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Science and Fascism: The Case of Enrico Fermi

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ABSTRACT *This article describes the work and fate of Enrico Fermi's group (the 'Via Panisperna Boys') under the dictatorship of Benito Mussolini. It examines the fundamental research the group did and its significance and demonstrates how scientists cannot work under conditions innimical to freedom such as those that existed under the Fascist regime.*

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 in the background, not as a factor in twentieth century life shaping 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 research institutions such as the *Consiglio Nazionale delle Ricerche* (National Research Council, CNR, founded in 1923), and through people who were not necessarily Fascists. When it came time for Mussolini to allocate greater funds for Fermi's research, he foolishly 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 anti-Semitic laws of 1938, interfering with and thwarting the mission of science in its search for truth. Nevertheless, the regime did find ample consensus in the scientific community. This was particularly true during the Ethiopian War in 1935-1936, when scientists rallied to the cause after the League of Nations imposed sanctions on Italy. For example, between 1 and 7 November 1936, during the annual meeting of the Italian Society for the Progress of Science – held in Tripoli

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to celebrate the Fascist Empire – Enrico Fermi exhibited a "tireless" presence at the podium at which the officers sat.[1] 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.

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. Fermi's story, and that of his collaborators, has important implications for the world, for science, and for the scientific profession. Fermi was the first to organise 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 in one area it identified as being most likely to achieve the maximum result for the laboratory as a whole.[2]

In discussing Fermi—a superb leader and teacher—it is important to keep in mind the personal and professional fates of Fermi's most valuable 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 specialised 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 this 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, the visitor 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 Segrè. The visitor asked Segrè 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," Segrè responded, lost in thought. Upon observing a questioning gaze on the visitor's face, Segrè 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. Looking crazed, both ran past several more times before the Spaniard encoun-

tered someone to interrogate: the courtly, Turin-born Gian Carlo Wick, who would inherit Fermi's University of Rome 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.[3]

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 these elements. The researchers concocted a neutron source derived from a gramme 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 that 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 gramme 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.[4] 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."[5] Ironically, the birds had already been hit—and by neutrons. By appropriating only about a thousand dollars for the Rome experiments, Mussolini's Fascist government had financed early work towards the atom bomb. Segrè wrote about the finances for this research in a manuscript now found at Rome's Central Archives:

> That enterprise cost relatively (and absolutely) little. A telephone call by Fermi to Magrini [secretary] of the CNR [*Consiglio Nazionale delle Ricerche*, or National Research Council] resulted in the arrival of 20,000 lire (1934 value). The administration consisted of writing on a scrap of paper how they were spent. Sometimes I carried part of these funds in my pocket to buy supplies. It is surprising how many things one can buy using cash and without reams of paper.[6]

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 30 April 1876, Corbino became hooked on physics in secondary school. He studied at the University of Palermo and made important contributions to 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 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 28 July 1928, during a 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's *The Making of the Atomic Bomb*. 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 that later 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.[12] 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.[13]

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 current thinking and the limitations of 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?

Mussolini himself destroyed this possibility through the introduction of racial laws into Italy. Until that time, anti-Semitism in Italy had not had a notable history, despite the anti-Semitic policies of some Popes. The reasons for Mussolini's passage of the laws, despite his own past statements favorable to the Jews, are still unclear. The effect of the laws on Italian science, however, have accurately been described as nothing less than "devastating". They caused irreparable damage to the fields of chemistry, biology, medicine, and mathematics.[14] In physics, they caused the emigration of Enrico Fermi, married to a Jewish woman, one of the world's foremost practitioners of quantum mechanics and Italy's most important researcher in that field.[15] When the person who had first split the uranium atom left, along with most of his group – thanks to the Duce's racial and totalitarian policies – no possibility of building a nuclear weapon could ever exist in Italy.

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 – as well as 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 Segrè 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 dictatorships in prewar Europe has not been explored in Italy's case, 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 remains 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, in fact, they approved of the visit. 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.[16]

The letter is marked "No" by Mussolini.

Italian Scientists and the Regime

This incident bring up the question of Fermi's view of Fascism, and more broadly, how Italian scientists saw Fascism and—considering the momentous occurrences in physics that would lead to development of an atomic weapon—how Mussolini viewed science.

