Albert Einstein

"Einstein" redirects here. For other uses, see Albert Einstein (disambiguation) and Einstein (disambiguation).

Albert Einstein (/ˈaɪnstaɪn/;[3] German: [ˈalbɐrt ˈaɪnʃtaɪn]; 14 March 1879 – 18 April 1955) was a German-born theoretical physicist. He developed the general theory of relativity, one of the two pillars of modern physics (alongside quantum mechanics).[2][4]:274 Einstein's work is also known for its influence on the philosophy of science.[5][6] Einstein is best known in popular culture for his mass–energy equivalence formula $E = mc^2$ (which has been dubbed "the world's most famous equation").[7] He received the 1921 Nobel Prize in Physics for his "services to theoretical physics", in particular his discovery of the law of the photoelectric effect, a pivotal step in the evolution of quantum theory.[8]

Near the beginning of his career, Einstein thought that Newtonian mechanics was no longer enough to reconcile the laws of classical mechanics with the laws of the electromagnetic field. This led to the development of his special theory of relativity. He realized, however, that the principle of relativity could also be extended to gravitational fields, and with his subsequent theory of gravitation in 1916, he published a paper on general relativity. He continued to deal with problems of statistical mechanics and quantum theory, which led to his explanations of particle theory and the motion of molecules. He also investigated the thermal properties of light which laid the foundation of the photon theory of light. In 1917, Einstein applied the general theory of relativity to model the large-scale structure of the universe.[9][10]

He was visiting the United States when Adolf Hitler came to power in 1933 and, being Jewish, did not go back to Germany, where he had been a professor at the Berlin Academy of Sciences. He settled in the U.S., becoming an American citizen in 1940.[11] On the eve of World War II, he endorsed a letter to President Franklin D. Roosevelt alerting him to the potential development of "extremely powerful bombs of a new type" and recommending that the U.S. begin similar research. This eventually led to what would become the Manhattan Project. Einstein supported defending the Allied forces, but largely denounced the idea of using the newly discovered nuclear fission as a weapon. Later, with the British philosopher Bertrand Russell, Einstein signed the Russell–Einstein Manifesto, which highlighted the danger of nuclear weapons. Einstein was affiliated with the Institute for Advanced Study in Princeton, New Jersey, until his death in 1955.

Einstein published more than 300 scientific papers along with over 150 non-scientific works.[9][12] On 5 December 2014, universities and archives announced the release of Einstein's papers, comprising more than 30,000 unique documents.[13][14] Einstein's intellectual achievements and originality have made the word "Einstein" synonymous with "genius".[15]

1 Biography

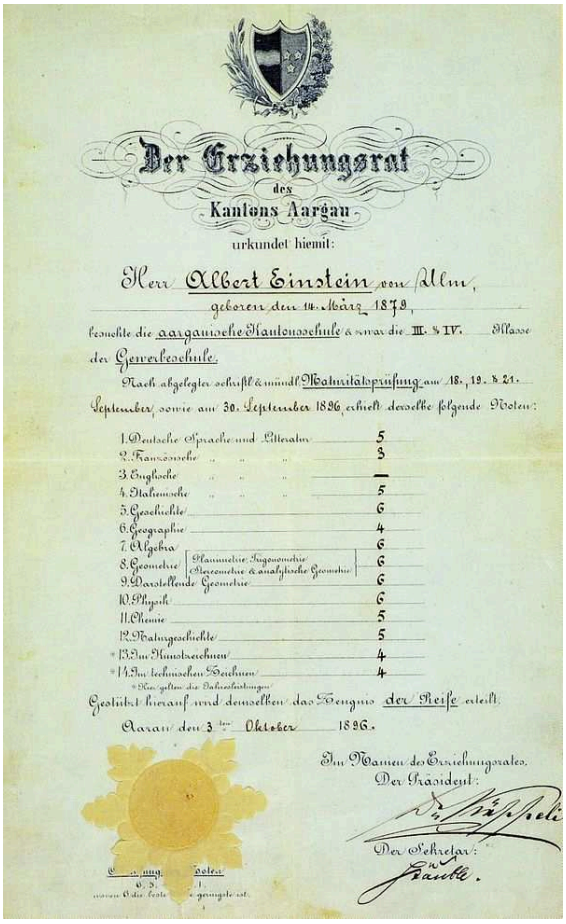
1.1 Early life and education

See also: Einstein family

Albert Einstein was born in Ulm, in the Kingdom of Württemberg in the German Empire on 14 March 1879.[16] His parents were Hermann Einstein, a salesman and engineer, and Pauline Koch. In 1880, the family moved to Munich, where his father and his uncle founded *Elektrotechnische Fabrik J. Einstein & Cie*, a company that

Einstein at the age of 3 in 1882

Albert Einstein in 1893 (age 14)



Der Erziehungsrat
des
Kantons Aargau
urkundet hiemit:

Herr Albert Einstein von Ulm,
geboren den 14. März 1879,
besuchte die aargauische Kantonsschule & zwar die III. & IV. Classe
der Gewerbeschule.
Nach abgelegter schriftl. & mündl. Maturitätsprüfung am 18., 19. & 21.
September, sowie am 30. September 1896 erhielt derselbe folgende Noten:

1. Deutsche Sprache und Literatur	5
2. Französische	3
3. Englische	—
4. Italienische	5
5. Geschichte	6
6. Geographie	4
7. Algebra	6
8. Geometrie (Planimetrie, Trigonometrie; Stereometrie & analytische Geometrie)	6
9. Darstellende Geometrie	6
10. Physik	6
11. Chemie	5
12. Naturgeschichte	5
* 13. Buchhaltung	4
* 14. Technisches Zeichnen	4

* Diese gelten als Fakultativfächer.

Gestützt hierauf wird demselben das Zeugnis der Reife erteilt.

Aarau, den 3ten Oktober 1896.

Im Namen des Erziehungsrates,
Der Präsident:

Der Sekretär:

Einstein's matriculation certificate at the age of 17, showing his final grades from the Argovian cantonal school (Aargauische Kantonsschule, on a scale of 1–6, with 6 being the highest possible mark)

manufactured electrical equipment based on direct current.[16]

The Einsteins were non-observant Ashkenazi Jews. Albert attended a Catholic elementary school from the age of 5 for three years. At the age of 8, he was transferred to the Luitpold Gymnasium (now known as the Albert Einstein Gymnasium), where he received advanced primary and secondary school education until he left Germany seven years later.[17]

In 1894, his father's company failed: direct current (DC) lost the War of Currents to alternating current (AC). In search of business, the Einstein family moved to Italy, first to Milan and then, a few months later, to Pavia. When the family moved to Pavia, Einstein stayed in Munich to finish his studies at the Luitpold Gymnasium. His father intended for him to pursue electrical engineering, but Einstein clashed with authorities and resented the school's regimen and teaching method. He later wrote that the spirit of learning and creative thought were lost in strict rote learning. At the end of December 1894, he travelled to Italy to join his family in Pavia, convincing the school to let him go by using a doctor's note.[18] It was during his time in Italy that he wrote a short essay with the title "On the Investigation of the State of the Ether in a Magnetic Field.[19][20]

In 1895, at the age of 16, Einstein sat the entrance examinations for the Swiss Federal Polytechnic in Zürich (later the Eidgenössische Technische Hochschule ETH). He failed to reach the required standard in the general part of the examination,[21] but obtained exceptional grades in physics and mathematics.[22] On the advice of the principal of the Polytechnic, he attended the Argovian cantonal school (gymnasium) in Aarau, Switzerland, in 1895–96 to complete his secondary schooling. While lodging with the family of Professor Jost Winteler, he fell in love with Winteler's daughter, Marie. (Albert's sister Maja later married Wintelers' son Paul.)[23] In January 1896, with his father's approval, he renounced his citizenship in the German Kingdom of Württemberg to avoid military service.[24] In September 1896, he passed the Swiss Matura with mostly good grades, including a top grade of 6 in physics and mathematical subjects, on a scale of 1–6.[25] Though only 17, he enrolled in the four-year mathematics and physics teaching diploma program at the Zürich Polytechnic. Marie Winteler moved to Olsberg, Switzerland for a teaching post.

