Enrico Fermi: A Twentieth Century Life

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Spencer M. Di Scala

Although the public is familiar with the name Enrico Fermi, few people know about the background and importance of this twentieth century figure. Fermi conducted fundamental research in nuclear physics in Italy and participated in the development of the atomic bomb. He made outstanding contributions to the understanding of our world and was a major force in the advances in physics during the past century. Fermi's story is full of dramatic events and of fascinating characters, most of them unknown even to educated readers because there is no full-scale biography of Fermi in English or Italian.

Furthermore, in the works that are written about the great physicist most treat the Fascism of his native country as something that was running in the background, not as a fact of twentieth century life that shaped the careers of Fermi and his fellow scientists in Italy. As a totalitarian ideology, Fascism could not and did not neglect science. On the positive side, Mussolini's regime allocated sums of money to Fermi's lab that provided the spadework for the atomic age. However, these grants worked not so much through the Fascist regime but through institutions that already existed, such as the Consiglio Nazionale delle Ricerche (CNR), and through people who had little to do with Fascism. When it came time for Mussolini to allocate greater funds for Fermi's research, he refused, providing a major reason for Fermi to leave the country. In addition, the regime misused science, for example, attempting to find a "scientific" basis for the disastrous anti-Semitic laws of 1938. Nevertheless, the regime did find ample consensus in the sci[1]entific community. This was particularly true during the Ethiopian War in 1935-1936 when scientists rallied to the cause when the League of Nations imposed sanctions on Italy. For example, between November 1 and 7, 1936, during the annual meeting of the Italian Society for the Progress of Science, held in Tripoli to celebrate the Empire, Enrico Fermi exhibited a "tireless" presence at the podium at which the officers sat.[2] Even though Italian science had become integrated into the regime, Mussolini's policies would drive many Italian scientists away—chief of whom Fermi himself—alter their lives, and irrevocably change the face of Italian science.

Perhaps the best book on Fermi's life is the one by his friend and fellow-researcher Emilio Segre` in 1970. <u>Enrico Fermi: Physicist</u> attempts to provide readers who are not scientists with an understanding of Fermi's fundamental contributions to the physics of the twentieth century. Segre`, a Nobel prizewinner for his work on antimatter, is the author of several popular books on physics and a memoir of his own life (<u>A Mind Always in Motion</u>). His account of Fermi's life succeeds in giving an idea of Fermi's work and provides valuable personal insights—especially into Fermi's life in Italy before emigrating to the United States—but is too brief (185 pages) to provide a comprehensive view of Fermi's contributions and their scope. Perhaps more importantly, the book does not give a complete picture of the times and context in which Fermi lived and worked. If Fermi's role in the modern history of Italy, Europe, and the United States is to be understood, this is a particularly important aspect of any biography. With the passage of time, this aspect of his life must be examined carefully, especially if younger people are to appreciate his importance.

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If Segre``s book touches on Fermi's personal life while endeavoring to give an idea of his importance as a physicist, Laura Fermi's memoir Atoms in the Family is primarily personal while touching on his scientific contributions. The observations of a wife regarding her husband's life are always important for the understanding of any important protagonist in modern history. However, this book, published in the year of Fermi's death, 1954, cannot do justice to Fermi's importance (nor was it meant to do so). The work provides insight into some aspects of Fermi's character and, to a certain extent, enlivens it for those of us used to thinking of scientists as dull characters whose research happened to have an enormous impact. It is obvious that contemporary memoirs such as those of Laura Fermi and of Emilio Segre`--wife and student—cannot judge the scientist's role and impact from the viewpoint of time passed and generally tend to be acritical.

The same may be said about a series of articles by Fermi's collaborators who attempted to put his work into context around the time he died. Although occasionally they add important details, but they tend to repeat the information mentioned in the works of Segre` and of Laura Fermi, with the addition of their own observations. The best of these short works include Samuel K. Allison, "Enrico Fermi 1901-1954," in National Academy of Sciences of the United States of America. Biographical Memoirs (30: 125-155) (New York: Columbia University Press, 1957, and E. Bretscher and J.D. Cockcroft, "Enrico Fermi 1901-1954," in Biographical Memoirs of Fellows of the Royal Society, Vol. 1 (London: The Royal Society, 1955). Other articles of this kind can be found here and there in the literature.

