and Hermann Minkowski. He wrote his Ph.D. thesis on the subject of "Stability of Elastica in a Plane and Space", winning the university's Philosophy Faculty Prize. In 1905, he began researching special relativity with Minkowski, and subsequently wrote his habilitation thesis on the Thomson model of the atom. A chance meeting with Fritz Haber in Berlin in 1918 led to discussion of how an ionic compound is formed when a metal reacts with a halogen, which is today known as the Born–Haber cycle.

In World War I, after originally being placed as a radio operator, he was moved to research duties regarding sound ranging due to his specialist knowledge. In 1921, Born returned to Göttingen, arranging another chair for his long-time friend and colleague James Franck. Under Born, Göttingen became one of the world's foremost centres for physics. In 1925, Born and Werner Heisenberg formulated the matrix mechanics representation of quantum mechanics. The following year, he formulated the now-standard interpretation of the probability density function for ψ*ψ in the Schrödinger equation, for which he was awarded the Nobel Prize in 1954. His influence

Max Born

Portrait c. 1930s

Born	11 December 1882 Breslau, German Empire
Died	5 January 1970 (aged 87) Göttingen, West Germany
Resting place	Stadtfriedhof, Göttingen
Citizenship	German, British
Alma mater	University of Göttingen
Known for	Born approximation Born coordinates Born equation Born probability Born reciprocity Born rigidity Born rule Born series Born square Born–Landé equation Born–Infeld theory Born–Haber cycle Born–Huang approximation Born–von Karman boundary condition

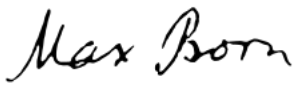
extended far beyond his own research. Max Delbrück, Siegfried Flügge, Friedrich Hund, Pascual Jordan, Maria Goeppert-Mayer, Lothar Wolfgang Nordheim, Robert Oppenheimer, and Victor Weisskopf all received their Ph.D. degrees under Born at Göttingen, and his assistants included Enrico Fermi, Werner Heisenberg, Gerhard Herzberg, Friedrich Hund, Pascual Jordan, Wolfgang Pauli, Léon Rosenfeld, Edward Teller, and Eugene Wigner.

In January 1933, the Nazi Party came to power in Germany, and Born, who was Jewish, was suspended from his professorship at the University of Göttingen. He emigrated to the United Kingdom, where he took a job at St John's College, Cambridge, and wrote a popular science book, *The Restless Universe*, as well as *Atomic Physics*, which soon became a standard textbook. In October 1936, he became the Tait Professor of Natural Philosophy at the University of Edinburgh, where, working with German-born assistants E. Walter Kellermann and Klaus Fuchs, he continued his research into physics. Born became a naturalised British subject on 31 August 1939, one day before World War II broke out in Europe. He remained in Edinburgh until 1952. He retired to Bad Pyrmont, in West Germany, and died in hospital in Göttingen on 5 January 1970.[8]

Contents

	Born–Oppenheimer approximation BBGKY hierarchy Cauchy–Born rule Adiabatic theorem Canonical commutation relation
Spouse(s)	Hedwig (Hedi) Ehrenberg (m. 1913–1970)
Children	3, including Gustav Victor Rudolf Born
Relatives	Olivia Newton-John (granddaughter)
Awards	Nobel Prize in Physics (1954) Hughes Medal (1950) Max Planck Medal (1948) Fellow of the Royal Society (1939)
Scientific career	
Fields	Theoretical physics
Institutions	University of Frankfurt University of Göttingen University of Edinburgh University of Cambridge
Thesis	*Untersuchungen über die Stabilität der elastischen Linie in Ebene und Raum unter verschiedenen Grenzbedingungen ("Investigations on the stability of the elastic line in plane and space under different boundary conditions")* (1906)
Doctoral advisor	Carl Runge
Other academic advisors	Woldemar Voigt Karl Schwarzschild Joseph Larmor J. J. Thomson

