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Bruno Rossi and the Racial Laws of Fascist Italy

Luisa Bonolis*

Bruno Rossi (1905–1993), one of the giants of 20th-century physics, was a pioneer in cosmic-ray physics and virtually every other aspect of high-energy astrophysics. His scientific career began at the University of Florence in 1928 and continued at the University of Padua until 1938, when the Fascist anti-Semitic racial laws were passed in Italy. He was dismissed from his professorship and was forced to emigrate, as described in unpublished letters and documents that display the international character of physics and physicists. His young bride Nora Lombroso, his love of physics, and the solidarity of the physics community gave him the courage to begin a new life in Copenhagen, Manchester, and in the New World at the University of Chicago, Cornell University, Los Alamos, and after the Second World War at the Massachusetts Institute of Technology where he became the center of a worldwide research network.

Key words: Bruno Rossi; Nora Lombroso; Enrico Fermi; Benito Mussolini; Antonio Garbasso; Sergio De Benedetti; Walther Bothe; Robert A. Millikan; Arthur H. Compton; Niels Bohr; Hans A. Bethe; Patrick M.S. Blackett; Arcetri; University of Florence; University of Padua; Niels Bohr Institute; University of Manchester; University of Chicago; Cornell University; Los Alamos; Massachusetts Institute of Technology; Fascism; anti-Semitism; racial laws; Society for the Protection of Science and Learning; Rossi coincidence circuit; cosmic rays; mesotrons; X-ray astronomy; solar wind; internationalism of physics; history of physics.

Introduction

Bruno Rossi (1905–1993, figure 1) opened the Preface of his 1990 autobiography, *Moments in the Life of a Scientist*, with the words:

> At this time, when recent developments have brought science to a prominent position both in the cultural life and in the everyday life of our society, it is of interest to recall the activities of scientists in the years when the foundations of these truly revolutionary developments were laid.
>
> I was one of these scientists.[1]

* Luisa Bonolis received her Ph.D. degree at the University of Bari in 2009. Her research is on the history of 20th-century physics, in which she has published books and articles and edited collections of oral-history interviews.

Fig. 1. Bruno Rossi (1905–1993). *Credit*: American Institute of Physics Emilio Segrè Visual Archives, Physics Today Collection.

Rossi was conscious of being one of the physicists who had upset our view of the universe and had changed the course of human history, being both one of the victims of tyrants and one of the makers of horrific new weapons. His life and scientific career were tightly entangled with earthshaking historical developments. Between the beginning of 1930 and the fall of 1938, a period full of "ironies of wonder and of fear,"[2] Rossi became an internationally well-known scientist. Mussolini then joined Hitler in his mad desire to conquer the world, and with the outbreak of war in Europe in 1939 millions of people were faced with a terrible destiny.

The Italian Years: Cosmic rays and Particles in the 1930s

In the early 1930s, as Enrico Fermi (1901–1954) was building up a research group in nuclear physics in Rome, Bruno Rossi was building up a research group in cosmic rays in Florence. He had studied two years at the University of Padua and another two years at the University of Bologna where he received his doctoral degree in physics *summa cum laude* at the end of 1927. Then, in early 1928, he became assistant to the professor of experimental physics at the University of Florence whose birth as a modern university had taken place only four years earlier. Its Physics Institute was located on the Arcetri hill, about three kilometers outside of and at least one-hundred and meters above the city, and close to the Villa Il Gioiello, where Galileo Galilei (1564–1642) spent the last four years of his life. Its Director was Antonio Garbasso (1871–1933), who had studied under Heinrich Hertz in Bonn, Germany, and Herman von Helmholtz in Berlin. Rossi's few students at Arcetri were not much younger than he himself was, so his relationship to them was very informal. The twenty-three-year-old Rossi was eager to begin work on some experimental project that would lead to "the discovery of some secret of nature" and solve some of "the fundamental problems of contemporary physics."[3]