Einstein's future wife, Mileva Marić, also enrolled at the Polytechnic that same year. She was the only woman among the six students in the mathematics and physics section of the teaching diploma course. Over the next few years, Einstein and Marić's friendship developed into romance, and they read books together on extra-curricular

physics in which Einstein was taking an increasing interest. In 1900, Einstein was awarded the Zürich Polytechnic teaching diploma, but Marić failed the examination with a poor grade in the mathematics component, theory of functions.[26] There have been claims that Marić collaborated with Einstein on his celebrated 1905 papers,[27][28] but historians of physics who have studied the issue find no evidence that she made any substantive contributions.[29][30][31][32]

1.2 Marriages and children

Albert Einstein in 1904 (age 25)

The discovery and publication in 1987 of an early correspondence between Einstein and Marić revealed that they had had a daughter, called "Lieserl" in their letters, born in early 1902 in Novi Sad where Marić was staying with her parents. Marić returned to Switzerland without the child, whose real name and fate are unknown. Einstein probably never saw his daughter. The contents of his letter to Marić in September 1903 suggest that the girl was either adopted or died of scarlet fever in infancy.[33][34]

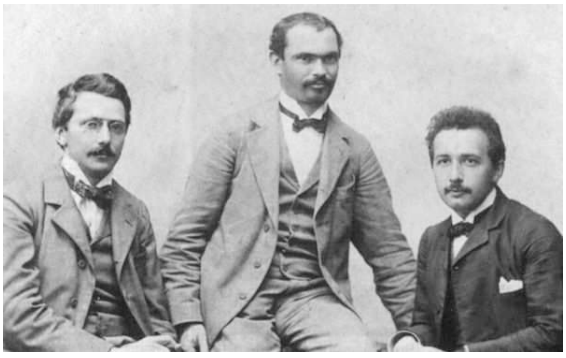
Einstein and Marić married in January 1903. In May 1904, the couple's first son, Hans Albert Einstein, was born in Bern, Switzerland. Their second son, Eduard, was born in Zürich in July 1910. In 1914, the couple separated; Einstein moved to Berlin and his wife remained in Zürich with their sons. They divorced on 14 February 1919, having lived apart for five years. Eduard, whom his father called "Tete" (for *petit*), had a breakdown at about age 20 and was diagnosed with schizophrenia. His mother cared for him and he was also committed to asylums for several periods, including full-time after her death.

Einstein with his wife Elsa

The marriage with Marić does not seem to have been very happy. In letters revealed in 2015, Einstein wrote to his early love, Marie Winteler, about his marriage and his still strong feelings for Marie. In 1910 he wrote to her that "I think of you in heartfelt love every spare minute and am so unhappy as only a man can be" while his wife was pregnant with their second child. Einstein spoke about a "misguided love" and a "missed life" regarding his love for Marie.[35]

Einstein married Elsa Löwenthal on 2 June 1919, after having had a relationship with her since 1912. She was a first cousin maternally and a second cousin paternally. In 1933, they emigrated to the United States. In 1935, Elsa Einstein was diagnosed with heart and kidney problems; she died in December 1936.[36]

1.3 Patent office



Conrad Habicht, Maurice Solovine and Einstein, who founded the Olympia Academy

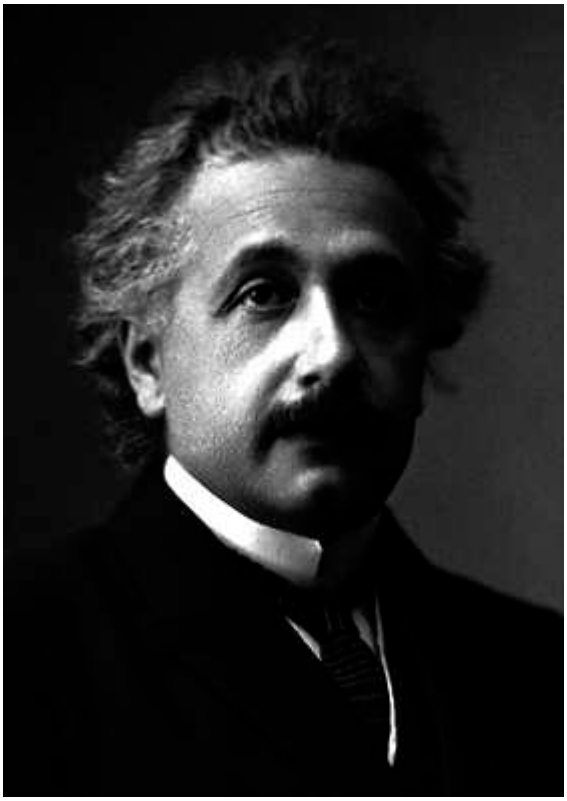
After graduating, Einstein spent almost two frustrating years searching for a teaching post. He acquired Swiss citizenship in February 1901,[37] but was not

conscripted for medical reasons. With the help of Marcel Grossmann's father Einstein secured a job in Bern at the Federal Office for Intellectual Property, the patent office,[38][39] as an assistant examiner.[40][41] He evaluated patent applications for a variety of devices including a gravel sorter and an electromechanical typewriter.[41] In 1903, Einstein's position at the Swiss Patent Office became permanent, although he was passed over for promotion until he "fully mastered machine technology".[42]:370

Much of his work at the patent office related to questions about transmission of electric signals and electrical-mechanical synchronization of time, two technical problems that show up conspicuously in the thought experiments that eventually led Einstein to his radical conclusions about the nature of light and the fundamental connection between space and time.[42]:377

With a few friends he had met in Bern, Einstein started a small discussion group, self-mockingly named "The Olympia Academy", which met regularly to discuss science and philosophy. Their readings included the works of Henri Poincaré, Ernst Mach, and David Hume, which influenced his scientific and philosophical outlook.[43]

1.4 Academic career



Einstein's official 1921 portrait after receiving the Nobel Prize in Physics

In 1900, his paper "Folgerungen aus den Capillaritätserscheinungen" ("Conclusions from the Capillarity Phenomena") was published in the prestigious *Annalen der Physik*.[44][45] On 30 April 1905, Einstein completed his thesis, with Alfred Kleiner, Professor of Experimental Physics, serving as *pro-forma* advisor. As a result, Einstein was awarded a PhD by the University of Zürich, with his dissertation entitled, "A New Determination of Molecular Dimensions."[1][46] That same year, which has been called Einstein's *annus mirabilis* (miracle year), he published four groundbreaking papers, on the photoelectric effect, Brownian motion, special relativity, and the equivalence of mass and energy, which were to bring him to the notice of the academic world.

By 1908, he was recognized as a leading scientist and was appointed lecturer at the University of Bern. The following year, after giving a lecture on electrodynamics and the relativity principle at the University of Zurich, Alfred Kleiner recommended him to the faculty for a newly created professorship in theoretical physics. Einstein was appointed associate professor in 1909.[47]

Einstein became a full professor at the German Charles-Ferdinand University in Prague in April 1911, accepting Austrian citizenship in the Austro-Hungarian empire to do so.[48][49] During his Prague stay Einstein wrote 11 scientific works, 5 of them on radiation mathematics and on quantum theory of the solids. In July 1912 he returned to his alma mater in Zürich. From 1912 until 1914 he was professor of theoretical physics at the ETH Zurich, where he taught analytical mechanics and thermodynamics. He also studied continuum mechanics, the molecular theory of heat, and the problem of gravitation, on which he worked with mathematician and his friend Marcel Grossmann.[50]

In 1914, he returned to the German Empire after being appointed director of the Kaiser Wilhelm Institute for Physics (1914–1932)[51] and a professor at the Humboldt University of Berlin, but freed from most teaching obligations. He soon became a member of the Prussian Academy of Sciences, and in 1916 was appointed president of the German Physical Society (1916–1918).[52]

Based on calculations Einstein made in 1911, about his new theory of general relativity, light from another star would be bent by the Sun's gravity. In 1919 that prediction was confirmed by Sir Arthur Eddington during the solar eclipse of 29 May 1919. Those observations were published in the international media, making Einstein world famous. On 7 November 1919, the leading British newspaper *The Times* printed a banner headline that read: "Revolution in Science – New Theory of the Universe – Newtonian Ideas Overthrown".[53]

In 1920, he became Foreign Member of the Royal Netherlands Academy of Arts and Sciences.[54] In 1921, Einstein was awarded the Nobel Prize in Physics for his explanation of the photoelectric effect, as relativity was considered still somewhat controversial. Einstein was elected a Foreign Member of the Royal Society (ForMemRS) in 1921.[2] He also received the Copley Medal from the Royal Society in 1925.[2]

1.5 1921–1922: Travels abroad

Einstein in New York, 1921, his first visit to the United States

Einstein visited New York City for the first time on 2 April 1921, where he received an official welcome by Mayor John Francis Hylan, followed by three weeks of lectures and receptions. He went on to deliver several lectures at Columbia University and Princeton University, and in Washington he accompanied representatives of the National Academy of Science on a visit to the White House. On his return to Europe he was the guest of the British statesman and philosopher Viscount Haldane in London, where he met several renowned scientific, intellectual and political figures, and delivered a lecture at King's College.[55] [56]

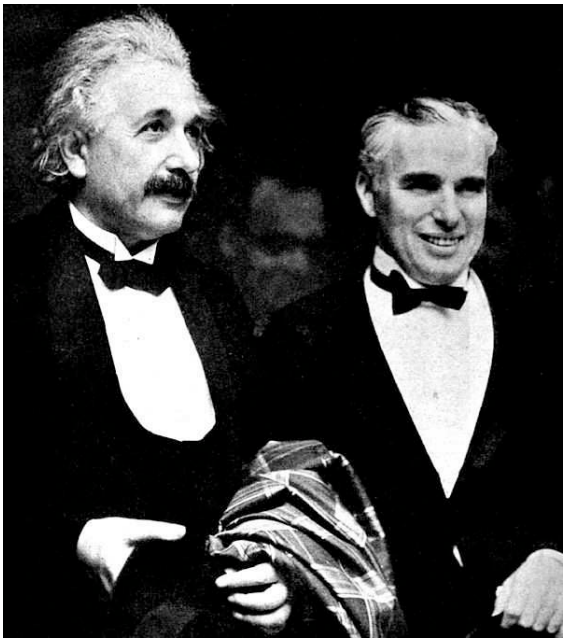
He also published an essay, "My First Impression of the U.S.A.," in July 1921, in which he tried briefly to describe some characteristics of Americans, much as Alexis de Tocqueville did, who published his own impressions in *Democracy in America* (1835).[57] For some of his observations, Einstein was clearly surprised: "What strikes a visitor is the joyous, positive attitude to life . . . The American is friendly, self-confident, optimistic, and without envy."[58]:20