The literature also records rare profiles of Fermi. An interesting one is Pierre de Latil's Enrico Fermi ou le Cristophe Colomb de l'atome (Paris: Seghers, 1974, translated into Italy as Fermi: la vita le ricerche le testimonianze, Milan: L'Accademia, 1974). The thesis of this book is that Fermi was the "Christopher Columbus" of the atom—that he discovered a new world. The book is a sympathetic portrait of Fermi, a well-written and well-argued account of his life and work. De Latil makes a compelling case for his argument and also visited the sites of Fermi's most important work, lamenting the lack of markers memorializing the events that took place at those sites. The author also makes a good attempt to explain the significance of Fermi's most important accomplishments in physics by using clear language understandable to laymen. While this book is comprehensible, it is far from comprehensive. There is little attempt to put Fermi into the context of his times and it is based on secondary materials with little if any work done in archival sources.

Interestingly enough for a person whose research was so complex and wide-ranging that it hampers production of a full-length, comprehensive biography, there have been several biographies published on him for young people. See for example Dan Cooper, Enrico Fermi: And the Revolutions of Modern Physics (Oxford Portraits in Science series, Oxford University Press, 1998, 144 pages).

A Twentieth Century Life

What is clear is that a life such as Enrico Fermi's could have been lived only in the twentieth century. There were revolutionary changes in physics during the 1920s, 1930s, and 1940s, when it was the premier science and avidly followed by the public, but this is not the only reason. His story, and that of his collaborators, has important implications for the world, for science, and for the scientific profession. Fermi was the first to organize his laboratory in a modern manner that has now become standard. The

Cavendish lab in Britain, for example, dispersed the work among different groups with the Director serving as a general advisor. The Rome lab concentrated all its forces on one project and focussed all its expertise in a major effort one area that it identified as being most likely to achieve the maximum result for the laboratory as a whole.[3]

In discussing Fermi—a superb leader and teacher—it is important to keep in mind the personal and professional fates of Fermi's most important Italian collaborators known as the "ragazzi di via Panisperna" [the Via Panisperna boys, from the location of the Physics Institute at the University of Rome]. Most of these physicists immigrated to the United States and all had unusual destinies. It is crucial to understand the individual and group responses of Fermi and the scientists around him to the Italian and American politics of the period, including fascism, racism, and the implications of their nuclear research for the world's future. There is great drama in the stories of persons studying natural phenomena in a specialized field who are suddenly yanked out of their laboratories, thrown into the cauldron of international politics, and abruptly lavished with limitless funds for their research. How did they deal with their New World, now changed beyond recognition, and with their power to alter the destiny of the planet?

Who Knows Enrico Fermi?

One day in early 1934—the exact date is unknown—a sedate Spanish scientist visited the nuclear physics laboratory of the University of Rome at Via Panisperna, 89A. Anxious to make a good impression on the eminent physicist he had come to meet, he wore a black suit and a white shirt, the standard issue for gentlemen of the time. Wandering in the intimidating halls of the old building, he bumped into one of Fermi's students, future 1959 Nobel Prize winner Emilio Segre`. The visitor asked Segre` where he could find “His Excellency Fermi,” for in 1929, at age twenty-nine, Enrico Fermi had been named to the Royal Academy of Italy. The Pope is upstairs,” Segre` responded, lost in thought. On observing a questioning gaze on the visitor’s face, Segre` added, “I mean Fermi, of course.” The Via Panisperna scientists had nicknames for each other, and, given Fermi’s reputation for infallibility, they crowned him “The Pope.” Climbing the stairs to the second floor, the Spaniard was almost overrun by two people tearing down the hall, a youngster and a stocky thirty-three year old man, dirty gray coats flying behind them, and carrying peculiar objects in their hands. The two lunatics ran several other races before the Spaniard encountered someone to interrogate: the courtly, Turin-born Gian Carlo Wick, who would inherit Fermi’s Rome university chair and later teach at the University of Notre Dame. Wick called to Fermi, who, on the run, shouted back to bring the stranger to his “office,” a room with clicking Geiger counters. Fermi ignored the visitor, chatting with him as he took readings and scribbled notes on pieces of paper.[4]