During his first two years in Arcetri, Rossi's research had no clear focus. Then a paper by Walther Bothe (1891–1957) and Werner Kolhörster (1887–1946) on the

nature of the extraterrestrial penetrating radiation appeared,[4] which was "like a flash of light revealing the existence of an unsuspected world, full of mysteries, which no one had yet begun to explore."[5] They had presented evidence that this radiation, which the American physicist Robert A. Millikan (1868–1973) had dubbed "cosmic rays,"[6] was not gamma radiation, as Millikan and most physicists believed, but charged particles. This cosmic radiation had a penetrating power far exceeding that of the gamma rays emitted by radioactive substances, and since gamma rays could eject electrons from atoms by the Compton effect,[7] it was expected that in passing through matter they would produce a flow of "soft" secondary electrons, which after passing through an absorber would be detected by a Geiger-Müller counter. Bothe's innovation was to place one Geiger-Müller counter above another one, with a 4.1-centimeter layer of gold between them and then record the coincidences between the two counters.* Since Compton electrons have a low penetrating power they should be completely absorbed by a very thin layer of gold, but to their great surprise they found that 76 percent of the charged particles present in the cosmic radiation near sea level could penetrate 4.1 centimeters of gold. Bothe and Kolhörster concluded that the charged particles constituting the penetrating cosmic rays could not consist of Compton electrons—which greatly aroused Rossi's curiosity:

> Here lay before me a field of inquiry rich in mystery and promises. Working in a field of this kind had been my dream. Now it seemed that this dream was coming true.[8]

Bothe and Kolhörster's innovative use of the Geiger-Müller counter had opened up "a new technological window," and Rossi now set about designing and making a coincidence circuit that combined Geiger-Müller counters and electronic tubes—which constituted the first use of Geiger-Müller counters in Italy and soon thereafter also would play a crucial role in Fermi's discovery of neutron-induced artificial radioactivity.[9] The Rossi coincidence circuit (figure 2),[10] as it soon was called, thus was a crucial invention for both experimental cosmic-ray and nuclear-physics research. In the former, by recording the passage of a charged particle through successive Geiger-Müller counters it served as a *telescope* for observing cosmic rays. Rossi thus inaugurated a research program that from the outset aimed at proving their corpuscular nature and determining their properties.

Rossi first used an electromagnet to verify that cosmic rays carry an electric charge and to determine its sign, and then conjectured that besides the predicted latitude effect, that is, that the intensity of cosmic rays should vary with geomagnetic latitude, there should be an *east–west* effect, that is, there should be an asymmetry in their intensity relative to the geomagnetic meridian, with more

* Bothe later shared the Nobel Prize in Physics for 1954 "for the coincidence method and his discoveries made therewith"; see The Nobel Foundation, *Nobel Lectures. Physics 1942–1962* (Amsterdam, London, New York: Elsevier Publishing Company, 1964), p. 251.

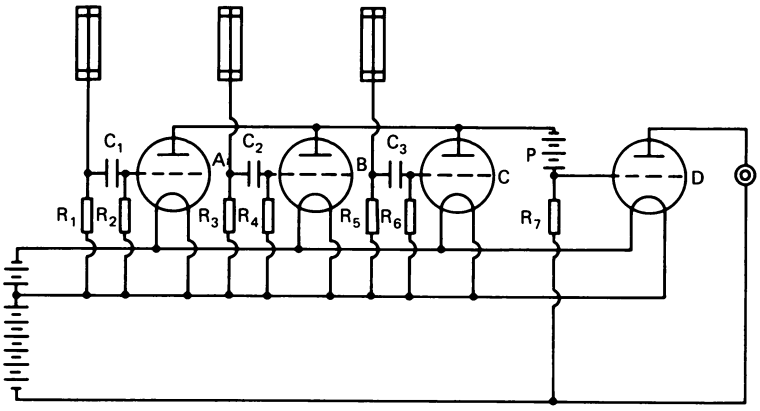

Fig. 2. Rossi's coincidence circuit, the first fast electronic coincidence circuit of the parallel type, became essential in cosmic-ray research. It allowed the simultaneous registration of electrical pulses from any number of Geiger-Müller counters and had a resolving time of 10^{-3} second, an order of magnitude faster than Walther Bothe's coincidence circuit. The plates of the three triodes *A*, *B*, and *C* are connected together and to the positive terminal of a battery *P* whose negative terminal is grounded through the resistance R_7. The grids of the three triodes are coupled electrostatically to the central wires of the three Geiger-Müller counters. The grids of the three triodes in a normal state are grounded, so a current then flows in them and in their common plate resistor R_7, and the potential drop through it holds the grid of the triode *D* at a negative potential, thus inhibiting the plate current. If a charged particle enters one of the Geiger-Müller counters and causes it to discharge, then the corresponding grid will experience a negative potential and the plate current will stop. If this happens in one or two of the triodes, then the current in the third one will still experience a potential drop in the ground resistor R_7, and the current in the triode *D* will still be inhibited. Only when all three Geiger-Müller counters discharge simultaneously will the current in the resistor R_7 stop, bringing the grid of the triode *D* to ground potential and starting a current flow in it. *Source*: Rossi, "Method of Registering" (ref. 10), p. 636.