In 1922, his travels took him to Asia and later to Palestine, as part of a six-month excursion and speaking tour, as he visited Singapore, Ceylon and Japan, where he gave a series of lectures to thousands of Japanese. After his first public lecture, he met the emperor and empress at the Imperial Palace, where thousands came to watch. In a letter to his sons, Einstein described his impression of the Japanese as being modest, intelligent, considerate, and having a true feel for art.[59]

On his return voyage, he visited Palestine for 12 days in what would become his only visit to that region. Einstein was greeted as if he were a head of state, rather than a physicist, which included a cannon salute upon arriving at the home of the British high commissioner, Sir Herbert Samuel. During one reception, the building was stormed by people who wanted to see and hear him. In Einstein's talk to the audience, he expressed happiness that the Jewish people were beginning to be recognized as a force in the world.[60]

1.6 1930–1931: Travel to U.S.

In December 1930, Einstein visited America for the second time, originally intended as a two-month working visit as a research fellow at the California Institute of Technology. After the national attention he received during his first trip to the U.S., he and his arrangers aimed to protect his privacy. Although swamped with telegrams and invitations to receive awards or speak publicly, he declined them all.[61]



Charlie Chaplin and Einstein at the Hollywood premier of City Lights*, January 1931*

After arriving in New York City, Einstein was taken to various places and events, including Chinatown, a lunch with the editors of the *New York Times*, and a performance of *Carmen* at the Metropolitan Opera, where he was cheered by the audience on his arrival. During the days following, he was given the keys to the city by Mayor Jimmy Walker and met the president of Columbia University, who described Einstein as "the ruling monarch of the mind."[62] Harry Emerson Fosdick, pastor at New York's Riverside Church, gave Einstein a tour of the church and showed him a full-size statue that the church made of Einstein, standing at the entrance.[62] Also during his stay in New York, he joined a crowd of 15,000 people at Madison Square Garden during a Hanukkah celebration.[62]

Einstein next traveled to California where he met Caltech president and Nobel laureate, Robert A. Millikan. His friendship with Millikan was "awkward", as Millikan "had a penchant for patriotic militarism," where Einstein

was a pronounced pacifist.[63] During an address to Caltech's students, Einstein noted that science was often inclined to do more harm than good.[64]

This aversion to war also led Einstein to befriend author Upton Sinclair and film star Charlie Chaplin, both noted for their pacifism. Carl Laemmle, head of Universal Studios, gave Einstein a tour of his studio and introduced him to Chaplin. They had an instant rapport, with Chaplin inviting Einstein and his wife, Elsa, to his home for dinner. Chaplin said Einstein's outward persona, calm and gentle, seemed to conceal a "highly emotional temperament," from which came his "extraordinary intellectual energy."[65]:320

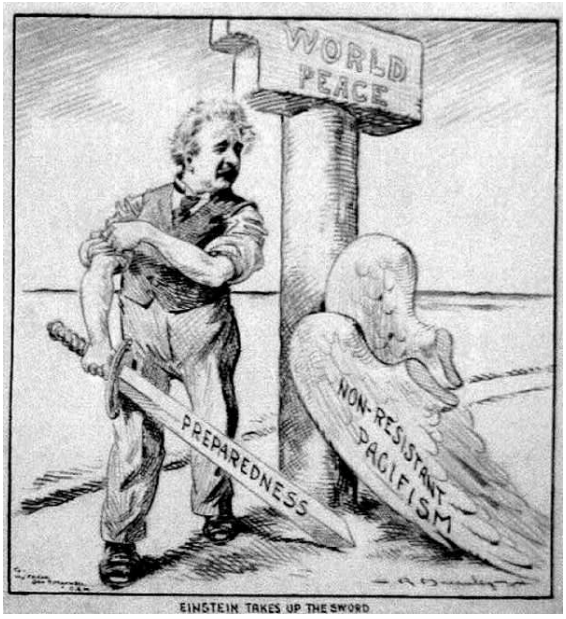
Chaplin also remembers Elsa telling him about the time Einstein conceived his theory of relativity. During breakfast one morning, he seemed lost in thought and ignored his food. She asked him if something was bothering him. He sat down at his piano and started playing. He continued playing and writing notes for half an hour, then went upstairs to his study, where he remained for two weeks, with Elsa bringing up his food. At the end of the two weeks he came downstairs with two sheets of paper bearing his theory.[65]:320

Chaplin's film, *City Lights*, was to premier a few days later in Hollywood, and Chaplin invited Einstein and Elsa to join him as his special guests. Walter Isaacson, Einstein's biographer, described this as "one of the most memorable scenes in the new era of celebrity." Einstein and Chaplin arrived together, in black tie, with Elsa joining them, "beaming." The audience applauded as they entered the theater.[64] Chaplin visited Einstein at his home on a later trip to Berlin, and recalled his "modest little flat" and the piano at which he had begun writing his theory. Chaplin speculated that it was "possibly used as kindling wood by the Nazis."[65]:322

1.7 1933: Emigration to the U.S.

In February 1933 while on a visit to the United States, Einstein knew he could not return to Germany with the rise to power of the Nazis under Germany's new chancellor, Adolf Hitler.[66][67]

While at American universities in early 1933, he undertook his third two-month visiting professorship at the California Institute of Technology in Pasadena. He and his wife Elsa returned to Belgium by ship in March, and during the trip they learned that their cottage was raided by the Nazis and his personal sailboat confiscated. Upon landing in Antwerp on 28 March, he immediately went to the German consulate and turned in his passport, formally renouncing his German citizenship.[68] A few years later, the Nazis sold his boat and turned his cottage into an Aryan youth camp.[69]



Cartoon of Einstein, who has shed his "Pacifism" wings, standing next to a pillar labeled "World Peace." He is rolling up his sleeves and holding a sword labeled "Preparedness" (by Charles R. Macauley, c. 1933).

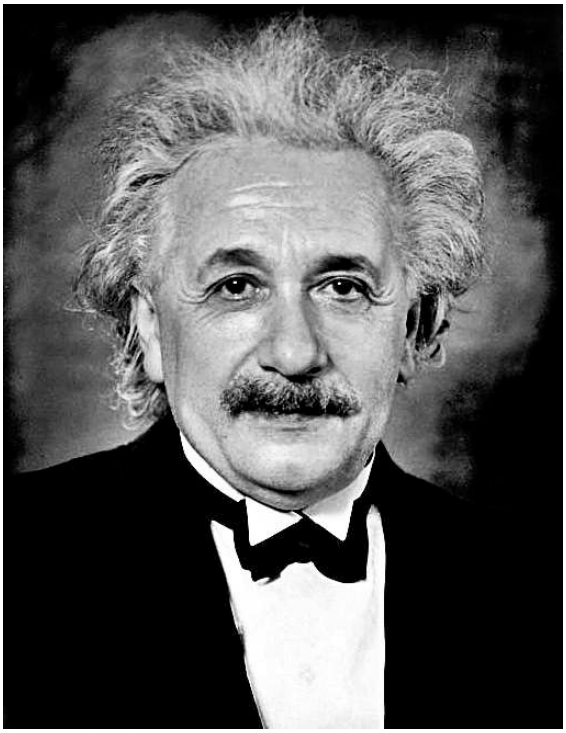
1.7.1 Refugee status

In April 1933, he also discovered that the new German government had passed laws barring Jews from holding any official positions, including teaching at universities.[68] Historian Gerald Holton describes how, with "virtually no audible protest being raised by their colleagues," thousands of Jewish scientists were suddenly forced to give up their university positions and their names were removed from the rolls of institutions where they were employed.[58]

A month later, Einstein's works were among those targeted by Nazi book burnings, with Nazi propaganda minister Joseph Goebbels proclaiming, "Jewish intellectualism is dead."[68] One German magazine included him in a list of enemies of the German regime with the phrase, "not yet hanged", offering a $5,000 bounty on his head.[68][70] In a subsequent letter to physicist and friend, Max Born, who had already emigrated from Germany to England, Einstein wrote, "... I must confess that the degree of their brutality and cowardice came as something of a surprise."[68] After moving to the U.S., he described the book burnings as a "spontaneous emotional outburst" by those who "shun popular enlightenment," and "more than anything else in the world, fear the influence of men of intellectual independence."[71]

Einstein was now without a permanent home, unsure where he would live and work, and equally worried about the fate of countless other scientists still in Germany. He rented a house in De Haan, Belgium where he lived for a few months. In late July 1933, he went to England for about six weeks at the personal invitation of British

Einstein surrounded by Oliver Locker-Lampson (seated) and assistants assigned to protect him