There was a good reason why Enrico Fermi and his student Edoardo Amaldi ran down the hall. In January 1934, French physicists Frederic Joliot and his wife Irene Curie had reported that they could induce artificial radioactivity by bombarding substances with alpha particles (helium nuclei). Fermi and his group figured that they could get better results by using neutrons. These particles had no electric charge and therefore could enter the positively charged atomic nuclei easier than alpha particles, which had a positive charge. By changing the nucleus, the scientists hoped to transform elements into different ones. The researchers concocted a neutron source derived from a gram of radium provided by “Divine Providence,” but in measuring the artificial radioactivity they induced they had to keep the Geiger counters down the hall so the radioactive source would not mask the results. But the artificial products decayed rapidly, hence the need for fast runners to transport the products of their experiment down the long hall to get accurate readings of the results. Fermi and Amaldi were the fastest runners in the group, although who was swifter is still in dispute. Professor Giulio Cesare Trabacchi made the experiments possible by supplying a gram of expensive radium, kept in a safe, which produced the radon gas necessary to create a source of neutrons. He headed the Public Health agency's physics laboratory, which possessed radium to treat cancer patients. Without his cooperation, they could not have conducted their experiments. For that reason, the "ragazzi" dubbed him "Divine Providence."

In that heroic year 1934, Fermi and his group also had the idea of slowing neutrons down so they would have a better chance of hitting the nucleus, and of systematically bombarding the elements to observe what would happen. In the course of these experiments, they split the uranium nucleus, opening up the road that eventually led to atomic weapons and nuclear energy.[5] Albert Einstein's theory of relativity had described the enormous energy that would result from splitting the atom, but as late as December 28, 1934, Einstein denied that it could be done in practice. "Spitting the atom by bombardment," he said, "is like shooting at birds in the dark in a region where there are few birds." Thinking that the neutron could be used to do the job, Einstein believed, was "fantasy." [6] Ironically, the birds had already been hit—an by neutrons. By appropriating only about a thousand dollars for the Rome experiments, Mussolini's Fascist government had financed the spadework for the atom bomb.

An Unlikely Dream

In order to understand the improbable origins of the Italian school of physics that Fermi headed, it is important to tell the story of an amazing Sicilian physicist who founded it practically out of the blue.

Short and stocky, Senator Orso Mario Corbino's body resembled a bear, the animal his name recalled in Italian, but his angelic face belied a bear's ferocity. Born in Augusta, Sicily, on April 30, 1876, Corbino became hooked on physics in secondary school. He studied at the University of Palermo and made important contributions in his field. In 1908, the director of the physics laboratory at the University of Rome invited Corbino to work with him. Pietro Blaserna had excellent connections that would help Corbino; he was president of the Italian Senate and a good friend of Queen Mother Margherita. At Rome Corbino did superb physics research and worked for the Italian armed forces during World War I. Following the conflict Italian industry and government sought him out for consulting work. In 1920 came appointment to the Italian Senate and in 1921 a cabinet post as Education Minister.

Corbino had only one regret about his career, his inability to continue research. As he once said: "I have become a senator, I have become a minister…, but I still yearn for science." Corbino dreamed of renewing Italian physics, whose glorious tradition dated to Galileo but which had fallen hopelessly behind the German, French, and British schools. Luckily for Italian science, Senator Corbino also headed the University of Rome's physics department. In the late 1920s, with Mussolini in power in Rome and Hitler waiting in the wings, the most exciting scientific research was being done in the realm of the very small—atomic physics. Corbino believed that physics research was at a delicate stage in which a relatively new research center could achieve dramatic results.[7]

Renewing Italian Physics

"I first met Senator Orso Mario Corbino," wrote Fermi, "when I returned to Rome immediately after my graduation. I was then twenty years old; Corbino was forty-six. He was a Senator of the Kingdom, had been a minister of public instruction, and was universally known as one of the most eminent scholars. Thus it was with understandable hesitation that I introduced myself to him, but the hesitation rapidly disappeared under the impact of his manner—at the same time cordial and interesting—as he began to discuss my studies."[8] Corbino chose Fermi to lead his attempt at establishing a prestigious national school of physics that could compete with the Germans, British, and French.