cosmic rays going from east to west, or from west to east, depending upon the sign of their charge. He attempted, unsuccessfully, to detect this effect at Arcetri and then, in the summer of 1930, realizing that it would be more pronounced at low latitudes and high altitudes, he planned an expedition to Asmara, the capital of the Italian colony of Eritrea at a latitude of 11°30′ N and an altitude of 2,370 meters, but was delayed owing to logistical problems. Three years later, he and Sergio De Benedetti did lead an expedition there, but just before they left Arcetri two Letters to the Editor of the *Physical Review* appeared, one by Thomas H. Johnson,[11] the other by Luis Alvarez and Arthur H. Compton,[12] reporting their observations of an east-west effect in Mexico City. Since Rossi had predicted this effect three years earlier, he was particularly upset when both Johnson and Alvarez and Compton cited for that prediction a paper that Georges Lamaitre and Manuel S. Vallarta had published in January 1933,[13] an "oversight" that Alvarez later acknowledged in a letter to him.[14] In any case, Rossi and De Benedetti now observed that "chance coincidences" occurred when their Geiger-Müller counters

were separated by large distances—which was the first observation of the extensive cosmic-ray showers that Pierre Auger and his collaborators studied in detail a few years later.

In parallel with his cosmic-ray research, from the middle of December 1931 to the end of September 1932, Rossi entered the field of microphysics by carrying out a series of remarkable experiments to determine both the absorption curve of cosmic rays in metal sheets and the nature of the soft secondary radiation they produced in them. His experiments involved changing the geometric arrangement of Geiger-Müller counters and metal sheets to create a series of "traps" to reveal the behavior of cosmic-ray particles when they interacted with matter. Thus, using the triangular array of Geiger-Müller counters inside a thick lead shield shown in figure 3, he found that cosmic rays produce strong secondary corpuscular radiation, even though that could not be explained by any known process.[15] He then changed the positions of the Geiger-Müller counters, placing sheets of various metals above and below them at various distances, and inserting absorbing screens

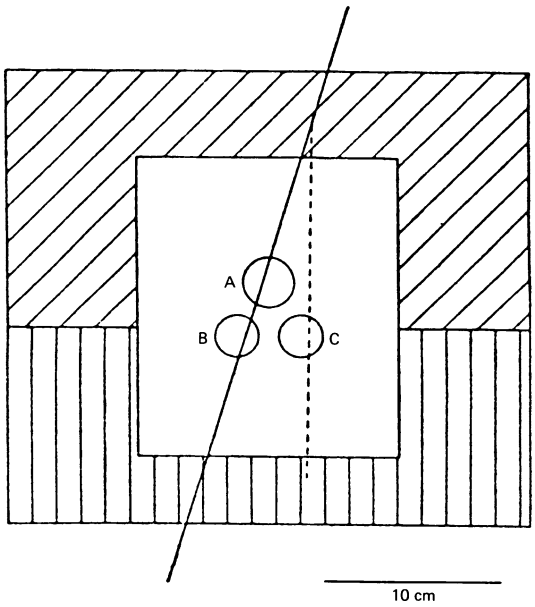

Fig. 3. Rossi's triangular array of three Geiger-Müller counters *A*, *B*, and *C*. Coincidences between all three are produced only when cosmic rays produce groups of secondary particles in the lead shield above them. Removing that shield reduces the number of coincidences considerably. At least two charged particles emerging simultaneously from this lead shield are required to produce a coincidence because a single particle moving in a straight line could not traverse all three of the Geiger-Müller counters. One of the two particles then might be a primary cosmic-ray particle, but the other one must have been generated in the lead shield above them. *Source*: Rossi, "Nachweis einer Sekundärstrahlung" (ref. 15), p. 305.