External links

Doctoral students	Mary Bradburn Kaijia Cheng Max Delbrück Walter Elsasser Siegfried Flügge Maria Goeppert-Mayer Herbert S. Green Friedrich Hund Pascual Jordan Edgar Krahn J. Robert Oppenheimer Lothar Wolfgang Nordheim Huanwu Peng Maurice Pryce Carl Hermann Bertha Swirles Victor Frederick Weisskopf[1] Liming Yang
Other notable students	Enrico Fermi Huang Kun Emil Wolf
Signature	

Early life

Max Born was born on 11 December 1882 in Breslau (now Wrocław, Poland), which at the time of Born's birth was part of the Prussian Province of Silesia in the German Empire, to a family of Jewish descent.[9] He was one of two children born to Gustav Born, an anatomist and embryologist, who was a professor of embryology at the University of Breslau,[10] and his wife Margarethe (Gretchen) née Kauffmann, from a Silesian family of industrialists. She died when Max was four years old, on 29 August 1886.[11] Max had a sister, Käthe, who was born in 1884, and a half-brother, Wolfgang, from his father's second marriage, to Bertha Lipstein. Wolfgang later became Professor of Art History at the City College of New York.[12]

Initially educated at the König-Wilhelm-Gymnasium in Breslau, Born entered the University of Breslau in 1901. The German university system allowed students to move easily from one university to another, so he spent summer semesters at Heidelberg University in 1902 and the University of Zurich in 1903. Fellow students at Breslau, Otto Toeplitz and Ernst Hellinger, told Born about the University of Göttingen,[13] and Born went there in April 1904. At Göttingen he found three renowned mathematicians: Felix Klein, David Hilbert and Hermann Minkowski. Very soon after his arrival, Born formed close ties to the latter two men. From the first class he took with Hilbert, Hilbert identified Born as having exceptional abilities and selected him as the lecture scribe, whose function was to write up the class notes for the students' mathematics reading room at the University of Göttingen. Being class scribe put Born into regular, invaluable contact with Hilbert. Hilbert became Born's mentor after selecting him to be the first to hold the unpaid, semi-official position of assistant. Born's introduction to Minkowski came through Born's stepmother, Bertha, as she knew Minkowski from dancing classes in Königsberg. The introduction netted Born invitations to the Minkowski household for Sunday dinners. In addition, while performing his duties as scribe and assistant, Born often saw Minkowski at Hilbert's house.[14][15]

Born's relationship with Klein was more problematic. Born attended a seminar conducted by Klein and professors of applied mathematics, Carl Runge and Ludwig Prandtl, on the subject of elasticity. Although not particularly interested in the subject, Born was obliged to present a paper. Using Hilbert's calculus of variations, he presented one in which, using a curved configuration of a wire with both ends fixed, he demonstrated would be the most stable. Klein was impressed, and invited

Born to submit a thesis on the subject of "Stability of Elastica in a Plane and Space" – a subject near and dear to Klein – which Klein had arranged to be the subject for the prestigious annual Philosophy Faculty Prize offered by the university. Entries could also qualify as doctoral dissertations. Born responded by turning down the offer, as applied mathematics was not his preferred area of study. Klein was greatly offended.[16][17]

Klein had the power to make or break academic careers, so Born felt compelled to atone by submitting an entry for the prize. Because Klein refused to supervise him, Born arranged for Carl Runge to be his supervisor. Woldemar Voigt and Karl Schwarzschild became his other examiners. Starting from his paper, Born developed the equations for the stability conditions. As he became more interested in the topic, he had an apparatus constructed that could test his predictions experimentally. On 13 June 1906, the rector announced that Born had won the prize. A month later, he passed his oral examination and was awarded his PhD in mathematics *magna cum laude*.[18]

On graduation, Born was obliged to perform his military service, which he had deferred while a student. He found himself drafted into the German army, and posted to the 2nd Guards Dragoons "Empress Alexandra of Russia", which was stationed in Berlin. His service was brief, as he was discharged early after an asthma attack in January 1907. He then travelled to England, where he was admitted to Gonville and Caius College, Cambridge, and studied physics for six months at the Cavendish Laboratory under J. J. Thomson, George Searle and Joseph Larmor. After Born returned to Germany, the Army re-inducted him, and he served with the elite 1st (Silesian) Life Cuirassiers "Great Elector" until he was again medically discharged after just six weeks' service. He then returned to Breslau, where he worked under the supervision of Otto Lummer and Ernst Pringsheim, hoping to do his habilitation in physics. A minor accident involving Born's black body experiment, a ruptured cooling water hose, and a flooded laboratory, led to Lummer telling him that he would never become a physicist.[19]