Fermi was born in Rome on September 29, 1901. He demonstrated a brilliant scientific mind. At age fourteen, he read an old multi-volume physics textbook written in Latin, and covered it with notes. His father's friend, the engineer Giuseppe Amidei, recognized the child's talent, guided his early education, and pointed him to the University of Pisa's elite Scuola Normale where Galileo and the flower of the scientific revolution had taught. Fermi became the "most influential authority" in the physics department, lecturing to his professors on quantum theory and making a significant discovery about relativity theory.

Several years of fellowships, travel, and teaching followed graduation while Corbino maneuvered to find Fermi a permanent academic position in the capital. Fermi published a paper elaborating a statistics essential to the new quantum mechanics that made a fundamental and lasting contribution to the field, after which Corbino secured for him the chair of theoretical physics at the University of Rome in 1926. According to the report, the committee "feels it can put in him the best hopes for the establishment and development of theoretical physics in Italy."[9] On July 28, 1928, during the blistering Rome summer, Fermi married Laura Capon, the daughter of a Jewish admiral in the Italian navy. They had been introduced two years earlier by mutual friends and the sixteen-year-old Laura had considered him strange and ancient at twenty-two. They had two children, born in 1931 and 1936.

Fermi brought collaborators to Rome and recruited brilliant young students to work at the physics institute at Via Panisperna. In an unusual combination of skills, he revealed himself a brilliant experimentalist as well as theoretician—probably the last of the breed. In two years, the lab achieved international fame, drawing eminent physicists from the rest of Europe and receiving invitations for its members to visit other celebrated laboratories. As a result of this success, the ubiquitous Corbino secured Fermi's appointment to the Royal Academy, established by Benito Mussolini, even though neither was Fascist. This was after Fermi's nomination to the prestigious Accademia dei Lincei was sabotaged by a colleague.[10]

With the development of quantum mechanics came a new direction in the Rome lab's research—concentration on the atom's nucleus. In late 1933 Fermi formulated his theory of beta decay, "the major theoretical work of his life," according to Richard Rhodes in The Making of the Atomic Bomb (New York: Simon and Schuster, 1986). Fermi's theory introduced the "weak interactive force," one of the four fundamental forces of nature, presented a new constant of nature, and described how, during radioactive decay, the atomic nucleus produces and expels high energy electrons. The theory remains definitive today. In 1934 came the more spectacular work in which the team bombarded the nuclei of elements with neutrons. The fundamental results of those experiments secured the 1938 Nobel Prize in physics for Fermi and changed his life.

Birth of the Atomic Age

The Rome group discovered that slowing down the speed of neutrons greatly increased the probability that they would produce artificial radioactivity. The scientists then invented a process that created slow neutrons. This research proved essential to the harnessing of nuclear energy for peaceful purposes and the development of nuclear weapons and gave birth to the Atomic Age. When the Italians bombarded the uranium nucleus with slow neutrons, they split the atom. The German chemist Ida Noddack suggested the possibility that the uranium atom had been split, but the group misread its breakthrough. Despite its uneasiness, the Fermi team leaned toward a more conventional explanation—that it had created new elements with a greater atomic number than uranium, the so-called "transuranic" elements. The Rome group named the elements ausonium and hesperium, ancient names for Italy. Fascist Party officials had attempted to fix Party names to them, but Corbino convinced them that because the half-lives of the elements were so brief, anti-Fascists might use the fact to ridicule the Party.[11]

In 1939, the Austrian physicist Lise Meitner and her nephew Otto Frisch formally gave the first theoretical explanation of fission. [120] For the Rome group, the failure to interpret the results of their experiment prompted bitter and endless self-recrimination. Although Fermi made other fundamental discoveries, he just missed going down in history as the discoverer of fission. Years later, on observing a bas-relief of a person working in a lab, a now world-famous Fermi remarked sardonically that it was a portrait of a scientist "not discovering fission." Ironically, Fermi probably did produce the transuranic element Neptunium (atomic number 93), identified in 1940, but it had a briefer half-life than the time needed to run down the hall of the Via Panisperna building.