Portrait taken in 1935 in Princeton

naval officer Commander Oliver Locker-Lampson, who had become friends with Einstein in the preceding years. To protect Einstein, Locker-Lampson secretly had two assistants watch over him at his secluded cottage outside of London, with the press publishing a photo of them guarding Einstein.[72]

Locker-Lampson took Einstein to meet Winston Churchill at his home, and later, Austen Chamberlain and former Prime Minister Lloyd George.[73] Einstein asked them to help bring Jewish scientists out of Germany. British historian Martin Gilbert notes that Churchill responded immediately, and sent his friend, physicist Frederick Lindemann to Germany to seek out Jewish scientists and place them in British universities.[74] Churchill later observed that as a result of Germany having driven the Jews out, they lowered their "technical standards," and had put the Allies' technology ahead of theirs.[74]

Einstein later contacted leaders of other nations, including Turkey's Prime Minister, İsmet İnönü, who he wrote in September 1933 requesting placement of unemployed German-Jewish scientists. As a result of Einstein's letter, Jewish invitees to Turkey eventually totaled over "1,000 saved individuals."[75]

Locker-Lampson also submitted a bill to parliament to extend British citizenship to Einstein, during which period Einstein made a number of public appearances describing the crisis brewing in Europe. The bill failed to become law, however, and Einstein then accepted an earlier offer from the Princeton Institute for Advanced Study, in the U.S., to become a resident scholar.[76]

1.7.2 Resident scholar at the Institute for Advanced Study

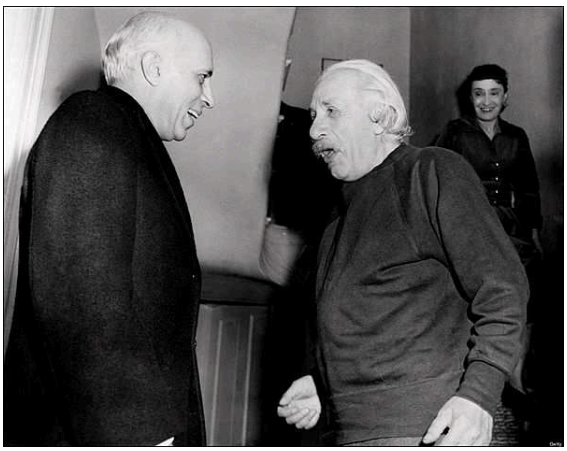
In October 1933 Einstein returned to the U.S. and took up a position at the Institute for Advanced Study (in Princeton, New Jersey),[76][77] noted for having become a refuge for scientists fleeing Nazi Germany.[78] At the time, most American universities, including Harvard, Princeton and Yale, had minimal or no Jewish faculty or students, as a result of their Jewish quota which lasted until the late 1940s.[78]

Einstein was still undecided on his future. He had offers from several European universities, including Oxford where he stayed for three short periods between May 1931 and June 1933,[79][80] however in 1935 he arrived at the decision to remain permanently in the United States and apply for citizenship.[76][81]

Einstein's affiliation with the Institute for Advanced Study would last until his death in 1955.[82] He was one of the four first selected (two of the others being John von Neumann and Kurt Gödel) at the new Institute, where he soon developed a close friendship with Gödel. The two would take long walks together discussing their work. Bruria Kaufman, his assistant, later became a physicist. During this period, Einstein tried to develop a unified field theory and to refute the accepted interpretation of quantum physics, both unsuccessfully.

1.7.3 World War II and the Manhattan Project

In 1939, a group of Hungarian scientists that included émigré physicist Leó Szilárd attempted to alert Washington of ongoing Nazi atomic bomb research. The group's warnings were discounted.[83] Einstein and Szilárd, along with other refugees such as Edward Teller and Eugene Wigner, "regarded it as their responsibility to alert Americans to the possibility that German scientists might win the race to build an atomic bomb, and to warn that Hitler would be more than willing to resort to such a weapon."[84][85]



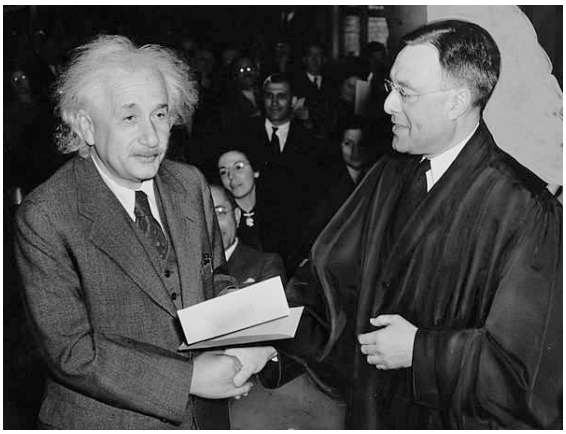
First Indian Prime Minister Jawaharlal Nehru with Einstein at Princeton University, 1949

To make certain the U.S. was aware of the danger, in July 1939, a few months before the beginning of World War II in Europe, Szilárd and Wigner visited Einstein to explain the possibility of atomic bombs, which Einstein, a pacifist, said he had never considered.[86] He was asked to lend his support by writing a letter, with Szilárd, to President Roosevelt, recommending the U.S. pay attention and engage in its own nuclear weapons research. A secret German facility, apparently the largest of the Third Reich, covering 75 acres in an underground complex, was being re-excavated in Austria in December 2014 and may have been planned for use in nuclear research and development.[87]

The letter is believed to be "arguably the key stimulus for the U.S. adoption of serious investigations into nuclear weapons on the eve of the U.S. entry into World War II".[88] In addition to the letter, Einstein used his connections with the Belgian Royal Family[89] and the Belgian queen mother[83] to get access with a personal envoy to the White House's Oval Office.[83] President Roosevelt could not take the risk of allowing Hitler to possess atomic bombs first. As a result of Einstein's letter and his meetings with Roosevelt, the U.S. entered the "race" to develop the bomb, drawing on its "immense material, financial, and scientific resources" to initiate the Manhattan Project. It became the only country to successfully develop an atomic bomb during World War II.

For Einstein, "war was a disease ... [and] he called for resistance to war." By signing the letter to Roosevelt he went against his pacifist principles.[90] In 1954, a year before his death, Einstein said to his old friend, Linus Pauling, "I made one great mistake in my life—when I signed the letter to President Roosevelt recommending that atom bombs be made; but there was some justification—the danger that the Germans would make them ..."[91]

1.7.4 U.S. citizenship



Einstein accepting U.S. citizenship certificate from judge Phillip Forman

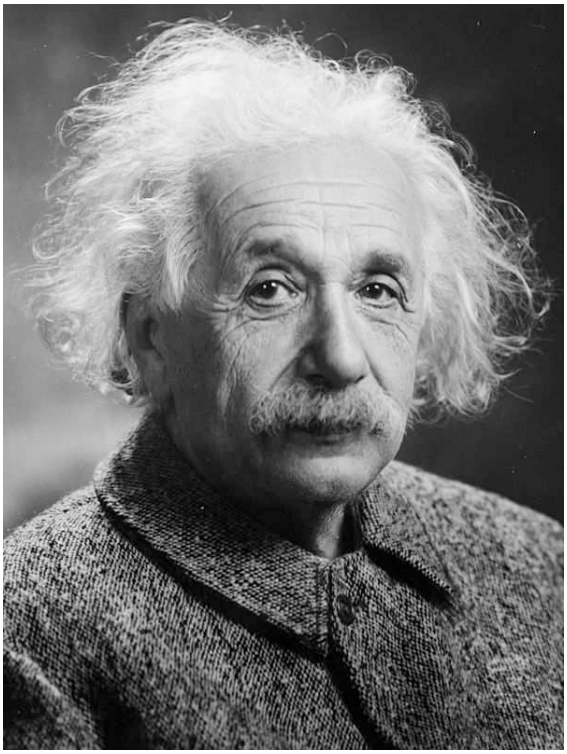
Einstein became an American citizen in 1940. Not long after settling into his career at the Institute for Advanced Study (in Princeton, New Jersey), he expressed his appreciation of the meritocracy in American culture when compared to Europe. He recognized the "right of individuals to say and think what they pleased", without social barriers, and as a result, individuals were encouraged, he said, to be more creative, a trait he valued from his own early education.[92]

1.8 Personal life

1.8.1 Supporter of civil rights

Einstein was a passionate, committed antiracist and joined National Association for the Advancement of Colored People (NAACP) in Princeton, where he campaigned for the civil rights of African Americans. He considered racism America's "worst disease,"[70] seeing it as "handed down from one generation to the next."[93] As part of his involvement, he corresponded with civil rights activist W. E. B. Du Bois and was prepared to testify on his behalf during his trial in 1951.[94]:565 When Einstein offered to be a character witness for Du Bois, the judge decided to drop the case.[95]

In 1946 Einstein visited Lincoln University in Pennsylvania where he was awarded an honorary degree. Lincoln was the first university in the United States to grant



Einstein in 1947

college degrees to blacks, including Langston Hughes and Thurgood Marshall. To its students, Einstein gave a speech about racism in America, adding, "I do not intend to be quiet about it."[96] A resident of Princeton recalls that Einstein had once paid the college tuition for a black student,[95] and black physicist Sylvester James Gates states that Einstein had been one of his early science heroes, later finding out about Einstein's support for civil rights.[95]

1.8.2 Assisting Zionist causes

Einstein was a figurehead leader in helping establish the Hebrew University of Jerusalem, which opened in 1925, and was among its first Board of Governors. Earlier, in 1921, he was asked by the biochemist and president of the World Zionist Organization, Chaim Weizmann, to help raise funds for the planned university.[97] He also submitted various suggestions as to its initial programs.

