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(*b*. Rome, Italy, 29 September 1901; *d*. Chicago, Illinois, 28 November 1954)

physics.

His father, Alberto Fermi, was an administrative employee of the Italian railroads; his mother, Ida de Gattis, was a schoolteacher. Fermi received a traditional education in the public schools of Rome, but his scientific formation was due more to the books he read than to personal contacts. It is possible to gather exact information on his readings from an extant notebook, and later in life he mentioned having studied such works as Poisson's *Traité de mécanique*, Richardson's *Electron Theory of Matter*, Planck's *Vorlesungen über Thermodynamik*, and several by Poincaré.

Fermi was fundamentally an agnostic, although he had been baptized a Catholic. In 1928 he married Laura Capon, the daughter of an admiral in the Italian navy. His wife's family was Jewish and was severely persecuted during the Nazi-Fascist period. Fermi, who enjoyed excellent health until his fatal illness, led a very simple, frugal life with outdoor activities as his main recreations. His unusual physical strength and endurance enabled him to hike, play tennis, ski, and swim; although in none of these sports was he outstanding.

Fermi was a member of a great many academies and scientific societies, including the Accademia dei Lincei, the U.S. National Academy of Sciences, and the Royal Society of London. He received the Nobel Prize in 1938 and the Fermi Prize, named for him, a few days before his death. His prominent part in the development of atomic energy involved him in numerous extrascientific activities that were not particularly attractive to him. He undertook administrative duties conscientiously and ably but without great enthusiasm.

Fermi's scientific accomplishments were in both theoretical and experimental physics, an unusual feat in the twentieth century, when increasing specialization tends to narrow the field of study. Fermi's statistics (independently found also by Paul Dirac) and his theory of beta decay were his greatest theoretical contributions. Artificial radioactivity produced by neutron bombardment, slow neutrons, and the realization of a nuclear chain reaction were his greatest experimental achievements. These highlights and his many other results have left their imprint on the most diverse parts of physics.

When Fermi attended school, humanistic literary studies were emphasized: Italian, Latin, and Greek. He was a model student and obtained consistently top marks. But he was primarily self-taught, from a very early age, and he said later that by age ten he had succeeded by concentrated effort in understanding practically unaided why the equation $x^2 + y^2 = r^2$ represents a circle. His older sister, Maria, and his older brother, Giulio, contributed to this early schooling. In grade school he also exhibited a prodigious memory for poems. In 1915 Giulio died unexpectedly, and the sad event left a deep mark on Enrico. Fortunately he then struck up a friendship with a schoolmate, Enrico Persico, and the two boys' common scientific interests led to a lifelong friendship. They became the first two professors of theoretical physics in Italy.

A colleague of Fermi's father, Adolfo Amidei, was perhaps the first adult to recognize Fermi's unusual talent. He lent him books on mathematics and physics in a pedagogically graduated progression. Fermi himself acquired some secondhand books on mechanics and mathematical physics, mainly Poisson's *Mécanique* and A. Caraffa's *Elementa physicae mathematicae* (Rome, 1840). By his seventeenth year, while still in high school, he had acquired a thorough knowledge of classical physics, comparable to that of an advanced graduate student in a university. Furthermore, Fermi and Persico had performed many experiments with apparatus they had built themselves, and thus had acquired an excellent grasp of contemporary experimental physics. For example, they determined precisely the value of the acceleration of gravity at Rome, the density of Rome tap water, and the earth's magnetic field. Fermi was also proficient at building small electric motors.

At Amidei's suggestion, Fermi competed for a fellowship at the Scuola Normale Superiore in Pisa, where he could acquire an education at no expense to his family. He had to write an assigned essay for the competition, "Distinctive Characters of Sound." (Fortunately the essay was preserved and after his death was found in the archives of the school.) On the first page is the partial differential equation for vibrating reeds, followed by about twenty pages for its solution through eigenfunctions, the determination of the characteristic frequencies, etc. One can easily imagine the surprise of the examiner who received this essay from a seventeen-year-old boy just out of high school. He was convinced of the candidate's genius and assured Fermi of that fact when he met him.

From the Scuola Normale Superiore, Fermi wrote regularly to Persico, and the letters give a vivid insight into his life there. He was by no means bashful, and after about a year in Pisa he said that he was the authority on quantum theory and that everybody, including the professors, depended on him to teach them the new physics. At Pisa he became a close friend of Franco Rasetti, another physics student of great ability.