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The incident raises important questions that concern scientists and humanists. What exactly is the process by which new concepts are discovered? In the context of the current thinking and the limits of the instruments used, the tentative interpretation of the Roman scientists was reasonable, if not entirely satisfactory even to them. The process by which Meitner and her nephew came to their conclusion illustrates the role of imagination in science. There is an intellectual leap and, suddenly, inexplicably, everything becomes clear. Nevertheless, why does something so obvious require a flash of insight to become comprehensible? In this particular case, another crucial question might be asked, this time political: What if Fascist Italy—and its Axis partner—had realized that its scientists had discovered fission?

Once the mechanism of fission was understood, Fermi's experience enabled him quickly to comprehend the possibilities of creating a chain reaction and to lead the research in this field. At the University of Chicago, Fermi would direct the team that first accomplished a self-sustaining and controlled chain reaction. His success led to the harnessing of nuclear energy for peaceful purposes—and to development of the atomic bomb and the "Super," a fusion bomb with an infinitely greater yield.

Meitner's report was based on her earlier work with Otto Hahn in Germany, but the Nazi racial laws forced her to leave Germany for Sweden. In Fermi's case, the political and racial aspects of his story are also crucial. Fermi's wife and some of his most important collaborators were Jewish, including Emilio Segre` and Bruno Pontecorvo. When Mussolini instituted the racial laws in Italy in 1938, Fermi took the occasion of his trip to Stockholm to collect the Nobel Prize to leave Italy and accept a position at Columbia University. The politics of race and resistance to the dictatorships in prewar Europe has not been explored about Italy and the Italian scientific Diaspora remains virtually unexplored. What effects did the Italian scientific emigration have during World War II in Italy, Europe, the US, and in the postwar world? This is still an unanswered question.

The story of Fermi's emigration, for example, has not been fully investigated. The usual view is that Fermi told the Fascist authorities that he was going to Stockholm to collect the Nobel Prize and then left for Columbia University without their knowledge or approval. This common interpretation is clearly false. The Fascist authorities, including the Duce, knew that Fermi would spend time at Columbia and that they approved. In addition, when Fermi decided to stay longer, he duly informed the government. There is one potentially disturbing aspect to this whole story, however. Before he left for the United States, Fermi sought a meeting with Mussolini. In a letter to Mussolini's appointments secretary Osvaldo Sebestiani dated December 3, 1938, Fermi wrote:

> I am about to leave for Stockholm on the evening of the 6th of this month for the ceremony that will confer the Nobel Prize. From there, I will leave for New York, where I will give courses at Columbia University.
>
> "It would be a high honor for me to be received by the Duce before my departure so I can receive eventual orders on the action that I will be able to undertake in the scientific communities of these countries. [Sarebbe per me alto onore poter essere ricevuto dal Duce prima della mia partenza, onde poter ricevere eventuali direttive sulla azione che io possa svolgere negli ambienti scientifici di questi paesi.] [132]

The letter is marked "No" by Mussolini.

The "Via Panisperna Boys" and the World of Enrico Fermi

When the Italian scientists made their most important discoveries, they did not realize that their world at Via Panisperna was about to end. In October 1935, Mussolini invaded Ethiopia, the event most immediately responsible for his drawing closer to Hitler. In 1937, Corbino died, removing their powerful protector. In 1938, the Fascist regime introduced the anti-Semitic laws, reversing the acceptance of Jews that had marked the country's modern history. Despite his prominent position, Fermi feared for his Jewish wife and for his children. In 1938, the group began breaking up. Fermi went to New York and all the inventors of slow neutrons, makers of the Atomic Age, encountered unusual fates.

Ettore Majorana, a mathematical genius Fermi described as another Galileo, made fundamental contributions to nuclear physics but was a strange person who either refused to publish or destroyed his own work. At a time when electrons were thought to inhabit the nucleus, he developed a model of the nucleus as containing neutrons and protons and analyzed the forces involved. He rejected Fermi's pleas to make the idea known, leaving others to come to the same conclusion later. Toward the end of his association with the group, Majorana withdrew more and more into himself.