In 1905, Albert Einstein published his paper *On the Electrodynamics of Moving Bodies* about special relativity. Born was intrigued, and began researching the subject. He was devastated to discover that Minkowski was also researching special relativity along the same lines, but when he wrote to Minkowski about his results, Minkowski asked him to return to Göttingen and do his habilitation there. Born accepted. Toeplitz helped Born brush up on his matrix algebra so he could work with the four-dimensional Minkowski space matrices used in the latter's project to reconcile relativity with electrodynamics. Born and Minkowski got along well, and their work made good progress, but Minkowski died suddenly of appendicitis on 12 January 1909. The mathematics students had Born speak on their behalf at the funeral.[20]

A few weeks later, Born attempted to present their results at a meeting of the Göttingen Mathematics Society. He did not get far before he was publicly challenged by Klein and Max Abraham, who rejected relativity, forcing him to terminate the lecture. However, Hilbert and Runge were interested in Born's work, and, after some discussion with Born, they became convinced of the veracity of his results and persuaded him to give the lecture again. This time he was not interrupted, and Voigt offered to sponsor Born's habilitation thesis.[21] Born subsequently published his talk as an article on "The Theory of the Rigid Electron in the Kinematics of the Principle of Relativity" (German: *Die Theorie des starren Elektrons in der Kinematik des Relativitätsprinzips*),[22] which introduced the concept of Born rigidity. On 23 October Born presented his habilitation lecture on the Thomson model of the atom.[21]

Career

Berlin and Frankfurt

Born settled in as a young academic at Göttingen as a privatdozent. In Göttingen, Born stayed at a boarding house run by Sister Annie at Dahlmannstraße 17, known as El BoKaReBo. The name was derived from the first letters of the last names of its boarders: "El" for Ella Philipson (a medical student), "Bo" for Born and Hans Bolza (a physics student), "Ka" for Theodore von Kármán (a Privatdozent), and "Re" for Albrecht Renner (another medical student). A frequent visitor to the boarding house was Paul Peter Ewald, a doctoral student of Arnold Sommerfeld on loan to Hilbert at Göttingen as a special assistant for physics. Richard Courant, a mathematician and Privatdozent, called these people the "in group."[23]

In 1912, Born met Hedwig (Hedi) Ehrenberg, the daughter of a Leipzig University law professor, and a friend of Carl Runge's daughter Iris. She was of Jewish background on her father's side, although he had become a practising Lutheran when he got married, as did Max's sister Käthe. Despite never practising his religion, Born refused to convert, and his wedding on 2 August 1913 was a garden ceremony. However, he was baptised as a Lutheran in March 1914 by the same pastor who had performed his wedding ceremony. Born regarded "religious professions and churches as a matter of no importance".[24] His decision to be baptised was made partly in deference to his wife, and partly due to his desire to assimilate into German society.[24] The marriage produced three children: two daughters, Irene, born in 1914, and Margarethe (Gritli), born in 1915, and a son, Gustav, born in 1921.[25] Through marriage, Born is related to jurists Victor Ehrenberg, his father-in-law, and Rudolf von Jhering, his wife's maternal grandfather, as well as to philosopher and theologian Hans Ehrenberg, and is a great uncle of British comedian Ben Elton.[26]