at various positions (figure 4). His results suggested the existence of two cosmic-ray components at sea level, a "hard" component that was able to pass through one meter of lead after being filtered through a metal screen ten centimeters thick,[16] and a previously unknown "soft" component that produced groups of particles in metal screens before being absorbed. He synthesized his results in a curve that became universally known as the "Rossi curve," which showed how the coincidence rate of the three Geiger-Müller counters in a triangular array depend on the thickness of layers of lead and iron (in mass per unit area) placed above them.[17]

Fermi, who was becoming a center of attraction for young physicists, held Rossi's pioneering experimental researches in the highest esteem, as did other theoretical physicists, notably including Hans Bethe, an expert on the interaction of radiation and matter who spent several months with Fermi in Rome in 1931–1932 and also visited Rossi in Florence. Werner Heisenberg also was greatly interested in Rossi's work, which he cited warmly in a 1932 article on cosmic rays.[18] In the late 1930s, Heisenberg and Wolfgang Pauli probed the foundations

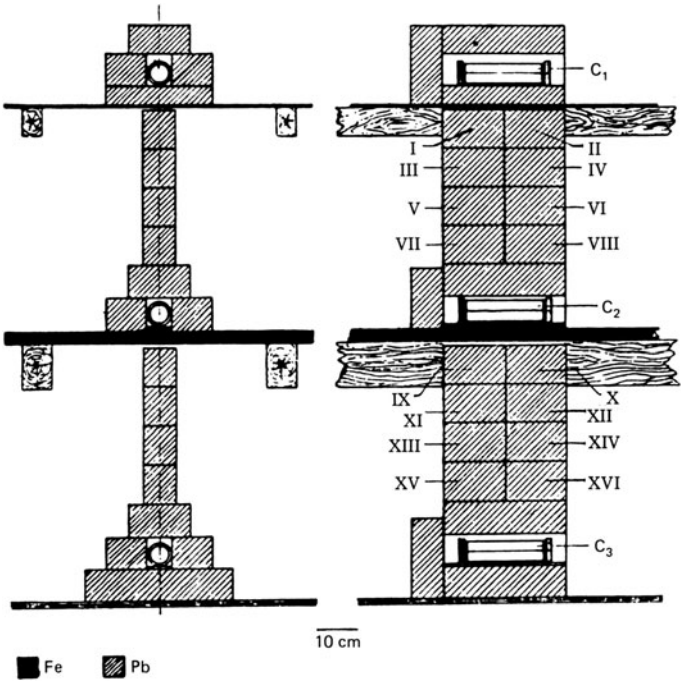

Fig. 4. Rossi's experimental arrangement in which he observed coincidences in the three Geiger-Müller counters C_1, C_2 and C_3, with a layer of lead fifty centimeters thick between counters C_1 and C_2 and between counters C_2 and C_3, thus proving that half of the cosmic-ray particles that could traverse ten centimeters of lead could still pass through a layer of lead one meter thick. *Source*: Rossi, "Über die Eigenschaften" (ref. 17), p. 154.

of quantum electrodynamics, and since the divergence difficulties that arose appeared to be related to high-energy cosmic-ray processes, Rossi's experiments then also were of the greatest interest to them and other theorists.

Rossi had met Heisenberg in the summer of 1930 when Antonio Garbasso had obtained a travel grant for Rossi to enable him to spend that summer in Bothe's laboratory in the Physikalich-Technische Reichsanstalt in Berlin, and Heisenberg had traveled from Leipzig to attend one of the weekly seminars at the University of Berlin.[19] Then, after Rossi returned to Florence that fall, Heisenberg exchanged letters with him, asking him about his work in some detail as he was writing his 1932 article on cosmic rays. Conversely, Heisenberg came to Rossi's aid when Rossi submitted a short note on his experiments on the production of secondary radiation to a German journal, probably *Die Naturwissenschaften*, which rejected it for publication. As Rossi recalled many years later: "The paper was then accepted by *Physikalische Zeitschrift* after Heisenberg had vouched for my credibility."[20]

That Fermi valued Rossi's cosmic-ray experiments highly became apparent when he organized the first fully international conference on nuclear physics in Rome from October 11–18, 1931 (figure 5),[21] which was sponsored by the Royal Academy of Italy (*Reale Accademia d'Italia*) and supported by the Alessandro Volta Foundation.* Fermi asked Rossi to talk on the problems associated with cosmic rays on its fourth day, October 14, and after presenting its general aspects Rossi tackled the hottest issue, the origin and nature of cosmic rays, explaining in detail why he thought that Millikan's view, that cosmic rays consist of extremely high-energy gamma rays,[22] could not be correct,[23] a view that Walter Bothe strongly supported.[24] Rossi recalled:

> Millikan [figure 6] clearly resented having his beloved theory torn to pieces by a mere youth, so much so that from that moment on he refused to recognize my existence…. On the other hand my talk roused the interest of Arthur Compton who previously had not worked on cosmic rays. Years later he was kind enough to tell me that his interest in cosmic rays was born from my presentation.[25]

The Rome conference thus "marked the beginning of the historical debate about the nature of cosmic rays…."[26] Less than two years later, at the beginning of 1933, Fermi (figure 7) presented a paper written in collaboration with Rossi to the *Accademia dei Lincei* on the influence of the Earth's magnetic field on cosmic rays,[27] which offered the possibility of determining the sign of the charge of the primary cosmic-ray particles, then thought to be fast electrons although, as they pointed out, they also might be protons.

* Duce Benito Mussolini opened the conference and inaugural lectures were delivered by its Honorary President, Senator Guglielmo Marconi, and its Effective President, Senator Orso Mario Corbino.

Fig. 5. Participants in the first fully international conference on nuclear physics in Rome from October 11–18, 1931, with those mentioned in the text in **boldface**. Foreground (*left to right*): Otto Stern (1888–1969), Peter Debye (1884–1966), Owen W. Richardson (1879–1959), **Robert A. Millikan (1868–1973)**, **Arthur H. Compton (1892–1962)**, Marie Curie (1867–1934), **Guglielmo Marconi (1874–1937)**, **Niels Bohr (1885–1962)**, Francis W. Aston (1877–1945), **Walther Bothe (1891–1957)**, **Bruno Rossi (1905–1993)**, and Lise Meitner (1878–1968, obscured). Behind Stern and Debye is **Werner Heisenberg (1901–1976, obscured)**, Léon Brillouin (1889–1969), **Patrick M.S. Blackett (1897–1974, above Brillouin)**, and John S.E. Townsend (1868–1957). Between Curie and Marconi is Jean Perrin (1870–1942) and behind him is Paul Ehrenfest (1880–1933) and **Enrico Fermi (1901–1954)**. In the row just above Ehrenfest (not the top row) and to his left is (*left to right*) Emil Rupp (1898-1979), Quirino Majorana (1871–1957), and **Antonio Garbasso (1871–1933**). Above Marconi is **Orso Mario Corbino (1876–1937),** above Bohr is Giulio Cesare Trabacchi (1884–1959), and above and to the right of Aston against the wall in profile is **Franco Rasetti (1901–2001)**. Behind and to the left of Meitner is Arnold Sommerfeld (1868–1951). Among those missing from the photograph are **Hans Geiger (1882–1945)**, **Wolfgang Pauli (1900–1958)**, and Léon Rosenfeld. *Source*: Reale Accademia d'Italia, *Atti dei Convegno* (ref. 21), frontispiece.

In June 1932 Rossi won a competition that resulted in his appointment as Professor of Experimental Physics at the University of Padua. Fermi, who was a member of the judging commission and was fully aware of the impressive amount of pioneering work that Rossi had carried out in the preceding two years, chose Rossi as his candidate over his own first student and close collaborator, Emilio Segrè. By that time, nuclear physics was undergoing fundamental transformation. Harold C. Urey had discovered deuterium in December 1931;[28] James Chadwick

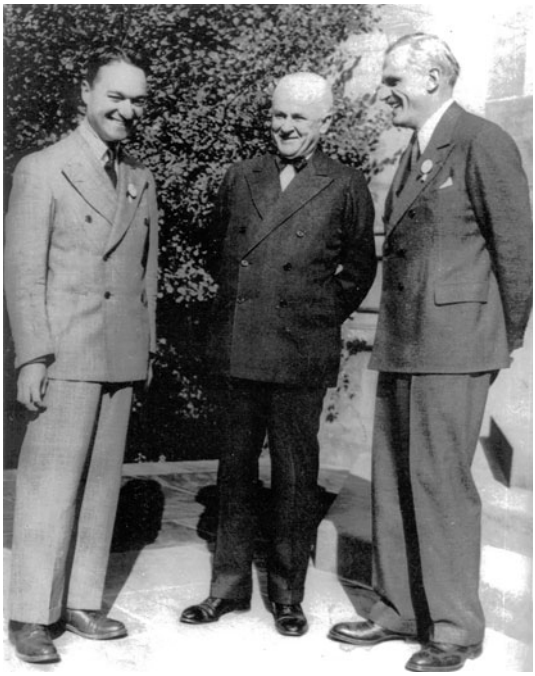

Fig. 6. Bruno Rossi (1905–1993), Robert A. Millikan (1868–1973), and Arthur H. Compton (1892–1962) at the Rome conference, October 11–18, 1931. *Credit*: Amaldi Archives, Dipartimento di Fisica, Università "Sapienza" Rome.