Fermi received his doctorate from the University of Pisa in 1922 and then returned to Rome. At that time he met Orso Mario Corbino, director of the physics laboratory at the University of Rome. Corbino immediately recognized Fermi’s talent and became his lifelong friend and patron. Above all, he saw Fermi as the instrument for one of his fondest aspirations—the rebirth of Italian physics.

To acquire a direct knowledge of modern physics beyond the provincial state of Italian physics, Fermi had to see the world, and to be in touch with foreign scientists. He therefore competed for a foreign fellowship and spent some time at Max Born’s institute at Göttingen and then with Paul Ehrenfest at Leiden. With the latter he struck up a warm friendship, and Ehrenfest greatly encouraged him. He and Arnold Sommerfeld helped to introduce Fermi to other physicists. When the fellowship expired in 1924, Fermi returned to Florence with the post of lecturer. He then competed for a chair of mathematical physics; he did not win although he was supported by Tullio Levi-Civita and Vito Volterra.

Up to this time Fermi’s work had been primarily in general relativity (tensor analysis), where he had developed a theorem of permanent value: that in the vicinity of a world line, space can always be approximated by a pseudo-Euclidean metric (FP no. 3 in *Collected Papers*). In statistical mechanics he had written subtle papers on the ergodic hypothesis (FP no. 11) and on quantum theory. Here he had developed an original form of analyzing collisions of charged particles. He developed the field produced by the charged particle by the Fourier integral and used the information from optical processes to determine the result of the collision (FP no. 23). This method was later refined and better justified on the basis of quantum mechanics and is generally known as the Weizsäcker-Williams method. Other studies on the entropy constant of a perfect gas are historically important as preparation for things to come. An experiment done with Rasetti, who was also in Florence, on the depolarization of resonance light in an alternating magnetic field was the subject of Fermi’s first important experimental paper (FP no. 28). This experiment was the first of a series that, in subsequent years, was to become extremely important in the hands of other physicists.

In 1925 Wolfgang Pauli discovered the exclusion principle, which in the language of the old quantum theory prevents more than one electron from occupying an orbit completely defined by its quantum numbers. This principle had far-reaching consequences in statistical mechanics for a particulate gas when its temperature and density are such that the cube of the de Broglie wavelength is large compared with the total volume divided by the number of particles in the formula $N/V \gg (2\pi kmT)^{3/2}h^{-3}$. Peculiar phenomena, comprised under the technical name of “degeneracy,” then appear: for instance, the specific heat of the gas vanishes. The problems of gas degeneracy had been known for many years. Bose and Einstein had shown in 1924 that they could be solved by a modification of classical statistical mechanics (Bose-Einstein statistics). Bose-Einstein statistics are applicable to light quanta and account for Planck’s radiation formula. But Bose-Einstein statistics are not applicable to particles obeying Pauli’s principle, for which one needs the new type of statistics discovered by Fermi early in 1926 (FP no. 30). Dirac independently found the same result a few months later and connected it to the new quantum mechanics. Fermi statistics, which are applicable to electrons, protons, neutrons, and all particles of half integral spin, have a pervading importance in atomic and nuclear physics and in solid-state theory. The importance of Fermi statistics was immediately appreciated by physicists and established Fermi as a leader in the international community of theoreticians, as was obvious at the International Conference in Physics held at Como in 1927.

In 1927, mainly through the efforts of Corbino, a chair in theoretical physics, the first such in Italy, was established at the University of Rome. In the competition for the position Fermi placed first and Persico second. Fermi then came to Rome, to the Physics Institute in Via Panisperna, to join Corbino. He had friends there among the mathematicians also, and he was soon joined by Rasetti.