Among those, he advised first creating an Institute of Agriculture in order to settle the undeveloped land. That should be followed, he suggested, by a Chemical Institute and an Institute of Microbiology, to fight the various ongoing epidemics such as malaria, which he called an "evil" that was undermining a third of the country's development.[98]:161 Establishing an Oriental Studies Institute, to include language courses given in both Hebrew and Arabic, for scientific exploration of the country and its historical monuments, was also important.[98]:158

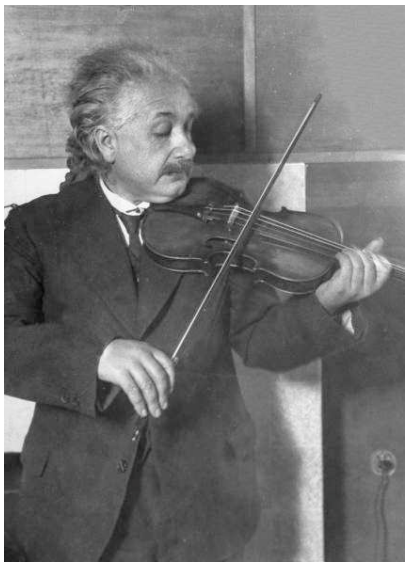
Chaim Weizmann later became Israel's first president. Upon his death while in office in November 1952 and at the urging of Ezriel Carlebach, Prime Minister David Ben-Gurion offered Einstein the position of President of Israel, a mostly ceremonial post.[99][100] The offer was presented by Israel's ambassador in Washington, Abba Eban, who explained that the offer "embodies the deepest respect which the Jewish people can repose in any of its sons".[101] Einstein declined, and wrote in his response that he was "deeply moved", and "at once saddened and ashamed" that he could not accept it.[101]

1.8.3 Love of music

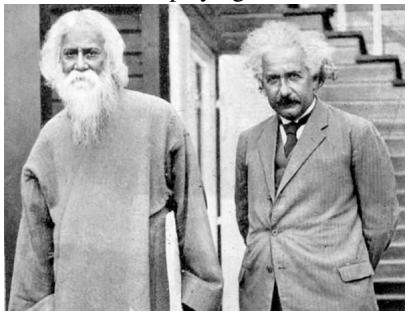
If I were not a physicist, I would probably be a musician. I often think in music. I live my daydreams in music. I see my life in terms of music... I get most joy in life out of music.

Albert Einstein[102][103]

Einstein developed an appreciation of music at an early age. His mother played the piano reasonably well and wanted her son to learn the violin, not only to instill in him a love of music but also to help him assimilate into German culture. According to conductor Leon Botstein, Einstein is said to have begun playing when he was 5, although he did not enjoy it at that age.[104]



Albert Einstein playing violin



Einstein with writer and musician and Nobel laureate Rabindranath Tagore, 1930

When he turned 13 he discovered the violin sonatas of Mozart, whereupon "Einstein fell in love" with Mozart's music and studied music more willingly. He taught himself to play without "ever practicing systematically", he said, deciding that "love is a better teacher than a sense of duty."[104] At age 17, he was heard by a school examiner in Aarau as he played Beethoven's violin sonatas, the examiner stating afterward that his playing was "remarkable and revealing of 'great insight'." What struck the examiner, writes Botstein, was that Einstein "displayed a deep love of the music, a quality that was and remains in short supply. Music possessed an unusual meaning for this student."[104]

Music took on a pivotal and permanent role in Einstein's life from that period on. Although the idea of becoming a professional himself was not on his mind at any time, among those with whom Einstein played chamber music were a few professionals, and he performed for private audiences and friends. Chamber music had also become a regular part of his social life while living in Bern, Zürich, and Berlin, where he played with Max Planck and his son, among others. He is sometimes erroneously credited as the editor of the 1937 edition of the Köchel catalogue of Mozart's work; that edition was actually prepared by Alfred Einstein.

In 1931, while engaged in research at the California Institute of Technology, he visited the Zoellner family conservatory in Los Angeles, where he played some of Beethoven and Mozart's works with members of the Zoellner Quartet.[105][106] Near the end of his life, when the young Juilliard Quartet visited him in Princeton, he played his violin with them, and the quartet was "impressed by Einstein's level of coordination and intonation."[104]

1.8.4 Political and religious views

Main articles: Albert Einstein's political views and Albert Einstein's religious views

Einstein's political view was in favor of socialism and critical of capitalism, which he detailed in his essays such as "Why Socialism?".[107][108] Einstein offered and was called on to give judgments and opinions on matters often unrelated to theoretical physics or mathematics.[76] He strongly advocated the idea of a democratic global government that would check the power of nation-states in the framework of a world federation.[109]

Einstein's views about religious belief have been collected from interviews and original writings. He called himself an agnostic, while disassociating himself from the label atheist.[110] He said he believed in the "pantheistic" God of Baruch Spinoza, but not in a personal god, a belief he criticized.[111][112] Einstein once wrote: "I do not believe in a personal God and I have never denied this but expressed it clearly".[113]

Albert Einstein with his wife Elsa Einstein and Zionist leaders, including future President of Israel Chaim Weizmann, his wife Vera Weizmann, Menahem Ussishkin, and Ben-Zion Mossinson on arrival in New York City in 1921

1.9 Death

On 17 April 1955, Albert Einstein experienced internal bleeding caused by the rupture of an abdominal aortic aneurysm, which had previously been reinforced surgically by Rudolph Nissen in 1948.[114] He took the draft of a speech he was preparing for a television appearance commemorating the State of Israel's seventh anniversary with him to the hospital, but he did not live long enough to complete it.[115]

Einstein refused surgery, saying: "I want to go when I want. It is tasteless to prolong life artificially. I have done my share, it is time to go. I will do it elegantly."[116] He died in Princeton Hospital early the next morning at the age of 76, having continued to work until near the end.

During the autopsy, the pathologist of Princeton Hospital, Thomas Stoltz Harvey, removed Einstein's brain for preservation without the permission of his family, in the hope that the neuroscience of the future would be able to discover what made Einstein so intelligent.[117] Einstein's remains were cremated and his ashes were scattered at an undisclosed location.[118][119]

In his lecture at Einstein's memorial, nuclear physicist Robert Oppenheimer summarized his impression of him as a person: "He was almost wholly without sophistication and wholly without worldliness ... There was always with him a wonderful purity at once childlike and profoundly stubborn."[120]

2 Scientific career

Throughout his life, Einstein published hundreds of books and articles.[12][16] He published more than 300 scientific papers and 150 non-scientific ones [9][12] On 5 December 2014, universities and archives announced the release of Einstein's papers, comprising more than 30,000

unique documents.[13][14] Einstein's intellectual achievements and originality have made the word "Einstein" synonymous with "genius".[15] In addition to the work he did by himself he also collaborated with other scientists on additional projects including the Bose–Einstein statistics, the Einstein refrigerator and others.[121]

2.1 1905 – Annus Mirabilis papers

Main articles: Annus Mirabilis papers, Photoelectric effect, Special theory of relativity, Mass–energy equivalence and Brownian motion

The *Annus Mirabilis* papers are four articles pertaining to the photoelectric effect (which gave rise to quantum theory), Brownian motion, the special theory of relativity, and E = mc² that Albert Einstein published in the *Annalen der Physik* scientific journal in 1905. These four works contributed substantially to the foundation of modern physics and changed views on space, time, and matter. The four papers are:

2.2 Thermodynamic fluctuations and statistical physics

Main articles: Statistical mechanics, thermal fluctuations and statistical physics

Albert Einstein's first paper[126] submitted in 1900 to *Annalen der Physik* was on capillary attraction. It was published in 1901 with the title "Folgerungen aus den Capillaritätserscheinungen", which translates as "Conclusions from the capillarity phenomena". Two papers he published in 1902–1903 (thermodynamics) attempted to interpret atomic phenomena from a statistical point of view. These papers were the foundation for the 1905 paper on Brownian motion, which showed that Brownian movement can be construed as firm evidence that molecules exist. His research in 1903 and 1904 was mainly concerned with the effect of finite atomic size on diffusion phenomena.[126]

2.3 General principles

He articulated the principle of relativity. This was understood by Hermann Minkowski to be a generalization of rotational invariance from space to space-time. Other principles postulated by Einstein and later vindicated are the principle of equivalence and the principle of adiabatic invariance of the quantum number.