Fig. 7. Bruno Rossi (1905–1993) and Enrico Fermi (1901–1954). *Credit*: Reproduced by permission of Nora Lombroso Rossi.

had discovered the neutron in February 1932;[29] Ernest O. Lawrence and John D. Cockcroft and Ernest T.S. Walton had invented new particle accelerators that same month;[30] and Carl D. Anderson, Millikan's student at the California Institute of Technology, would report the existence of another new particle, the positive electron, in August 1932.[31] Anderson built a cloud chamber and placed it in a strong magnetic field, "and in the very first experiments, it became clear that … something new was happening."[32] Then, in the summer of 1932, he hit on the brilliant idea of inserting a thin lead plate (thickness 6 millimeters) through the center of his cloud chamber, and of the thousands of cloud-chamber photographs he took, one revealed a track whose curvature was opposite to that produced by a negatively charged electron. The following March Patrick M.S. Blackett and Rossi's former student, Giuseppe ("Beppo") P.S. Occhialini (figure 8),[33] working at the University of Manchester, published a paper containing many cloud-chamber photographs that showed tracks of particles of positive charge and electronic mass,[34] and thus established a firm connection to Paul A.M. Dirac's prediction of the existence of an "anti-electron." Rossi then recognized that these

Fig. 8. Giuseppe ("Beppo") P.S. Occhialini (1907–1993) and Patrick M.S. Blackett (1897–1974) in 1932 or 1933. *Credit*: Giuseppe Occhialini and Constance Dilworth Archive, Università degli Studi di Milano.

were unquestionably the cause of the coincidences he had observed between his out-of-line Geiger-Müller counters.

The existence of antimatter, as Blackett and Occhialini noted, explained the materialization of matter through the creation of electron-positron pairs and thus the formation of cosmic-ray showers, a cascade process that begins with an electron radiating a high-energy photon, the photon then materializing into an electron-positron pair, the new and original electrons radiating more photons, and so on.[35] This cascade process, however, left completely open the origin of the hard component of cosmic rays, a corpuscular radiation that at sea level could traverse more than one meter of lead, as Rossi had observed in 1932.[36] Five years later, J. F. Carlson and J. Robert Oppenheimer concluded that these particles had "to be ascribed to the presence of a penetrating component other than electrons and photons," that in fact they had to be "particles not previously known to physics."[37] Seth Neddermeyer and Anderson then found experimentally that "there exist particles of unit charge, but with a mass (which may not have a unique value) larger than that of a normal free electron and much smaller than that of a proton…."[38] Their mass was soon accepted to be about 210 electron masses, and they soon were named mesotrons. Their discovery represented a new chapter in particle physics, to which Rossi eventually made important contributions. Meanwhile, in 1935, he published a monograph in which he compiled the results of his work to date on cosmic rays.[39]

The "Disaster of Physics in Italy"

After moving from Arcetri to the University of Padua as Professor of Experimental Physics in 1932, Rossi's increased duties prevented him from devoting full time to research, as he had in his Florentine golden years. He enjoyed teaching and devoted much of his time to it in Padua, and he also became deeply involved in planning and supervising the construction and equipping of his new Physics Institute there. At the same time, he was working under both ominous political clouds and bright personal skies.

> Several circumstances hampered my scientific activity after the mid-1930s. Foremost among them was a growing concern over political events, which prevented me from focusing my mind on problems of physics….
>
> The sky over Europe was dark and becoming darker day by day. But, in the midst of the pervading gloom, my own horizon was growing brighter. I saw Nora [Lombroso] for the first time in Venice, at the wedding of one of her cousins…. Some time later, in 1937, we chanced to meet at the Lido, where she was spending her summer vacations…. We were married the following April….[40]

At first the young couple closed their eyes to "what was going on around them" and began arranging their life together, renting an apartment, furnishing it, and "making plans for what we thought would be our life in Padua."[41] His new Physics

Fig. 9. Bruno Rossi's new Physics Institute at the University of Padua. *Source*: Bruno Rossi, "Il nuovo Istituto di Fisica della R. Università di Padova," *La Ricerca Scientifica* **1** (1937), 220–227, on 226.