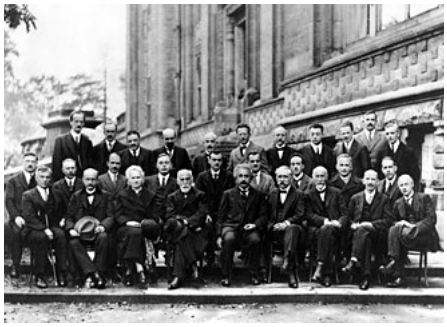
By the end of 1913, Born had published 27 papers, including important work on relativity and the dynamics of crystal lattices (3 with Theodore von Karman),[27] which became a book.[28] In 1914, received a letter from Max Planck explaining that a new professor extraordinarius chair of theoretical physics had been created at the University of Berlin. The chair had been offered to Max von Laue, but he had turned it down. Born accepted.[29] The First World War was now raging. Soon after arriving in Berlin in 1915, he enlisted in an Army signals unit. In October, he joined the *Artillerie-Prüfungs-Kommission*, the Army's Berlin-based artillery research and development organisation, under Rudolf Ladenburg, who had established a special unit dedicated to the new technology of sound ranging. In Berlin, Born formed a lifelong friendship with Einstein, who became a frequent visitor to Born's home.[30] Within days of the armistice in November 1918, Planck had the Army release Born. A chance meeting with Fritz Haber that month led to discussion of the manner in which an ionic compound is formed when a metal reacts with a halogen, which is today known as the Born–Haber cycle.[31]

Even before Born had taken up the chair in Berlin, von Laue had changed his mind, and decided that he wanted it after all.[29] He arranged with Born and the faculties concerned for them to exchange jobs. In April 1919, Born became professor ordinarius and Director of the Institute of Theoretical Physics on the science faculty at the University of Frankfurt am Main.[28] While there, he was approached by the University of Göttingen, which was looking for a replacement for Peter Debye as Director of the Physical Institute.[32] "Theoretical physics," Einstein advised him, "will flourish wherever *you* happen to be; there is no other Born to be found in Germany today."[33] In negotiating for the position with the education ministry, Born arranged for another chair, of

experimental physics, at Göttingen for his long-time friend and colleague James Franck.[32]

In 1919 Elisabeth Bormann joined the Institut für Theoretische Physik as his assistant.[34] She developed the first atomic beams. Working with Born, Bormann was the first to measure the free path of atoms in gases and the size of molecules.[35][36]

Göttingen



Solvay Conference, 1927. Born is second from the right in the second row, between Louis de Broglie and Niels Bohr.

For the 12 years Born and Franck were at the University of Göttingen (1921 to 1933), Born had a collaborator with shared views on basic scientific concepts—a benefit for teaching and research. Born's collaborative approach with experimental physicists was similar to that of Arnold Sommerfeld at the University of Munich, who was ordinarius professor of theoretical physics and Director of the Institute of Theoretical Physics—also a prime mover in the development of quantum theory. Born and Sommerfeld collaborated with experimental physicists to test and advance their theories. In 1922, when lecturing in the United States at the University of Wisconsin–Madison, Sommerfeld sent his student Werner Heisenberg to be Born's assistant. Heisenberg returned to Göttingen in 1923, where he completed his habilitation under Born in 1924, and became a privatdozent at Göttingen.[37][38]

In 1919 and 1920, Max Born became displeased about the large number of objections[39] against Einstein's relativity, and gave speeches in the winter of 1919 in support of Einstein. Born received pay for his relativity speeches which helped with expenses through the year of rapid inflation. The speeches in German language became a book published in 1920 of which Einstein received the proofs before publication.[40] A third edition was published in 1922 and an English translation was published in 1924. Born represented light speed as a function of curvature,[41] "the velocity of light is much greater for some directions of the light ray than its ordinary value c, and other bodies can also attain much greater velocities.[42]"

In 1925, Born and Heisenberg formulated the matrix mechanics representation of quantum mechanics. On 9 July, Heisenberg gave Born a paper entitled *Über quantentheoretische Umdeutung kinematischer und mechanischer Beziehungen* ("Quantum-Theoretical Re-interpretation of Kinematic and Mechanical Relations") to review, and submit for publication. In the paper, Heisenberg formulated quantum theory, avoiding the concrete, but unobservable, representations of electron orbits by using parameters such as transition probabilities for quantum jumps, which necessitated using two indexes corresponding to the initial and final states.[43][44] When Born read the paper, he recognized the formulation as one which could be transcribed and extended to the systematic language of matrices,[45] which he had learned from his study under Jakob Rosanes at Breslau University.[46]