According to Emilio Segrè, Enrico Fermi was "neutral" with regard to Fascism until 1934 (or 1933), when he became "hostile" to it.[17] Dedicated to his physics, for Fermi everything was secondary to it. He was very practical and refused to get into battles without the certainty of winning. He knew his worth and "DID NOT WANT TO WASTE TIME." He was almost always right, but his attitude displeased colleagues attempting to win better professional positions. Summing up Fermi's style: "No force in the world could ever induce him to do something that [he believed] was not just after a dispassionate, careful, and profound investigation made him conclude that something was just."

The great scientist was very reserved and did not like to "waste time in political discussions and kept his opinions to himself." Segrè portrays him as very severe in his professional attitudes, even towards his closest collaborators. If he were sitting on a committee to judge candidates for a professorship or promotion, it was imperative that a person present his best work, "or else you didn't get his vote, period." When Fermi praised you, however, "it was like hearing the voice of God." Because of his devotion to physics, Segrè believed that Fermi would have left Italy even if the racial laws affecting his wife and her family had never been passed.[18]

On the other hand, all of the Via Panisperna scientists had been turned off by Fascism by the time they were doing their best research, and thus contemplated emigration, especially to the United States. They quickly concluded that Mussolini was headed for a war which it would lose, or that Italy would end up as Nazi Germany's handmaiden, which they considered worse. With the quality

of their work gaining worldwide recognition, they received invitations from famous labs all over the world. Franco Rasetti seems to have initiated Italian scientific interest regarding employment in the United States. Rasetti, who had participated in Mussolini's March on Rome as a member of the Fascist squads, later turned against Fascism. After a visit to Cal Tech, he returned to Italy so enthusiastic about the United States that he purchased a Ford. Fermi had been a visiting professor at the University of Michigan (Ann Arbor) in 1930 and had reached similar conclusions.

Segrè, a Jew whose father had been sympathetic to Fascism, was indifferent until 1929 and 1930, when he visited Holland and Germany on a Rockefeller grant. In Holland, he found many critics of the Duce, and in Hamburg the nationalist fanaticism of the youth and the criticism that the Italian consul general made of his own country induced him to turn against Fascism, even if it was conveyed through the passive opposition expressed by most scientists. In 1933, he became convinced that he would have to leave Italy. By 1938 he was professor at the University of Palermo – where there were many anti-Fascists among the faculty – but the racial laws of later that year induced him into doing research at the University of California at Berkeley, where he would eventually teach. Prudently, he had arranged for a visa for his wife and son Claudio and immigrated to the United States.

Their patron, Orso Mario Corbino, also not a card-carrying Fascist, had lost his position as a minister on account of Mussolini's opposition. Occasionally he would describe the affair to the Via Panisperna group and refer to the Fascists in ironic and humorous ways that, however, would make the scientists reflect about the mistaken direction their country had taken. With regard to the great discoveries of the Rome group, Mussolini cared little or nothing, except where he thought his regime could win some favourable publicity. In the light of how much faith the Duce would have during World War Two in the Nazi discovery of a "secret weapon" to win the war, it is ironic that he alienated the scientists who – perhaps in conjunction with the Germans – might have given the Axis an atomic weapon. He turned down Fermi's request for the establishment of a national physics institute, and a bored Senate scarcely listened to Corbino's reports on the meaning of the Rome group's scientific discoveries.

Indeed, Mussolini's techniques encouraged scientists to lie to him. The Fascists were particularly interested in chemistry, which they considered more practical than physics. Asked to analyse a mineral for the presence of manganese by an official, the chemist who worked with Fermi, Oscar D'Agostino, said that there was a high percentage simply because that was what the regime wanted to hear in order to reinforce its policy of "autarky", or self-sufficiency. The newspapers gave great play to this "finding". The same thing happened in the case of aluminum.[19]