They strove to establish a modern school of physics in Rome. The first task was to recruit students suitable for advanced training and capable of later becoming independent scientists. The first was Emilio Segrè, who was then an engineering student but who had always had a strong interest in physics. When he became acquainted with Rasetti and Fermi through mutual friends, he enthusiastically joined the group as an advanced student. Segrè informed his schoolmate and friend Ettore Majorana of the new opportunity and introduced him to Fermi and Rasetti. Majorana soon (1928) transferred from engineering to physics. Edoardo Amaldi was recruited directly from undergraduate work in physics. Later they were joined by many others. Some came as temporary visitors: Giulio Racah, later rector of the University of Jerusalem and known mainly for his studies on the Racah coefficients and atomic spectra; Giovanni Gentile, Jr., later professor of theoretical physics at Milan; Gilberto Bernardini, later an experimental physicist and director of the Scuola Normale Superiore; and Bruno Rossi, who was a pioneer in the study of cosmic rays. Others joined them as students or fellows: Bruno Pontecorvo; Ugo Fano, later professor of theoretical physics at the University of Chicago; Eugenio Fubini; Renato Einaudi, later professor of mechanics at the University of Turin; and Leo Pincherle, later professor of physics at London University. Gian Carlo Wick came at a later date as an assistant professor. The activity in Rome helped to reanimate several other centers, including Florence (Rossi, Bernardini, Giuseppe Occhialini, Racah) and Turin (Gleb, Wataghin, Wick), and brought about a notable rebirth of physics in Italy.

Fermi’s next important study was the application of his statistics to an atomic model. This had been anticipated, however, by L. H. Thomas, who was working independently. The Thomas-Fermi atom gives very good approximations in a great number of problems. The fundamental idea was to compute the density of the electronic cloud around the nucleus as an atmosphere of a totally degenerate gas of electrons attracted by the nucleus. Fermi made numerous applications of his method to X-ray spectroscopy, to the periodic system of the elements, to optical spectroscopy, and later to ions. This work required a considerable amount of numerical calculation, which he performed with a primitive desk calculator. Many of these results were summarized in a paper he read at the University of Leipzig in 1928 (FP no. 49). Other studies in atomic and molecular physics followed.

Another important group of papers which were devoted to the reformulation of quantum electrodynamics made this important subject accessible to many physicists (FP no. 67). Dirac had written a fundamental but difficult paper on the subject. Fermi, after reading the paper, decided to obtain the same results by more familiar methods. He developed by Fourier analysis the electromagnetic field which obeys Maxwell's equations, and he quantized the single harmonic components as oscillators. He thus wrote the Hamiltonian of the free field, giving a Hamiltonian form to Maxwell's theory. To this Hamiltonian, he added the Hamiltonian of an atom and a term representing the interaction between atom and radiation. The complete system was then treated by perturbation theory.

Corbino did not miss any occasion to extol Fermi's work, and early official recognition followed. Mussolini named Fermi to the newly created Accademia d'Italia. He was the only physicist so honored, and this singular recognition was also accompanied by a substantial stipend. He was subsequently elected to the Accademia dei Lincei, at an unusually young age. In spite of some grumbling by older professors, it became clear to the academic world and to the cultivated public that Fermi was indeed the leading Italian physicist. His economic position became comfortable although not affluent.

At this time quantum mechanics had reached its full development; nonrelativistic problems, at least in principle, were soluble except for mathematical difficulties. In this sense atomic physics was showing signs of exhaustion, and one could expect the next really important advances to be in the study of the nucleus. Realizing this, Fermi decided to switch to nuclear physics. He initially investigated the theory of the hyperfine structure of the spectral lines and the nuclear magnetic momenta (FP no. 57), a suitable subject for making the transition from atomic to nuclear physics.

The development of experimental physics at Rome presented greater problems than had theoretical physics. In the latter Fermi was a leader of worldwide reputation at the peak of his powers; no substantial amount of money was needed; and it was relatively easy to attract young people from Italy and from abroad. Indeed, very early promising physicists destined to leave their mark in science came to Rome. Besides the Italians mentioned earlier, several foreign physicists studied there, among them Hans Bethe, Edward Teller, Rudolf Peierls, Fritz London, Felix Bloch, George Placzek, and Homi Bhabha. The state of experimental physics was different. Rasetti was the senior man, and although he had outstanding ability he was no Fermi. The only techniques known locally were spectroscopic, and therefore the equipment available was predominantly spectroscopic. Shops were poor and money was scarce. In this situation, with the object of widening the techniques available and ultimately turning to nuclear physics, Rasetti, Amaldi, and Segre spent periods of about a year in the laboratories of Lise Meitner, Peter Debye, and Otto Stern, respectively, learning various experimental techniques.

