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ENRICO FERMI

1901-1954

Enrico Fermi, the man who designed the first nuclear reactor, was born in 1901, in Rome, Italy. He was a remarkably brilliant student and received a Ph.D. in physics from the University of Pisa before he was twenty-one years old. By the time he was twenty-six, he was a full professor at the University of Rome. By then he had already published his first major paper, one which concerned an abstruse branch of physics called quantum statistics. In that paper, Fermi developed the statistical theory used to describe the behavior of large aggregations of particles of the type today referred to as *fermions*. Since electrons, protons, and neutrons—the three "building blocks" of which ordinary matter is composed—are all fermions, Fermi's theory is of considerable scientific importance. Fermi's equations have enabled us to gain a better understanding of the nucleus of the atoms, of the behavior of degenerate matter (such as occurs in the interior of

certain types of stars), and of the properties and behavior of metals—a topic of obvious practical utility.

In 1933, Fermi formulated a theory of beta decay (a type of radioactivity) which included the first quantitative discussion of the neutrino and of weak interactions, both important topics in present-day physics. Research of that kind, though not readily comprehensible by laymen, established Fermi as one of the world's leading physicists. However, Fermi's most important accomplishments were yet to come.

In 1932, the British physicist James Chadwick had discovered a new subatomic particle, the neutron. Starting in 1934, Fermi proceeded to bombard most of the known chemical elements with neutrons. His experiments showed that many types of atoms were able to absorb neutrons, and that in many cases the atoms resulting from such a nuclear transformation were radioactive. One might have expected that it would be easier for a neutron to penetrate an atomic nucleus if the neutron were moving very rapidly. But Fermi's experiments showed that the reverse was true, and that if fast neutrons were first slowed down by making them pass through paraffin or water, they could then be more readily absorbed by atoms. This discovery of Fermi's has a very important application in the construction of nuclear reactors. The material which is used in reactors to slow down the neutrons is referred to as a *moderator.*

In 1938, Fermi's important research on the absorption of neutrons resulted in his being awarded a Nobel Prize in physics. Meanwhile, however, he was having trouble in Italy. In the first place, Fermi's wife was Jewish, and the Fascist government in Italy had promulgated a set of harshly anti-Semitic laws. In the second place, Fermi was strongly opposed to Fascism—a dangerous attitude under Mussolini's dictatorship. In December 1938, when he went to Stockholm to accept his Nobel Prize, Fermi did not return to Italy. Instead, he went to New York, where Columbia University, delighted to add one of the world's greatest scientists to its staff, had offered him a position. Fermi became a United States citizen in 1944.

In early 1939, it was reported by Lise Meitner, Otto Hahn, and Fritz Strassmann that the absorption of neutrons sometimes caused uranium atoms to fission. When that report came out, Fermi (like several other leading physicists) promptly realized that a fissioning uranium atom might release enough neutrons to start a chain reaction. Furthermore, Fermi (again like several others) soon foresaw the military potentialities of such a chain reaction. By March 1939, Fermi had contacted the United States navy and tried to interest them in the development of atomic weapons. However, it was not until several months later, after Albert Einstein had written a letter on the subject to President Roosevelt, that the United States government became interested in atomic energy.

Once the American government did become interested, the scientists' first task was to construct a prototype atomic pile in order to see whether a self-sustaining chain reaction was indeed feasible. Since Enrico Fermi was the world's leading authority on neutrons, and since he combined both experimental and theoretical talents, he was chosen to head the group attempting to construct the world's first nuclear reactor. He worked first at Columbia University and then at the University of Chicago. It was in Chicago, on December 2, 1942, that the nuclear reactor which had been designed and constructed under Fermi's supervision first went into successful operation. That was the true beginning of the atomic age, for that was the first time that mankind succeeded in setting off a nuclear chain reaction. Notice of the successful test was promptly sent back East with the cryptic but prophetic words, "The Italian navigator has entered the new world." Following this successful test, it was decided to go ahead at full speed with the Manhattan Project. Fermi continued to play an important role in that project as a leading scientific advisor.

After the war, Fermi became a professor at the University of Chicago. He died in 1954. Fermi was married and had two children. Chemical element number 100, fermium, is named in his honor.

Fermi is an important figure for several reasons. In the first place, he was indisputably one of the greatest scientists of the twentieth century, and one of the very few who was outstanding both as a theoretician and as an experimenter. Only a few of his most important scientific achievements have been described in this article, but Fermi actually wrote well over 250 scientific articles during his career.

In the second place, Fermi was a very important figure in the creation of the atomic bomb, though several other persons played equally important roles in that development.

Fermi's chief importance, however, derives from the leading role he played in the invention of the nuclear reactor. That Fermi deserves the principal credit for that invention is quite clear. He first made major contributions to the underlying theory, and then actually supervised the design and construction of the first reactor.

Since 1945, no atomic weapons have been used in warfare, but a large number of nuclear reactors have been built to generate energy for peaceful purposes. Reactors are likely to be an even more important source of energy in the future. Furthermore, some reactors are used to produce useful radioisotopes, with applications in medicine and in scientific research. Reactors are also—and more ominously—a source of plutonium, a substance which can be used to build atomic weapons. There are understandable fears that the nuclear reactor may pose great hazards to humanity, but nobody claims that it is an insignificant invention. For better or worse, Fermi's work is likely to have a large influence on the world in the years to come.