Up until this time, matrices were seldom used by physicists; they were considered to belong to the realm of pure mathematics. Gustav Mie had used them in a paper on electrodynamics in 1912, and Born had used them in his work on the lattices theory of crystals in 1921. While matrices were used in these cases, the algebra of matrices with their multiplication did not enter the picture as they did in the matrix formulation of quantum mechanics.[47] With the help of his assistant and former

student Pascual Jordan, Born began immediately to make a transcription and extension, and they submitted their results for publication; the paper was received for publication just 60 days after Heisenberg's paper.[4] A follow-on paper was submitted for publication before the end of the year by all three authors.[48] The result was a surprising formulation:

$$pq - qp = \frac{h}{2\pi i} I$$

where p and q were matrices for location and momentum, and I is the identity matrix. Note that the left hand side of the equation is not zero because matrix multiplication is not commutative.[46] This formulation was entirely attributable to Born, who also established that all the elements not on the diagonal of the matrix were zero. Born considered that his paper with Jordan contained "the most important principles of quantum mechanics including its extension to electrodynamics."[46] The paper put Heisenberg's approach on a solid mathematical basis. [49]

Born was surprised to discover that Paul Dirac had been thinking along the same lines as Heisenberg. Soon, Wolfgang Pauli used the matrix method to calculate the energy values of the hydrogen atom and found that they agreed with the Bohr model. Another important contribution was made by Erwin Schrödinger, who looked at the problem using wave mechanics. This had a great deal of appeal to many at the time, as it offered the possibility of returning to deterministic classical physics. Born would have none of this, as it ran counter to facts determined by experiment.[46] He formulated the now-standard interpretation of the probability density function for ψ*ψ in the Schrödinger equation, which he published in July 1926.[50][49]

In a letter to Born on 4 December 1926, Einstein made his famous remark regarding quantum mechanics:

> Quantum mechanics is certainly imposing. But an inner voice tells me that it is not yet the real thing. The theory says a lot, but does not really bring us any closer to the secret of the 'old one'. I, at any rate, am convinced that *He* is not playing at dice.[51]

This quotation is often paraphrased as 'God does not play dice'.[52]

In 1928, Einstein nominated Heisenberg, Born, and Jordan for the Nobel Prize in Physics,[53] [54] but Heisenberg alone won the 1932 Prize "for the creation of quantum mechanics, the application of which has led to the discovery of the allotropic forms of hydrogen",[55] while Schrödinger and Dirac shared the 1933 Prize "for the discovery of new productive forms of atomic theory".[55] On 25 November 1933, Born received a letter from Heisenberg in which he said he had been delayed in writing due to a "bad conscience" that he alone had received the Prize "for work done in Göttingen in collaboration—you, Jordan and I."[56] Heisenberg went on to say that Born and Jordan's contribution to quantum mechanics cannot be changed by "a wrong decision from the outside."[56] In 1954, Heisenberg wrote an article honouring Planck for his insight in 1900, in which he credited Born and Jordan for the final mathematical formulation of matrix mechanics and Heisenberg went on to stress how great their contributions were to quantum mechanics, which were not "adequately acknowledged in the public eye."[57]

Those who received their Ph.D. degrees under Born at Göttingen included Max Delbrück, Siegfried Flügge, Friedrich Hund, Pascual Jordan, Maria Goeppert-Mayer, Lothar Wolfgang Nordheim,

Robert Oppenheimer, and Victor Weisskopf.[1][58] Born's assistants at the University of Göttingen's Institute for Theoretical Physics included Enrico Fermi, Werner Heisenberg, Gerhard Herzberg, Friedrich Hund, Pascual Jordan, Wolfgang Pauli, Léon Rosenfeld, Edward Teller, and Eugene Wigner.[59] Walter Heitler became an assistant to Born in 1928, and completed his habilitation under him in 1929. Born not only recognised talent to work with him, but he "let his superstars stretch past him; to those less gifted, he patiently handed out respectable but doable assignments."[60] Delbrück, and Goeppert-Mayer went on to win Nobel Prizes.[61][62]