In Rome, about 1929, Rasetti and Fermi began experiments on nuclear subjects. In the meantime the great discoveries of the early 1930's, the portents of the impending revolution in nuclear physics, were being made: positron, neutron, deuterium, and artificial acceleration. The Solvay Conference of 1933 was devoted to the nucleus, and shortly thereafter Fermi developed the theory of beta decay, based on the hypothesis of the neutrino formulated for the first time in 1930 by Wolfgang Pauli. Beta decay—the spontaneous emission of electrons by nuclei—presented major theoretical difficulties. Apparently, energy and momentum were not conserved. There were also other difficulties with angular momentum and the statistics of the nuclei. Pauli sought a way out of the apparent paradoxes by postulating the simultaneous emission of the electron and of a practically undetectable particle, later named "neutrino" by Fermi. There remained the task of giving substance to this hypothesis and of showing that it could account quantitatively for the observed facts.

An entirely new type of force had to be postulated, the so-called weak interaction. This new force, together with gravity, electromagnetism, and the strong interaction which binds the particles of the nucleus, constitutes the family of forces presently known in physics. They should account for the whole universe. Weak interactions occur between all particles and are thus unlike electromagnetic or strong interactions, which are restricted to certain particles. The first manifestation of the weak interaction to be treated in detail was the beta decay. The treatment was accomplished by applying second quantization and destruction and creation operators for fermions and by adopting (or better, guessing) a Hamiltonian for weak interactions on the basis of formal criteria, such as relativistic invariance, linearity, and absence of derivatives. Of the five possible choices which satisfied the formal requirements, Fermi treated the vector interaction in detail, mainly because of its analogy with electromagnetism.

In his paper on beta decay, Fermi also introduced a new fundamental constant of nature, the Fermi constant, G, which plays a role analogous to that of the charge of the electron in electromagnetism. This constant has been experimentally determined from the energy available in beta decay and the mean life of the decaying substance. Its value is 1.415×10^{-49} erg cm^3. To clarify its significance we point out that the electromagnetic interaction is of the order of 10^{12} times stronger than the weak interaction. More precisely, the dimensionless number $e^2/\hbar c = 1/137$ is to be compared with $\mathrm{G}^2(\hbar c)^{-2}(\hbar/mc)^{-4} \sim 5.10^{-14}$, where m is the mass of the pion. The famous paper in which Fermi developed this theory had far-reaching consequences for the future development of nuclear and particle physics (FP no. 80). For instance, it served as an inspiration to Hideki Yukawa in his theory of the nuclear forces. It is probably the most important theoretical paper written by Fermi.

Soon thereafter Frédéric Joliet and Irène Joliot-Curie discovered artificial radioactivity—the creation of radioactive isotopes of stable nuclei by alpha particle bombardment. The Joliots' discovery provided the occasion for experimental activity which Fermi continued for the rest of his life. Fermi reasoned that neutrons should be more effective than alpha particles in producing radioactive elements because they are not repelled by the nuclear charge and thus have a much greater probability of entering the target nuclei.

Acting on this idea, Fermi bombarded several elements of increasing atomic numbers with neutrons. He hoped to find an artificial radioactivity produced by the neutrons. His first success was with fluorine. The neutron source was a small ampul containing beryllium metal and radon gas. The detecting apparatus consisted of rather primitive Geiger–Müller counters. Immediately thereafter Fermi, with the help of Amaldi, D'Agostino, Rasetti, and Segrè, carried out a systematic investigation of the behavior of elements throughout the periodic table. In most cases they performed chemical analysis to identify the chemical element that was the carrier of the activity. In the first survey, out of sixty-three elements investigated, thirty-seven showed an easily detectable activity. The nuclear reactions of (n, α), (n, p), and (n, γ) were then identified, and all available elements, including uranium and thorium, were irradiated. In uranium and thorium the investigators found several forms of activity after bombardment but did not recognize fission. Fermi and his collaborators, having proved that no radioactive isotopes were formed between lead and uranium, put forward the natural hypothesis that the activity was due to transuranic elements. These studies, which were continued by Otto Hahn, Lise Meitner, Irène Joliot Curie, Frédéric Joliot, and Savitch, culminated in 1938 in the discovery of fission by Hahn and Fritz Strassmann.