Then one day in March 1938, Ettore Majorana vanished from the face of the earth, leaving the Italian police to conduct a fruitless nationwide hunt and a stunned world to debate his disappearance ever since. Did he commit suicide or did he understand that his research would lead to the development of monstrous new weapons? If he committed suicide, why did he withdraw several months' pay and take out a passport? Did he retire to a monastery or flee to Argentina? [3]

Those who might be skeptical of the depth of feeling against the possible military uses of the scientists' research would do well to consider the story of Franco Rasetti, Fermi's "Cardinal Vicar" and outstanding experimentalist. In 1939, he left Italy for Laval University in Quebec to establish a new physics laboratory and in 1947 was appointed professor at Johns Hopkins in Baltimore. He remained in the field but turned his attention to paleontology and geology. He absolutely refused to work on the Manhattan Project: "I was convinced that no good could come out of new and more monstrous forms of destruction, and successive events have fully confirmed my suspicions. For all the perversity of the Axis powers, it was evident that the other side was falling to a similar moral (or immoral) level in the conduct of the war, as the massacre of 200,000 Japanese civilians at Hiroshima and Nagasaki amply testifies." [4]

Rasetti's colleague Emilio Segre` left his position at the University of Palermo because of the racial laws. At Los Alamos he was a prominent member of the team that built the bomb. Afterwards he joined the faculty at Berkeley, remained close to Fermi, and shared the 1959 Nobel Prize in physics for the discovery of the antiproton. Segre`, the most literate of the "Via Panisperna Boys," has left an autobiography in addition to books on the history of science and his memoirs of Fermi.

On the surface, Segre` seems to have adapted well to his new life in the United States, but the memoirs of his son Claudio indicate otherwise: "'In Tivoli we used to…'" or 'When we still lived in Tivoli…' my father would begin from time to time. In his voice I always heard nostalgia, regret for an Eden forsaken, a Paradise Lost." [5] In his views of Americans, even educated ones, we note the elitist attitudes of a European intellectual. Segre`, however, was not the standard emigrant, so he was also alienated from other Italian Americans, who came from very different backgrounds. There was in his life a tension that, in addition to the physics, is something that needs to be examined and applied to the other intellectuals forced to emigrate from Fascist Italy.

Bruno Pontecorvo, like Segre` Jewish and a co-discoverer of slow neutrons, left Italy with the advent of the racial laws. He went to Paris, the United States, Canada, and then Britain. In 1950, he was working at Harwell, the British atomic research center when the arrest of atomic spy Klaus Fuchs became known. Pontecorvo revealed that his brother in Italy was a Communist, but no one thought much of this revelation. During a vacation to Italy, however, he mysteriously disappeared and resurfaced in the Soviet Union. The Pontecorvo case was one of the most sensational episodes of the early Cold War. Was he a spy? Coincidentally, the Rome group was suing the American government for 10 million dollars for using its patented slow neutrons discovery. Pontecorvo's flight created a hostile atmosphere and the group found it expedient to settle its case with the government for practically nothing. [6]

Pontecorvo lived in the USSR for the next forty years, where he introduced Fermi's school of physics. Many questions remain regarding his defection and the reasons for it. Pontecorvo is still routinely described as a spy, but did he have any secrets to give? Clarifying the obscure elements of this sensational case would be an important task in defining Fermi's world, especially in light of new documents coming from the Soviet archives. [7]

Edoardo Amaldi, the only co-discoverer of slow neutrons to remain in Italy, might serve as a foil to Pontecorvo. His story illustrates a dilemma frequently found in the 1930s scientists. Should he have stayed in Italy doing research so as to be able to revive physics once the Fascist madness ended? Werner Heisenberg claimed that this was his reason for remaining in Nazi Germany, but Heisenberg's research during the war was relevant to building a Nazi bomb. Amaldi claimed to have changed the direction of his research so he and remaining physicists could not be asked to build the bomb for Fascist Italy. Indeed, what did Fascist Italy do about the possibility of building an atomic weapon?

After the war Amaldi did rebuild Italian nuclear physics, but within the context of Europe. He contributed to the process by which Italian physicists played a substantial role in European nuclear research, despite the prohibition against such research by the Allies following the war. Amaldi was instrumental in founding the European research institution CERN. This was "big physics," discussed in letters by Fermi and Amaldi, the wave of the future. [8]

A Strange New World

In accounts of the Atomic Bomb and early postwar physics in the United States, Enrico Fermi is a shadowy figure.