Later life

In January 1933, the Nazi Party came to power in Germany. In May, Born became one of six Jewish professors at Göttingen who were suspended with pay; Franck had already resigned. In twelve years they had built Göttingen into one of the world's foremost centres for physics.[63] Born began looking for a new job, writing to Maria Göppert-Mayer at Johns Hopkins University and Rudi Ladenburg at Princeton University. He accepted an offer from St John's College, Cambridge.[64] At Cambridge, he wrote a popular science book, *The Restless Universe*, and a textbook, *Atomic Physics*, that soon became a standard text, going through seven editions. His family soon settled into life in England, with his daughters Irene and Gritli becoming engaged to Welshman Brinley (Bryn) Newton-John (Olivia Newton-John's parents; Born is Olivia's grandfather and Irene is her mother)[65] and Englishman Maurice Pryce respectively.[66][67]

Born's gravestone in Göttingen is inscribed with the canonical commutation relation, which he put on rigid mathematical footing.


Max and Hedi Born in Indian clothes, Bangalore, India, c. 1937

Born's position at Cambridge was only a temporary one, and his tenure at Göttingen was terminated in May 1935. He therefore accepted an offer from C. V. Raman to go to Bangalore in 1935.[68] Born considered taking a permanent position there, but the Indian Institute of Science did not create an additional chair for him.[69] In November 1935, the Born family had their German citizenship revoked, rendering them stateless. A few weeks later Göttingen cancelled Born's doctorate.[70] Born considered an offer from Pyotr Kapitsa in Moscow, and started taking Russian lessons from Rudolf Peierls's Russian-born wife Genia. But then Charles Galton Darwin asked Born if he would consider becoming his successor as Tait Professor of Natural Philosophy at the University of Edinburgh, an offer that Born promptly accepted,[71] assuming the chair in October 1936.[66]

In Edinburgh, Born promoted the teaching of mathematical physics. He had two German assistants, E. Walter Kellermann and Klaus Fuchs, and one Scottish assistant, Robert Schlapp,[72] and together they continued to investigate the mysterious behaviour of electrons.[73] Born became a Fellow of the Royal Society of Edinburgh in 1937, and of the Royal Society of London in March 1939. During 1939, he got as many of his remaining friends and relatives still in Germany as he could out of the country, including his sister Käthe, in-laws Kurt and Marga, and the daughters of

his friend Heinrich Rausch von Traubenberg. Hedi ran a domestic bureau, placing young Jewish women in jobs. Born received his certificate of naturalisation as a British subject on 31 August 1939, one day before the Second World War broke out in Europe.[74]

Born remained at Edinburgh until he reached the retirement age of 70 in 1952. He retired to Bad Pyrmont, in West Germany, in 1954.[75] In October, he received word that he was being awarded the Nobel Prize. His fellow physicists had never stopped nominating him. Franck and Fermi had nominated him in 1947 and 1948 for his work on crystal lattices, and over the years, he had also been nominated for his work on solid state physics, quantum mechanics and other topics.[76] In 1954, he received the prize for "fundamental research in Quantum Mechanics, especially in the statistical interpretation of the wave function"[6]—something that he had worked on alone.[76] In his Nobel lecture he reflected on the philosophical implications of his work:

> I believe that ideas such as absolute certitude, absolute exactness, final truth, etc. are figments of the imagination which should not be admissible in any field of science. On the other hand, any assertion of probability is either right or wrong from the standpoint of the theory on which it is based. This loosening of thinking (*Lockerung des Denkens*) seems to me to be the greatest blessing which modern science has given to us. For the belief in a single truth and in being the possessor thereof is the root cause of all evil in the world.[77]

In retirement, he continued scientific work, and produced new editions of his books. In 1955 he became one of signatories to the Russell-Einstein Manifesto. He died at age 87 in hospital in Göttingen on 5 January 1970,[8] and is buried in the *Stadtfriedhof* there, in the same cemetery as Walther Nernst, Wilhelm Weber, Max von Laue, Otto Hahn, Max Planck, and David Hilbert.[78]