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

When the Italian scientists made their most important discoveries, they did not realise 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 scientific 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 to break 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. He had a habit of scribbling his research on the back of his cigarette packs and then throwing away the empty packs. At a time when electrons were thought to inhabit the nucleus, he developed a model of the nucleus as containing neutrons and protons, and analysed 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 increasingly withdrew 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? And if he committed suicide, why did he withdraw several months' pay, a significant amount of cash, and take out a passport before he disappeared? Did he retire to a monastery, or flee to Argentina?[20]

Those who might be sceptical of the depth of feeling against the possible military uses of scientific research would do well to consider the story of Franco Rasetti, Fermi's "Cardinal Vicar" and outstanding experimentalist. Dying on 5 December 2001, at over age 100, he was the most long-lived of the "ragazzi". 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.[21]

Rasetti's colleague Emilio Segrè 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 with Owen Chamberlain for the discovery of the antiproton. Segrè, the most literate of the "Via Panisperna Boys," left an autobiography, in addition to books on the history of science and his memoirs of Fermi.

On the surface, Segrè 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."[22] Emilio Segrè himself wrote that things in the United States were not easy for immigrants and that there were serious obstacles; immigrants had to be quite a bit better than the local competition. [23] In his views of

Americans, even educated ones, we note the elitist attitudes of a European intellectual. Segrè, 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 needing to be examined and applied to the other intellectuals forced to emigrate from Fascist Italy.

Bruno Pontecorvo, like Segrè 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 Britain. In 1950, he was working at Harwell, the British atomic research centre 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 later resurfaced in the Soviet Union. The Pontecorvo case was one of the most sensational episodes in the early Cold War. Was he a spy? Emilio Segrè recalls that he and his colleague Giuseppe Occhialini were instrumental in getting Pontecorvo a job in Tulsa after he was forced to flee Paris on a bicycle to escape the invading Nazis. "Fermi, always astute and intelligent, did not lift a finger to help him…." Segrè states that he saw nothing strange about Pontecorvo's politics until 1948 when, on a visit to Berkeley, "Pontecorvo's wife burst into tears and Pontecorvo himself went to Mexico." The result: the police grilled Segrè and Occhialini. Segrè writes that he did not know when Pontecorvo was converted to Communism and that his old colleague's flight to the Soviet Union also surprised him. Segrè speculates that French scientist Frederic Joliot influenced Pontecorvo's conversion.[24]

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.[25]

Pontecorvo lived in the USSR for the next forty years, where he introduced Fermi's school of physics. Many questions persist regarding his defection and the reasons for it. Pontecorvo is still routinely described as a spy, yet did he have any secrets to offer? 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.[26]

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 encountered amongst 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 weapons for Fascist Italy. The ALSOS mission to Italy confirmed that the Italian scientists were not working on the bomb.[27]

After the war Amaldi did rebuild Italian nuclear physics, but within a European context. He contributed to the process by which Italian physicists played a substantial role in nuclear research across Europe, despite the prohibition against such research by the Allies after 1945. 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. [28]

A Strange New World

In accounts of the Atomic Bomb and early postwar physics in the United States, Enrico Fermi remains 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 with respect to 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 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 indeed, exceeded it. Fermi's research aimed at discovering whether a self-sustainable, controlled chain reaction would occur in practice, as well as in theory. On 2 December 1942, in Chicago, Fermi proved it would, and in so doing, revolutionised 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.[29] His friend Segrè and Glenn T. Seaborg developed the more easily produced and fissionable plutonium. Soon thereafter, 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 favour of Oppenheimer, while Teller was equivocal. When Fermi was dying, he criticised Teller and his behaviour over 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."[30] Nonetheless, 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 centred 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 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 called Fermi Mussolini's greatest gift to America, and wrote what could only be the former's obituary: "He was a man of peace, but the necessities of our times turned his talents and his discoveries to the art of war." [31]