2.4 Theory of relativity and $E = mc^2$

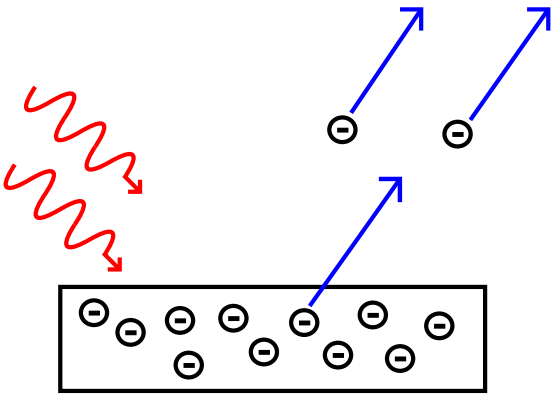
Main article: History of special relativity

Einstein's "*Zur Elektrodynamik bewegter Körper*" ("On the Electrodynamics of Moving Bodies") was received on 30 June 1905 and published 26 September of that same year. It reconciles Maxwell's equations for electricity and magnetism with the laws of mechanics, by introducing major changes to mechanics close to the speed of light. This later became known as Einstein's special theory of relativity.

Consequences of this include the time-space frame of a moving body appearing to slow down and contract (in the direction of motion) when measured in the frame of the observer. This paper also argued that the idea of a luminiferous aether—one of the leading theoretical entities in physics at the time—was superfluous.[127]

In his paper on mass–energy equivalence, Einstein produced $E = mc^2$ from his special relativity equations.[128] Einstein's 1905 work on relativity remained controversial for many years, but was accepted by leading physicists, starting with Max Planck.[129][130]

2.5 Photons and energy quanta



The photoelectric effect. Incoming photons on the left strike a metal plate (bottom), and eject electrons, depicted as flying off to the right.

Main articles: Photon and Quantum

In a 1905 paper,[131] Einstein postulated that light itself consists of localized particles (*quanta*). Einstein's light quanta were nearly universally rejected by all physicists, including Max Planck and Niels Bohr. This idea only became universally accepted in 1919, with Robert Millikan's detailed experiments on the photoelectric effect, and with the measurement of Compton scattering.

Einstein concluded that each wave of frequency f is associated with a collection of photons with energy hf each, where h is Planck's constant. He does not say much more,

because he is not sure how the particles are related to the wave. But he does suggest that this idea would explain certain experimental results, notably the photoelectric effect.[131]

2.6 Quantized atomic vibrations

Main article: Einstein solid

In 1907, Einstein proposed a model of matter where each atom in a lattice structure is an independent harmonic oscillator. In the Einstein model, each atom oscillates independently—a series of equally spaced quantized states for each oscillator. Einstein was aware that getting the frequency of the actual oscillations would be different, but he nevertheless proposed this theory because it was a particularly clear demonstration that quantum mechanics could solve the specific heat problem in classical mechanics. Peter Debye refined this model.[132]

2.7 Adiabatic principle and action-angle variables

Main article: Old quantum theory

Throughout the 1910s, quantum mechanics expanded in scope to cover many different systems. After Ernest Rutherford discovered the nucleus and proposed that electrons orbit like planets, Niels Bohr was able to show that the same quantum mechanical postulates introduced by Planck and developed by Einstein would explain the discrete motion of electrons in atoms, and the periodic table of the elements.

Einstein contributed to these developments by linking them with the 1898 arguments Wilhelm Wien had made. Wien had shown that the hypothesis of adiabatic invariance of a thermal equilibrium state allows all the blackbody curves at different temperature to be derived from one another by a simple shifting process. Einstein noted in 1911 that the same adiabatic principle shows that the quantity which is quantized in any mechanical motion must be an adiabatic invariant. Arnold Sommerfeld identified this adiabatic invariant as the action variable of classical mechanics.

2.8 Wave–particle duality

Main article: Wave–particle duality

Although the patent office promoted Einstein to Technical Examiner Second Class in 1906, he had not given up on academia. In 1908, he became a *Privatdozent* at the University of Bern.[133] In "*über die Entwicklung unserer Anschauungen über das Wesen und die Konstitution der*

Einstein during his visit to the United States

Strahlung" ("The Development of our Views on the Composition and Essence of Radiation"), on the quantization of light, and in an earlier 1909 paper, Einstein showed that Max Planck's energy quanta must have well-defined momenta and act in some respects as independent, point-like particles. This paper introduced the *photon* concept (although the name *photon* was introduced later by Gilbert N. Lewis in 1926) and inspired the notion of wave–particle duality in quantum mechanics. Einstein saw this wave-particle duality in radiation as concrete evidence for his conviction that physics needed a new, unified foundation.

2.9 Theory of critical opalescence

Main article: Critical opalescence

Einstein returned to the problem of thermodynamic fluctuations, giving a treatment of the density variations in a fluid at its critical point. Ordinarily the density fluctuations are controlled by the second derivative of the free energy with respect to the density. At the critical point, this derivative is zero, leading to large fluctuations. The effect of density fluctuations is that light of all wavelengths is scattered, making the fluid look

milky white. Einstein relates this to Rayleigh scattering, which is what happens when the fluctuation size is much smaller than the wavelength, and which explains why the sky is blue.[134] Einstein quantitatively derived critical opalescence from a treatment of density fluctuations, and demonstrated how both the effect and Rayleigh scattering originate from the atomistic constitution of matter.

2.10 Zero-point energy

Main article: Zero-point energy

In a series of works completed from 1911 to 1913, Planck reformulated his 1900 quantum theory and introduced the idea of zero-point energy in his "second quantum theory." Soon, this idea attracted the attention of Albert Einstein and his assistant Otto Stern. Assuming the energy of rotating diatomic molecules contains zero-point energy, they then compared the theoretical specific heat of hydrogen gas with the experimental data. The numbers matched nicely. However, after publishing the findings, they promptly withdrew their support, because they no longer had confidence in the correctness of the idea of zero-point energy.[135]

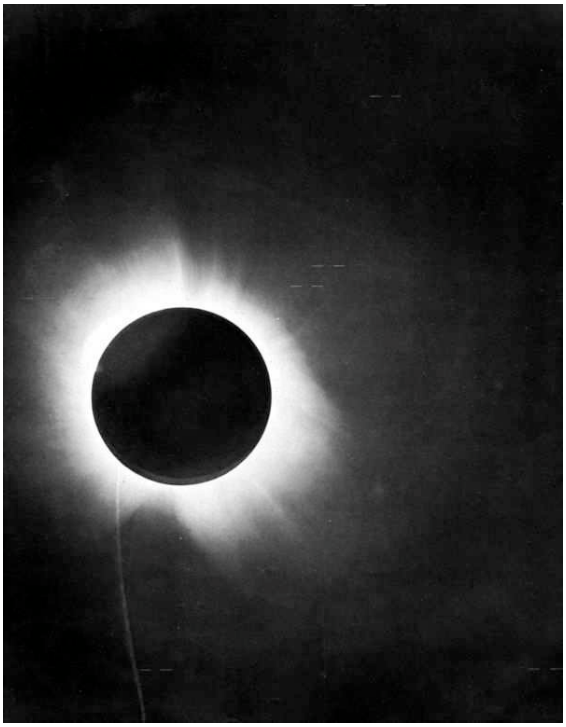
2.11 General relativity and the equivalence principle

Main article: History of general relativity
See also: Principle of equivalence, Theory of relativity and Einstein field equations

General relativity (GR) is a theory of gravitation that was developed by Albert Einstein between 1907 and 1915. According to general relativity, the observed gravitational attraction between masses results from the warping of space and time by those masses. General relativity has developed into an essential tool in modern astrophysics. It provides the foundation for the current understanding of black holes, regions of space where gravitational attraction is so strong that not even light can escape.

As Albert Einstein later said, the reason for the development of general relativity was that the preference of inertial motions within special relativity was unsatisfactory, while a theory which from the outset prefers no state of motion (even accelerated ones) should appear more satisfactory.[136] Consequently, in 1907 he published an article on acceleration under special relativity. In that article titled "On the Relativity Principle and the Conclusions Drawn from It", he argued that free fall is really inertial motion, and that for a free-falling observer the rules of special relativity must apply. This argument is called the equivalence principle. In the same article, Einstein also predicted the phenomena of gravitational time dilation, gravitational red shift and deflection of light.[137][138]

In 1911, Einstein published another article "On the Influence of Gravitation on the Propagation of Light" expanding on the 1907 article, in which he estimated the amount of deflection of light by massive bodies. Thus, the theoretical prediction of general relativity can for the first time be tested experimentally.[139]



Eddington's photograph of a solar eclipse

2.12 Hole argument and Entwurf theory

Main article: Hole argument

While developing general relativity, Einstein became confused about the gauge invariance in the theory. He formulated an argument that led him to conclude that a general relativistic field theory is impossible. He gave up looking for fully generally covariant tensor equations, and searched for equations that would be invariant under general linear transformations only.

In June 1913, the Entwurf ("draft") theory was the result of these investigations. As its name suggests, it was a sketch of a theory, less elegant and more difficult than general relativity, with the equations of motion supplemented by additional gauge fixing conditions. After more than two years of intensive work, Einstein realized that the hole argument was mistaken[140] and abandoned the theory in November 1915.