Personal life

Born's wife Hedwig (Hedi) Martha Ehrenberg (1891–1972) was a daughter of the jurist Victor Ehrenberg and Elise von Jhering (a daughter of the jurist Rudolf von Jhering). Born was survived by his wife Hedi and their children Irene, Gritli and Gustav.[75] Singer Olivia Newton-John is a daughter of Irene (1914-2003), while Gustav is the father of musician and academic Georgina Born and actor Max Born (*Fellini Satyricon*) who are thus also Max's grandchildren. His great-grandchildren include songwriter Brett Goldsmith, singer Tottie Goldsmith, racing car driver Emerson Newton-John,[79] and singer Chloe Rose Lattanzi.[80] Born helped his nephew, architect, Otto Königsberger (1908–1999) obtain commission in the Mysore State.[81]

Awards and honors

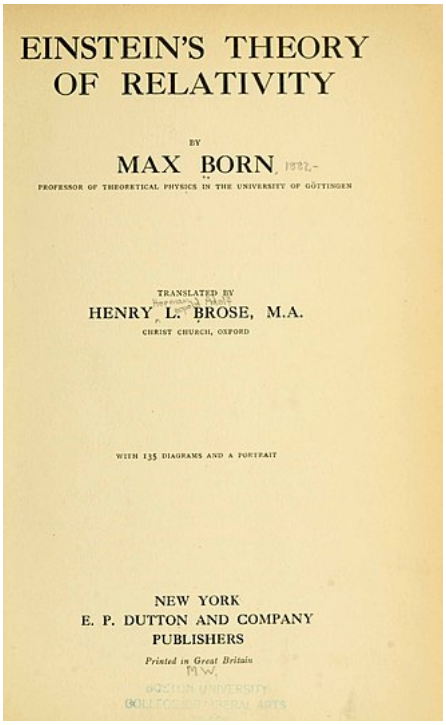
- 1934 – Stokes Medal of Cambridge[82]
- 1939 – Fellow of the Royal Society[82][83]
- 1945 – Makdougall–Brisbane Prize of the Royal Society of Edinburgh[84]
- 1945 – Gunning Victoria Jubilee Prize of the Royal Society of Edinburgh[85]
- 1948 – Max Planck Medaille der Deutschen Physikalischen Gesellschaft[82]
- 1950 – Hughes Medal of the Royal Society of London[82]

- 1953 – Honorary citizen of the town of Göttingen[82]
- 1954 – Nobel Prize in Physics The award was for Born's fundamental research in quantum mechanics, especially for his statistical interpretation of the wavefunction.[82]
  - 1954 – Nobel Prize Banquet Speech[86]
  - 1954 – Born Nobel Prize Lecture[87]
- 1956 – Hugo Grotius Medal for International Law, Munich[82]
- 1959 – Grand Cross of Merit with Star of the Order of Merit of the German Federal Republic[88]
- 1972 – Max Born Medal and Prize was created by the German Physical Society and the British Institute of Physics. It is awarded annually.[89][90]
- 1982 – Ceremony at the University of Göttingen in the 100th Birth Year of Max Born and James Franck, Institute Directors 1921–1933.[91]
- 1991 – Max-Born-Institut für Nichtlineare Optik und Kurzzeitspektroskopie – Institute named in his honor.[92]
- 2017 – On 11 December 2017, Google showed a Google doodle, designed by Kati Szilagyi, in honouring the 135th birth anniversary of Born.[93]

Bibliography

During his life, Born wrote several semi-popular and technical books. His volumes on topics like atomic physics and optics were very well received. They are considered classics in their fields, and are still in print. The following is a chronological listing of his major works:

- *Über das Thomson'sche Atommodell* Habilitations-Vortrag (FAM, 1909) – The Habilitation was done at the University of Göttingen, on 23 October 1909.[94]
- *Die Relativitätstheorie Einsteins und ihre physikalischen Grundlagen* (Springer, 1920) – Based on Born's lectures at the University of Frankfurt am Main.[95]
  - Available in English under the title *Einstein's Theory of Relativity*.[96]
- *Dynamik der Kristallgitter* (Teubner, 1915)[97] – After its publication, the physicist Arnold Sommerfeld asked Born to write an article based on it for the 5th volume of the *Mathematical Encyclopedia*. The First World War delayed the start of work on this article, but it was taken up in 1919 and finished in 1922. It was published as a revised edition under the title *Atomic Theory of Solid States*.[98]
- *Die Relativitätstheorie Einsteins und ihre*


EINSTEIN'S THEORY OF RELATIVITY

BY

MAX BORN

PROFESSOR OF THEORETICAL PHYSICS IN THE UNIVERSITY OF GÖTTINGEN

TRANSLATED BY

HENRY L. BROSE, M.A.

CHRIST CHURCH, OXFORD

WITH 135 DIAGRAMS AND A PORTRAIT

NEW YORK

E. P. DUTTON AND COMPANY

PUBLISHERS

Printed in Great Britain

Einstein's theory of relativity, 1922 (US edition of *Die Relativitätstheorie Einsteins und ihre physikalischen Grundlagen*, 1920)

physikalischen Grundlagen (https://gutenberg.beic.it/webclient/DeliveryManager?pid=3936972) (in German). Berlin. Springer. 1920.

  - *Einstein's theory of relativity* (https://gutenberg.beic.it/webclient/DeliveryManager?pid=10969245). New York. Dutton. 1922.
- *Vorlesungen über Atommechanik* (Springer, 1925)[97]
- *Problems of Atomic Dynamics* (MIT Press, 1926) – A first account of matrix mechanics being developed in Germany, based on two series of lectures given at MIT, over three months, in late 1925 and early 1926.[99][100]
- *Mechanics of the Atom* (George Bell & Sons, 1927) – Translated by J. W. Fisher and revised by D. R. Hartree.[101]
- *Elementare Quantenmechanik (Zweiter Band der Vorlesungen über Atommechanik)*, with Pascual Jordan. (Springer, 1930) – This was the first volume of what was intended as a two-volume work. This volume was limited to the work Born did with Jordan on matrix mechanics. The second volume was to deal with Erwin Schrödinger's wave mechanics. However, the second volume was not even started by Born, as he believed his friend and colleague Hermann Weyl had written it before he could do so.[102][103]
- *Optik: Ein Lehrbuch der elektromagnetische Lichttheorie* (Springer, 1933) – The book was released just as the Borns were emigrating to England.
- *Moderne Physik* (1933) – Based on seven lectures given at the Technischen Hochschule Berlin.[104]
- *Atomic Physics* (Blackie, London, 1935) – Authorized translation of *Moderne Physik* by John Dougall, with updates.[105]
- *The Restless Universe*[106] (Blackie and Son Limited, 1935) – A popularised rendition of the workshop of nature, translated by Winifred Margaret Deans. Born's nephew, Otto Königsberger, whose successful career as an architect in Berlin was brought to an end when the Nazis took over, was temporarily brought to England to illustrate the book.[104]
- *Experiment and Theory in Physics* (Cambridge University Press, 1943) – The address given King's College, Newcastle upon Tyne, at the request of the Durham Philosophical Society and the Pure Science Society. An expanded version of the lecture appeared in a 1956 Dover Publications edition.[107]
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- *Principles of Optics: Electromagnetic Theory of Propagation, Interference and Diffraction of Light*,[111] with Emil Wolf. (Pergamon, 1959) – This book is not an English translation of *Optik*, but rather a substantially new book. Shortly after World War II, a number of scientists suggested that Born update and translate his work into English. Since there had been many advances in optics in the intervening years, updating was warranted. In 1951, Wolf began as Born's private assistant on the book; it was eventually published in 1959 by Robert Maxwell's Pergamon Press.[112] – the delay being due to the lengthy time needed "to resolve all the financial and publishing tricks created by Maxwell."[113]
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See also

- List of things named after Max Born
- List of refugees

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External links

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