In October 1935 Fermi and his collaborators, now including Pontecorvo, observed that neutrons passed through substances containing hydrogen have increased efficiency for producing artificial radioactivity. Fermi interpreted this effect as due to the slowing down of the neutrons by elastic collisions with hydrogen atoms. Thus slow neutrons were discovered. The study of slow neutrons was to form the main object of Fermi's work for several years thereafter. Among other things, Fermi and his collaborators showed that the neutrons reached thermal energy and that neutrons of a few electron volts of energy could show sharp peaks (resonances) in the curve of the collision and absorption cross section, versus neutron energy. Fermi then developed a mathematical theory of the slowing down of neutrons, and he tested it experimentally in considerable detail. This work lasted until about 1936. All the neutron work, which cost approximately a thousand American dollars, was supported by the Consiglio Nazionale delle Ricerche of Italy. The tremendous experimental activity of the years 1934–1938 brought a considerable change in the working habits at the Rome Institute. Because of the lack of time, it became impossible for Fermi to follow all the developments in physics as he had done before. He was forced to curtail the extracurricular teaching of promising young men, nor could he spare time for foreign visitors, who practically stopped coming.

The Ethiopian War marked the beginning of the decline of the work at the Institute, and the death of Corbino on 23 January 1937 brought further serious complications. The deteriorating political situation also materially hampered the work, and finally the Fascist racial laws of 1938 directly affected Fermi's wife. The foregoing problems and his deep, although mute, resentment against injustice were the final arguments that convinced Fermi to leave Fascist Italy. He passed the word to Columbia University, where he had been previously, that he was willing to accept a position there. In December 1938 he received the Nobel Prize in Stockholm. He then proceeded directly from there to New York. He was not to return to Italy until 1949.

Fermi had barely settled himself at Columbia when Bohr brought to the United States the news of the discovery of fission. This discovery made a tremendous impression on all physicists. Fermi and others immediately saw the possibility of the emission of secondary neutrons and perhaps of a chain reaction; he started at once to experiment in this direction.

In the early period at Columbia, Fermi was helped by H. L. Anderson, a graduate student who later took his Ph.D. under Fermi and remained a close collaborator and friend to the end of Fermi's life. The young physicist Walter Zinn was also associated with Fermi for an extended period. Leo Szilard was independently pursuing similar studies, and there were active interchanges of ideas and even some collaboration with other Columbia and Princeton University groups during early research on the chain reaction.

The first problem was to investigate whether on the fission of uranium secondary neutrons were in fact emitted—as was expected because the fragments have excess neutrons for their stability. If such did occur, it might be possible to use these neutrons to produce further fission, and under favorable circumstances one could obtain a chain reaction. To make this possible it is necessary to use the fission neutrons economically, i.e., to employ the neutrons to produce other fissions and not to lose them in parasitic captures by uranium, by other materials used as a moderator to slow down the neutrons, or by escape from the body of the reactor. If one uses natural uranium and a graphite moderator with unseparated isotopes, the margin by which one can obtain a chain reaction is very small and utmost care is needed in husbanding the neutrons. It soon became apparent that more than two neutrons were emitted per fission. This is a necessary but not sufficient condition for a chain reaction. But the number, now known to be about 2.5, is small enough to create an extremely difficult technical problem.

Of the two isotopes contained in natural uranium, only the isotope of mass 235, present in one part out of 140, is fissionable by slow neutrons and the cross section is large at low energy. On the other hand, most of the fission neutrons are unable to produce fission in the abundant isotope uranium 238, but if they are slowed down they are easily captured by U^{235} and produce fission. Neutrons must therefore be slowed down, but in the collisions that reduce the energy of the neutrons there is always a fraction of neutrons which are captured without producing fission. The moderator must thus be carefully chosen. Hydrogen, the first obvious choice, captures too many neutrons, and deuterium was unavailable in sufficient quantities. So for practical purposes the only suitable, and available, substance in 1939 was graphite, and several physicists independently suggested its use. In a long series of measurements of great ingenuity, Fermi and his collaborators studied the purity of the materials (impurities were often important neutron capturers) and the best configuration in which to assemble them. In order to analyze the problems facing him, Fermi needed a great amount of quantitative information on cross sections, delayed neutrons, branching ratios of the fission reactions, and nuclear properties of several nuclei to be used in a future reactor. This information was not available. He then proceeded to collect it with the help of many collaborators. Other independent groups were of course working on the same problems, but exchange of information was limited by self-imposed secrecy.