2.13 Cosmology

Main article: Cosmology

In 1917, Einstein applied the general theory of relativity to model the structure of the universe as a whole. He apprehended that his equations predicted the universe to be either contracting or expanding. He wanted the universe to be eternal and unchanging, but this type of universe is not consistent with relativity. To fix this, Einstein modified the general theory by introducing a new notion, the cosmological constant, which he called Lambda.[141] The purpose of Lambda was to rectify the effects of gravity and allow the whole system to stay balanced. With a positive cosmological constant, the universe could be an eternal static sphere. However, in 1929, Edwin Hubble confirmed that the universe is expanding. After his Mount Wilson visit with Hubble, Einstein formally discarded the cosmological constant, claiming it is "theoretically unsatisfactory anyway".[142][143]

Einstein believed a spherical static universe is philosophically preferred, because it would obey Mach's principle. He had shown that general relativity incorporates Mach's principle to a certain extent in frame dragging by gravitomagnetic fields, but he knew that Mach's idea would not work if space goes on forever. In a closed universe, he believed that Mach's principle would hold. Mach's principle has generated much controversy over the years.

In many of Einstein biographies, writers claim that he called the creation of Lambda his "biggest blunder". Recently, astrophysicist Mario Livio showed that Einstein possibly never said that.[144] Instead of discarding Lambda, Einstein was continually experimenting with it.[145]

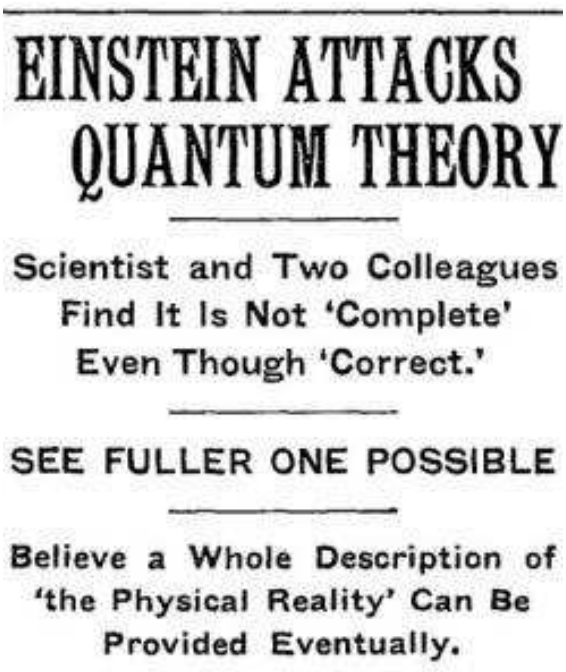
In late 2013, Irish physicist Cormac O'Raifeartaigh happened to discover a handwritten manuscript by Einstein which was since then overlooked by other scientists. The research paper was titled ""Zum kosmologischen Problem"" ("About the Cosmological Problem").[146][147] And Einstein proposed a revision of his model, still with a cosmological constant, but now the constant was responsible for the creation of new matter as the universe expanded. Thus, the average density of the system never changed. He stated in the paper, ""In what follows, I would like to draw attention to a solution to equation (1) that can account for Hubbel's [sic] facts, and in which the density is constant over time." And: "If one considers a physically bounded volume, particles of matter will be continually leaving it. For the density to remain constant, new particles of matter must be continually formed in the volume from space.""

This is consistent with the now-obsolete Steady State model of cosmology, proposed later in 1949, and with today's modern understanding of dark energy.[148]

2.14 Modern quantum theory

Main article: Schrödinger equation

Einstein was displeased with quantum theory and quantum mechanics (the very theory he helped create), de-


EINSTEIN ATTACKS QUANTUM THEORY

Scientist and Two Colleagues Find It Is Not 'Complete' Even Though 'Correct.'

SEE FULLER ONE POSSIBLE

Believe a Whole Description of 'the Physical Reality' Can Be Provided Eventually.

Newspaper headline on May 4, 1935

spite its acceptance by other physicists, stating that God "is not playing at dice."[149] Einstein continued to maintain his disbelief in the theory, and attempted unsuccessfully to disprove it until he died at the age of 76.[150] In 1917, at the height of his work on relativity, Einstein published an article in *Physikalische Zeitschrift* that proposed the possibility of stimulated emission, the physical process that makes possible the maser and the laser.[151] This article showed that the statistics of absorption and emission of light would only be consistent with Planck's distribution law if the emission of light into a mode with n photons would be enhanced statistically compared to the emission of light into an empty mode. This paper was enormously influential in the later development of quantum mechanics, because it was the first paper to show that the statistics of atomic transitions had simple laws. Einstein discovered Louis de Broglie's work, and supported his ideas, which were received skeptically at first. In another major paper from this era, Einstein gave a wave equation for de Broglie waves, which Einstein suggested was the Hamilton–Jacobi equation of mechanics. This paper would inspire Schrödinger's work of 1926.

2.15 Bose–Einstein statistics

Main article: Bose–Einstein statistics

In 1924, Einstein received a description of a statistical model from Indian physicist Satyendra Nath Bose, based on a counting method that assumed that light could be understood as a gas of indistinguishable particles. Einstein noted that Bose's statistics applied to some atoms as well

as to the proposed light particles, and submitted his translation of Bose's paper to the *Zeitschrift für Physik*. Einstein also published his own articles describing the model and its implications, among them the Bose–Einstein condensate phenomenon that some particulates should appear at very low temperatures.[152] It was not until 1995 that the first such condensate was produced experimentally by Eric Allin Cornell and Carl Wieman using ultracooling equipment built at the NIST–JILA laboratory at the University of Colorado at Boulder.[153] Bose–Einstein statistics are now used to describe the behaviors of any assembly of bosons. Einstein's sketches for this project may be seen in the Einstein Archive in the library of the Leiden University.[121]

2.16 Energy momentum pseudotensor

Main article: Stress-energy-momentum pseudotensor

General relativity includes a dynamical spacetime, so it is difficult to see how to identify the conserved energy and momentum. Noether's theorem allows these quantities to be determined from a Lagrangian with translation invariance, but general covariance makes translation invariance into something of a gauge symmetry. The energy and momentum derived within general relativity by Noether's presecriptions do not make a real tensor for this reason.

Einstein argued that this is true for fundamental reasons, because the gravitational field could be made to vanish by a choice of coordinates. He maintained that the non-covariant energy momentum pseudotensor was in fact the best description of the energy momentum distribution in a gravitational field. This approach has been echoed by Lev Landau and Evgeny Lifshitz, and others, and has become standard.

The use of non-covariant objects like pseudotensors was heavily criticized in 1917 by Erwin Schrödinger and others.

2.17 Unified field theory

Main article: Classical unified field theories

Following his research on general relativity, Einstein entered into a series of attempts to generalize his geometric theory of gravitation to include electromagnetism as another aspect of a single entity. In 1950, he described his "unified field theory" in a *Scientific American* article entitled "On the Generalized Theory of Gravitation".[154] Although he continued to be lauded for his work, Einstein became increasingly isolated in his research, and his efforts were ultimately unsuccessful. In his pursuit of a unification of the fundamental forces, Einstein ignored some mainstream developments in physics, most notably the strong and weak nuclear forces, which were not well understood until many years after his death. Mainstream physics, in turn, largely ignored Einstein's approaches to unification. Einstein's dream of unifying other laws of physics with gravity motivates modern quests for a theory of everything and in particular string theory, where geometrical fields emerge in a unified quantum-mechanical setting.

2.18 Wormholes

Main article: Wormhole

Einstein collaborated with others to produce a model of a wormhole. His motivation was to model elementary particles with charge as a solution of gravitational field equations, in line with the program outlined in the paper "Do Gravitational Fields play an Important Role in the Constitution of the Elementary Particles?". These solutions cut and pasted Schwarzschild black holes to make a bridge between two patches.

If one end of a wormhole was positively charged, the other end would be negatively charged. These properties led Einstein to believe that pairs of particles and antiparticles could be described in this way.

2.19 Einstein–Cartan theory

Main article: Einstein–Cartan theory
In order to incorporate spinning point particles into general relativity, the affine connection needed to be generalized to include an antisymmetric part, called the torsion. This modification was made by Einstein and Cartan in the 1920s.

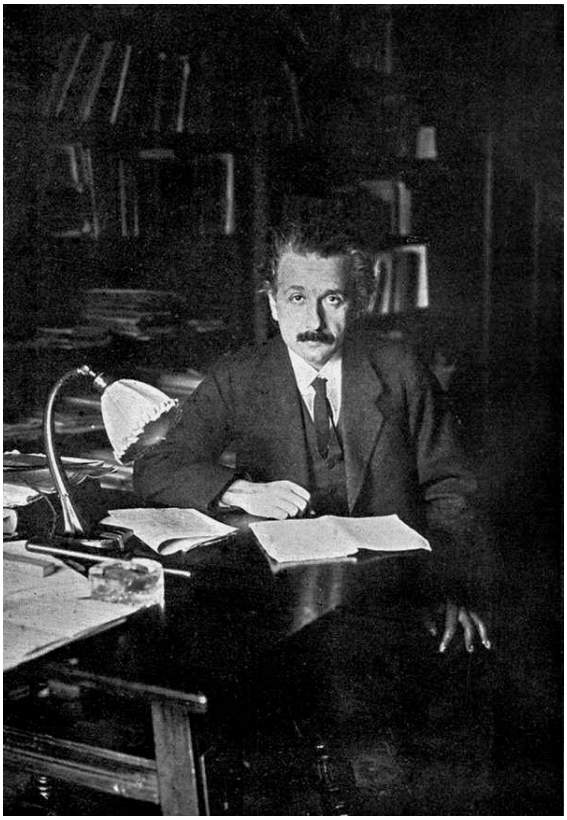
2.20 Equations of motion

Main article: Einstein–Infeld–Hoffmann equations

The theory of general relativity has a fundamental law—the Einstein equations which describe how space curves, the geodesic equation which describes how particles move may be derived from the Einstein equations.