Richard Rhodes and others have told the story of the atomic bomb's construction, but have not fully examined the role of Fermi and the Italian nuclear scientists in the New World. For them first came a painful Diaspora, then a struggle to adjust to a different world, then the Cold War. These themes have been discussed only superficially for other foreign scientists as well. Yet the diversity of scientists working on the Manhattan Project helps account for its success, while the homogeneity of the German effort contributed to its failure. European scientists had a tradition of sharing research but the atomic scientists had to keep their work secret, becoming strangers to persons who had once been their closest collaborators. How did they react to the guilt that this development brought for many of them? Moreover, the morality of building the bomb and the shape the postwar world because of its existence touched off a debate between the scientists and American policymakers.

What were Fermi's views on the Cold War and Pontecorvo? He attempted to interest General Electric in the possibility of nuclear energy but the company rejected his proposals as "science fiction." Exactly what did Fermi suggest and why? Ironically, Fermi and his collaborators were enemy aliens when they worked on the bomb; how did the security services view them? The court case concerning the patent on slow neutrons has similarly not received attention. Fermi is generally considered to have fit well into American life, but to what extent is that true, and what of his colleagues? Ironically, Fermi and his collaborators are known least in the United States, where they made their most important practical contributions.

"The Italian Navigator Has Just Landed"

Fermi had an offer from Columbia University before he came to the Unites States. In New York, he did experiments that reproduced his Rome work and went beyond it. Fermi's research aimed at discovering whether a self-sustainable, controlled chain reaction would occur in practice, as well as in theory. On December 2, 1942, in Chicago, Fermi proved it would, and he revolutionized the modern world.

Of all the brilliant scientists working on production of an atomic weapon, Fermi was the most versatile. After demonstrating that scientists were capable of creating a self-sustaining chain reaction and controlling it, Fermi worked on all aspects of developing a practical weapon. He served as troubleshooter when the researchers ran into snags and intimately involved himself with the building of the industrial plant and methods to separate the rare U-235 isotope from the more common U-238, which would not sustain a chain reaction. [9] His friend Segre` and Glenn T. Seaborg developed the more easily produced and fissionable plutonium. Very soon, Fermi became embroiled with the question of using the Atomic Bomb as a detonation device for a thermonuclear weapon.

This fact brought him into disharmony with Hungarian physicist Edward Teller, "Father of the hydrogen bomb." Fermi initially opposed development of the "Super." When J. Robert Oppenheimer, head of the Los Alamos laboratory, later found himself the target of an investigation and lost his security clearance, Fermi testified in favor of Oppenheimer, while Teller was equivocal. When Fermi was dying, he criticized Teller and his behavior about the Oppenheimer affair and the hydrogen bomb. Fermi's last words on Teller were: "The best thing Teller can do now is to shut up and to disappear from the public eye for a long time, in the hope that people may forget him." [0] The relationship between Fermi and Teller remains largely unexplored.

The Last Years

Fermi died of stomach cancer in 1954, shortly after his fifty-third birthday. In his last years, he served as a member of the Atomic Energy Commission's general advisory committee developing nuclear policy. His research interests centered in the new nuclear particles that were being posited and discovered. In Italy, he had been interested in cosmic rays and in his last years, he continued his studies of them and of the mesons they ejected from atoms. Fermi's contacts with Italian and European scientists resumed, following the war, as did those of the other "Via Panisperna Boys." Fermi had looked forward to using the giant new cyclotrons that were being developed, and to international cooperation in nuclear research, but had no time to do so. Two weeks before he died, the

Atomic Energy Commission awarded its first $25,000 prize to Fermi for his pioneering research in an award later named for him.

Fermi died blessed by a Catholic priest, a Protestant pastor, and a rabbi, each of whom came into his hospital room on different occasions. "It pleased them," Fermi commented, "and it did not harm me." Columbia's renowned physicist Professor I.I. Rabi wrote what could be his obituary: "He was a man of peace, but the necessities of our times turned his talents and his discoveries to the art of war." [1]