The potential overwhelming practical importance of this work was clear to physicists, and Fermi, together with George B. Pegram, chairman of the physics department at Columbia and a close personal friend, tried to alert the U.S. government to the implications of the recent discoveries. A small subsidy for further research was obtained from the U.S. Navy, and the studies that were to culminate in the atomic bomb were initiated. At the beginning the staff and equipment were completely inadequate. Perhaps Fermi thought he might be able to repeat, on a somewhat larger scale, work similar to the neutron research in Rome. He certainly did not realize, as very few scientists did, the project's colossal requirements of manpower and means for its successful completion. Fermi was always reluctant to take administrative responsibilities and he concentrated his efforts on the scientific side, leaving to others the staggering problems of organization and procurement. As an expert of exceptional ability and great authority, he naturally helped; but his activity was directed primarily to the scientific aspects of the problems. It must also be remembered that his position—first as an alien, and later, after the United States entered World War II, as an enemy alien—rendered his situation difficult.

Fermi concentrated his efforts on obtaining a chain reaction using ordinary uranium of normal isotopic composition. As soon as it was established that of the two isotopes present in natural uranium, only U^{235} is fissionable by slow neutrons, it became apparent that if one could obtain pure U^{235} or even enrich the mixture in U^{235}, the making of a reactor or possibly even of an atom bomb would be comparatively easy. Still, the isotope separation was such a staggering task that it discouraged most physicists. By the end of the war even this task had been mastered, and isotope separation was soon a normal industrial operation.

In 1939 and 1940, however, isotope separation was very uncertain and other avenues had to be explored. In December 1940, Fermi and Segrè discussed another possibility: the use of the still undiscovered element 94 (plutonium) of mass 239 (Pu^{239}). This substance promised to undergo slow neutron fission and thus to be a replacement for U^{235}. If it could be produced by neutron capture of U^{238} in a naturaluranium reactor, followed by two beta emissions, one could separate it chemically and obtain a pure isotope with, it was hoped, a large slow-neutron cross section. Similar ideas had independently occurred in England and Germany. J. W. Kennedy, Glenn Seaborg, Segrè, and Arthur Wahl undertook the preparation and measurement of the nuclear properties of Pu^{239}, using the Berkeley cyclotron. The favorable results of these experiments (January–April 1941) added impetus to the chain-reaction project because it opened another avenue for the realization of a nuclear bomb. By December 1941, the whole world was engulfed in war, and military applications were paramount. The United States developed, under government supervision, an immense organization, which evolved according to the technical necessities and led to the establishment of the Manhattan Engineer District (MED). The purpose of the MED was to make an atomic bomb in time to influence the course of the war. The history of this development is admirably recounted in the Smyth report. Fermi had a technically prominent part in the whole project. His work at Columbia was still on a small scale, but in 1942 he transferred to Chicago, where it was expanded. It culminated on 2 December 1942 with the first controlled nuclear chain reaction at Stagg Field at the University of Chicago.

The industrial and military developments of the release of nuclear energy, which are of immense importance, will not be treated here. The nuclear reactor, however, is also a scientific instrument of great capabilities, and these were immediately manifest to Fermi. Even during the war, under the extreme pressure of the times, he took advantage of these capabilities to begin research on neutron diffraction, neutron reflection and polarization, measurements of scattering lengths, etc. These investigations, developed later by other physicists, opened up whole new areas of a science sometimes called neutronology, i.e., application of neutronic methods to solid state and various other branches of physics.

When his work at Chicago was finished, Fermi went to Los Alamos, New Mexico, where the Los Alamos Laboratory of the Manhattan Engineer District, under the direction of J. R. Oppenheimer, had the assignment of assembling an atomic bomb. Fermi spent most of the period from September 1944 to early 1946 at Los Alamos, where he served as a general consultant. He also collaborated in the building of a small chain reactor using enriched uranium in U^{235} and heavy water. Fermi actively participated in the first test of the atomic bomb in the desert near Alamogordo, New Mexico, on 16 July 1945.

Following the successful test of the bomb, he was appointed by President Truman to the interim committee charged with advising the president on the use of the bomb and on many fundamental policies concerning atomic energy.