Since the equations of general relativity are non-linear, a lump of energy made out of pure gravitational fields, like a black hole, would move on a trajectory which is determined by the Einstein equations themselves, not by a new law. So Einstein proposed that the path of a singular solution, like a black hole, would be determined to be a geodesic from general relativity itself.

This was established by Einstein, Infeld, and Hoffmann for pointlike objects without angular momentum, and by Roy Kerr for spinning objects.



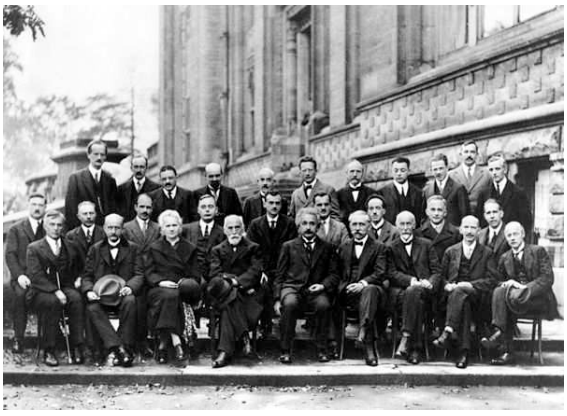
Einstein at his office, University of Berlin, 1920

2.21 Other investigations

Main article: Einstein's unsuccessful investigations

Einstein conducted other investigations that were unsuccessful and abandoned. These pertain to force, superconductivity, gravitational waves, and other research.

2.22 Collaboration with other scientists



The 1927 Solvay Conference in Brussels, a gathering of the world's top physicists. Einstein in the center.

In addition to longtime collaborators Leopold Infeld, Nathan Rosen, Peter Bergmann and others, Einstein also had some one-shot collaborations with various scientists.

2.22.1 Einstein–de Haas experiment

Main article: Einstein–de Haas effect

Einstein and De Haas demonstrated that magnetization is due to the motion of electrons, nowadays known to be the spin. In order to show this, they reversed the magnetization in an iron bar suspended on a torsion pendulum. They confirmed that this leads the bar to rotate, because the electron's angular momentum changes as the magnetization changes. This experiment needed to be sensitive, because the angular momentum associated with electrons is small, but it definitively established that electron motion of some kind is responsible for magnetization.

2.22.2 Schrödinger gas model

Einstein suggested to Erwin Schrödinger that he might be able to reproduce the statistics of a Bose–Einstein gas by considering a box. Then to each possible quantum motion of a particle in a box associate an independent harmonic oscillator. Quantizing these oscillators, each level will have an integer occupation number, which will be the number of particles in it.

This formulation is a form of second quantization, but it predates modern quantum mechanics. Erwin Schrödinger applied this to derive the thermodynamic properties of a semiclassical ideal gas. Schrödinger urged Einstein to add his name as co-author, although Einstein declined the invitation.[155]

2.22.3 Einstein refrigerator

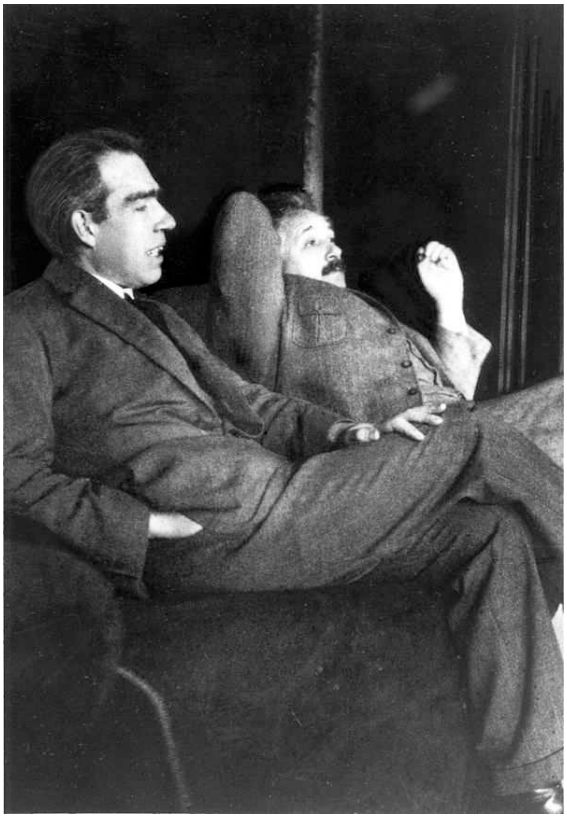
Main article: Einstein refrigerator

In 1926, Einstein and his former student Leó Szilárd co-invented (and in 1930, patented) the Einstein refrigerator. This absorption refrigerator was then revolutionary for having no moving parts and using only heat as an input.[156] On 11 November 1930, U.S. Patent 1,781,541 was awarded to Albert Einstein and Leó Szilárd for the refrigerator. Their invention was not immediately put into commercial production, and the most promising of their patents were acquired by the Swedish company Electrolux.[157]

2.23 Bohr versus Einstein

Main article: Bohr–Einstein debates

The Bohr–Einstein debates were a series of public dis-



Einstein and Niels Bohr, 1925

putes about quantum mechanics between Albert Einstein and Niels Bohr who were two of its founders. Their debates are remembered because of their importance to the philosophy of science.[158][159][160]

2.24 Einstein–Podolsky–Rosen paradox

Main article: EPR paradox

In 1935, Einstein returned to the question of quantum mechanics. He considered how a measurement on one of two entangled particles would affect the other. He noted, along with his collaborators, that by performing different measurements on the distant particle, either of position or momentum, different properties of the entangled partner could be discovered without disturbing it in any way.

He then used a hypothesis of local realism to conclude that the other particle had these properties already determined. The principle he proposed is that if it is possible to determine what the answer to a position or momentum measurement would be, without in any way disturbing the particle, then the particle actually has values of position or momentum.

This principle distilled the essence of Einstein's objection to quantum mechanics. As a physical principle, it was shown to be incorrect when the Aspect experiment of 1982 confirmed Bell's theorem, which had been promulgated in 1964.

3 Non-scientific legacy

While traveling, Einstein wrote daily to his wife Elsa and adopted stepdaughters Margot and Ilse. The letters were included in the papers bequeathed to The Hebrew University. Margot Einstein permitted the personal letters to be made available to the public, but requested that it not be done until twenty years after her death (she died in 1986[161]). Barbara Wolff, of The Hebrew University's Albert Einstein Archives, told the BBC that there are about 3,500 pages of private correspondence written between 1912 and 1955.[162]

Corbis, successor to The Roger Richman Agency, licenses the use of his name and associated imagery, as agent for the university.[163]

4 In popular culture

Main article: Albert Einstein in popular culture

In the period before World War II, *The New Yorker* published a vignette in their "The Talk of the Town" feature saying that Einstein was so well known in America that he would be stopped on the street by people wanting him to explain "that theory". He finally figured out a way to handle the incessant inquiries. He told his inquirers "Pardon me, sorry! Always I am mistaken for Professor Einstein."[164]

Einstein has been the subject of or inspiration for many novels, films, plays, and works of music.[165] He is a favorite model for depictions of mad scientists and absent-minded professors; his expressive face and distinctive hairstyle have been widely copied and exaggerated. *Time* magazine's Frederic Golden wrote that Einstein was "a cartoonist's dream come true".[166]

5 Awards and honors

Main article: Einstein's awards and honors

Einstein received numerous awards and honors, including the Nobel Prize in Physics.

6 Publications

The following publications by Albert Einstein are referenced in this article. A more complete list of his publications may be found at List of scientific publications by Albert Einstein.

- Einstein, Albert (1901) [Manuscript received: 16 December 1900], written at Zurich, Switzerland, "Folgerungen aus den Capillaritätserscheinungen" [Conclusions Drawn from the Phenomena of Capillarity] (PDF), *Annalen der Physik (Berlin)* (in German) (Hoboken, NJ, published 14 March 2006) **309** (3): 513–523, Bibcode:1901AnP...309..513E, doi:10.1002/andp.19013090306 – via Wiley Online Library

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7 See also

- Einstein notation
- *The Einstein Theory of Relativity* (educational film about the theory of relativity)
- Heinrich Burkhardt
- Historical Museum of Bern (Einstein museum)
- History of gravitational theory
- Introduction to special relativity
- List of coupled cousins
- List of German inventors and discoverers
- Jewish Nobel laureates
- List of peace activists
- Relativity priority dispute
- Sticky bead argument
- *Albert Einstein* – Wikipedia book

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- Einstein's Personal Correspondence: Religion, Politics, The Holocaust, and Philosophy Shapell Manuscript Foundation
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