Notes

1. Roberto Maiocchi, *Gli scienziati del Duce* (Rome: Carocci, 2003), p. 125.
2. Gerald Holton, *The Scientific Imagination: Case Studies* (Cambridge, UK: Cambridge University Press, 1978), pp. 155-98.
3. The incident is discussed in Laura Fermi, *Atoms in the Family: My Life With Enrico Fermi* (Chicago: The University of Chicago Press, 1954), pp. 89-90.
4. Emilio Segrè, *From X-Rays to Quarks: Modern Physicists and Their Discoveries* (New York: Freeman, 1980), pp. 204-05.
5. Denis Brian, *Einstein: A Life* (New York: Wiley, 1996); a caption under a photograph of an Einstein news conference in Pittsburgh on December 28, 1934, following p. 240. On the "fantasy" remark, see p. 240.
6. Letter of Emilio Segrè to Renzo De Felice, in Carte Renzo De Felice, Archivio Centrale dello Stato, Carte Renzo De Felice, busta 2, fascicolo 1, sottofascicolo 14, p. 9, note 5.
7. On Corbino, see Emilio Segrè, *Enrico Fermi: Physicist* (Chicago: University of Chicago Press, 1972), pp. 27-30.
8. Cited in ibid, p. 26.
9. Ibid., pp. 1-24.
10. Fermi (note 3), pp. 33-39; 55-75.
11. Segrè (note 7), pp. 76; 99.
12. See Deborah Crawford, *Lise Meitner: Atomic Pioneer* (New York: Crown Publishers, 1969), pp. 132-140.
13. See Emilio Segrè, *A Mind Always in Motion* (Berkeley and Los Angeles: University of California Press, 1993), pp.251-53.

14. Giorgio Israel and Pietro Nastasi, *Scienza e razza nell'Italia fascista* (Bologna: Il Mulino, 1998), pp. 315-17.
15. Roberto Maiocchi, *Scienza e fascismo* (Rome: Carocci, 2004), pp. 64-67.
16. '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', Archivio Centrale dello Stato, Segreteria Particolare del Duce, busta 189723.
17. "Appunto di Emilio Segrè," Archivio Centrale dello Stato, Carte Renzo De Felice, busta 3, Fascicolo 2.
18. For these thoughts, see ibid., as well as the letter in Archivio Centrale dello Stato, Carte Renzo De Felice, busta 2, fascicolo 1, sottofascicolo 14, pp. 8-9. [Note: For the statement regarding Fermi's refusing to do anything he believed was unjust, there is an obvious typographical error in the manuscript, p. 8, the sentence beginning line 5 from the bottom.]
19. The material in the previous paragraphs is from Segrè's manuscript in Archivio Centrale dello Stato, Carte Renzo de Felice, busta 2, fascicolo 1, sottofascicolo 14.
20. For the issues involved, see Leonardo Sciascia, *La scomparsa di Majorana* (Turin: Einaudi, 1975). For an examination of the disappearance, see Bruno Rossi, *Ettore Majorana: un giorno di marzo* (Palermo: Flaccovio, 1997).
21. Cited by Edoardo Amaldi, *Da Via Panisperna all'America* (Rome: Riuniti, 1997), eds., Giovanni Battimelli and Michelangelo De Maria, p. 37, my translation.
22. Claudio Segrè, *Atoms, Bombs and Eskimo Kisses* (New York: Viking, 1995), p. 93.
23. Archivio Centrale dello Stato, Carte Renzo De Felice, busta 2, fascicolo 1, sottofascicolo 14, p. 5.
24. Ibid.
25. Emilio Segrè (note 13), pp. 244-46.
26. For an indication of Pontecorvo's life, although not on his "defection," see Bruno Pontecorvo, *Enrico Fermi: Ricordi di allievi e amici* (Pordenone: Studio Tesi, 1993).
27. See Thomas Powers, *Heisenberg's War: The Secret History of the German Bomb* (New York: Da Capo, 2000), pp. 306-06.
28. On these problems and the letters, see Amaldi (note 21).
29. These issues are discussed by Richard Rhodes in *The Making of the Atomic Bomb* (New York: Simon and Schuster, 1986) and in *Dark Sun: The Making of the Hydrogen Bomb* (New York: Simon and Schuster, 1995).
30. Emilio Segrè (note 13), p. 251-52. In contrast to Segrè, Teller indicates a friendly relationship with Fermi. See Edward Teller and Judith Shoolery, *Memoirs: A Twentieth-Century Journey in Science and Politics* (New York: Basic Books, 2001).
31. Letter to *The New York Times*, published December 3, 1954.