In 1946 the University of Chicago created the Institute for Nuclear Studies and offered a professorship to Fermi. The Institute was promising in its financing and organization; and Fermi, although very influential in its direction, would be spared administrative duties. The offer proved attractive to Fermi, and early in 1946 he and his family left Los Alamos for Chicago. He remained at the University of Chicago for the rest of his life.

The new institute had Samuel K. Allison as director and a faculty in which the new generation of physicists who had been active in the Manhattan Project was strongly represented: Herbert Anderson, Maria Goeppert Mayer, Edward Teller, and Harold C. Urey were among the first members. At Chicago, Fermi rapidly formed a school of graduate students whom he instructed personally, in a fashion reminiscent of his earlier days in Rome. Among those who later distinguished themselves as physicists were Richard L. Garwin, Murray Gell-Mann, Geoffrey Chew, Owen Chamberlain, Marvin L. Goldberger, Leona Marshall, Darragh E. Nagle, T. D. Lee, and C. N. Yang. Chicago thus became an extremely active center in many different areas of physics.

Fermi himself had concluded, at the end of the war, that nuclear physics was reaching a stage of maturity and that the future fundamental developments would be in the study of elementary particles. He thus prepared himself for this new field by learning as much as possible of the theory and by fostering the building of suitable accelerators with which to perform experiments. We have a hint of his effort to assimilate the theory in his Silliman lectures at Yale in the spring of 1950, which were published as *Elementary Particles* (New Haven, 1951). He systematically organized a great number of calculations on all subjects, numerical data, important reprints, etc., which he called the “artificial memory.” This material was a daily working tool for him and substituted for books, which he scarcely used any more. It also helped his memory, which, although still excellent, was not as amazing as in his early youth and could not cope with the avalanche of new results.

During the postwar Chicago years, Fermi traveled a good deal, particularly to research centers, where he could meet young, active physicists. He repeatedly visited the Brookhaven National Laboratory, the Radiation Laboratory in Berkeley, the Los Alamos Laboratory, and many universities. He was welcomed everywhere, especially by the younger men who profited from these contacts with him and, in turn, helped Fermi to preserve his youthful spirit. He attended all the Rochester conferences on high-energy physics and taught in several summer schools. In 1949 he revisited Italy, where he was very well received by his former colleagues and by the new generation of physicists who had heard of him as an almost legendary figure.

As soon as the Chicago cyclotron was ready for operation, Fermi again started experimental work on pion-nucleon scattering. (He had coined the word “pion” to indicate pi-mesons.) He found experimentally the resonance in the isotopic spin 3/2, ordinary spin 3/2 state, which had been predicted by Keith Bruckner. The investigation became a major one. With H. L. Anderson and others, Fermi worked out the details up to an energy of about 400 MeV lab of the nucleon-pion interaction. The methods and techniques employed, including the extensive use of computers, were for many years models for the subsequent host of investigators of particle resonances.

In addition to this experimental activity, Fermi did theoretical work on the origin of cosmic rays, devising a mechanism of acceleration by which each proton tends to equipartition of energy with a whole galaxy. These ideas had an important influence on the subsequent studies on cosmic rays. He also developed a statistical method for treating high-energy collision phenomena and multiple production of particles. This method has also received wide and useful applications.

In 1954 Fermi’s health began to deteriorate, but with great will power he carried on almost as usual. He spent the summer in Europe, where he taught at summer schools in Italy and France, but on his return to Chicago in September he was hospitalized. An exploratory operation revealed an incurable stomach cancer. Fully aware of the seriousness of his illness and his impending death, he nevertheless maintained his remarkable equanimity and self-control. He died in November and was buried in Chicago.

It is too early to give a historically valid assessment of Fermi’s place in the history of physics. He was the only physicist in the twentieth century who excelled in both theory and experiment, and he was one of the most versatile. His greatest accomplishments are (chronologically) the statistics of particles obeying the exclusion principle, the application of these statistics to the Thomas-Fermi atom, the recasting of quantum electrodynamics, the theory of beta decay, the experimental study of artificial radioactivity produced by neutron bombardment and the connected discovery of slow neutrons and their phenomenology, the experimental realization of a nuclear chain reaction, and the experimental study of pion-nucleon collision. In addition there are Fermi’s innumerable, apparently isolated contributions to atomic, molecular, nuclear, and particle physics, cosmic rays, relativity, etc., many of which initiated whole new chapters of physics.

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