Institute (figure 9) was inaugurated in 1937, and Rossi proudly recalled that it "won the praise of whoever saw it."[42] It was particularly well equipped: He designed a large seven-ton electromagnet for deviating charged particles, built a cloud chamber, and began to construct a one-million-volt Cockcroft-Walton accelerator, the first one of this type in Italy along with one in Rome. His Physical Institute also included a twenty-nine-meter tower that was well equipped and suitably isolated for studying cosmic rays. Franco Rasetti, visiting from Rome, exclaimed:

> This is indeed a physics institute, not [a work of the fascist regime] an *Opera del Regime*!" But the story of the Institute had a sad ending, for, a short time after its opening, its doors were shut to me by the anti-Semitic laws. Others would use my Institute, but, as far as I was concerned, the time and effort I had spent in creating it had been wasted.[43]

In Germany, the Law for the Restoration of the Professional Civil Service* was passed on April 7, 1933,[44] compelling the dismissal of non-Aryan and politically unreliable professors and other civil servants from their positions, and the Law for the Protection of German Blood and German Honor** and the Reich Citizenship Law, the Nuremberg Laws, were passed on September 15, 1935,[45] banning all Jews from citizenship. The Nazi fist closed ever tighter. In November 1937, for example, the German Minister of Education Bernhard Rust declared that the journal *Nature* "must be expelled from general use in scientific libraries."[46]

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* *Gesetz zur Wiederherstellung des Berufsbeamtentums*.

** *Gesetz zum Schutze des deutschen Blutes und der deutschen Ehre* and *Reichsbürgergesetz*.

In Italy, its forty thousand Jews (in a population of forty-three million) had been fully integrated into Italian society, but that now changed dramatically. Hitler visited Italy in the spring of 1938, and soon thereafter Mussolini and the Fascists fully endorsed and supported Germany's anti-Semitic policies. They began with the *Manifesto della razza* [Manifesto of race] that Italian "scientists" issued on July 14, 1938. The Hungarian physicist Leo Szilard, with his usual foresight, saw it all coming, for exactly one day earlier, on July 13, Emilio Segrè had disembarked in New York on his way west, and he recalled that Szilard, whom he had met a few years earlier in England,

> came to see me off at Grand Central Station on my departure for San Francisco. He inquired about my plans, which I detailed to him. When I told him I expected to return to Palermo in October, he said that would be impossible because of what Mussolini might be expected to do; Italy might adopt Hitler's racist politics, and in any case, Hitler might start a world war soon.[47]

En route in Chicago Segrè read a short but chilling newspaper account about the *Manifesto della razza*, which was then followed in rapid succession by more draconian edicts, among them ones that deprived Italian Jews of most of their civil rights, expelled them from academic and governmental positions, banned Jewish students from public schools and universities, banned marriages between Jews and Christians, and forbade Jews from owning or managing large corporations. These anti-Semitic laws were accompanied by a violent press and literary campaign, the worst of which was carried out by the journal *La Difesa della Razza* [The Defence of Race] under the editorship of Telesio Interlandi.

In August 1938 Bruno and Nora Rossi, along with friends, including Edoardo and Ginestra Amaldi, Enrico and Laura Fermi, Gilberto Bernardini, and Franco Rasetti, went on vacation to San Martino di Castrozza in the Dolomites. Nora was astonished that, "No one was speaking of politics," as she often did at home, because her family had a strong anti-Fascist tradition. Ginestra and Laura also reserved rooms for their winter vacations there, and they suggested that Nora should as well. She replied that she had no idea of what would happen by then: "Those people appeared not to be really conscious that a major threat was hanging over their heads."[48]

Laura Fermi recalled later that when she had left Rome at the beginning of July there was no sign of the impending racial laws, but when they were still in the Dolomites on September 2 the first wave of them was enacted, prompting her husband Enrico to immediately write letters to four American universities from which he had received offers earlier, posting them in different towns to avoid suspicion.[49] Nora Rossi, with her sensitivity to political issues, was alarmed, and her worries immediately became reality: A series of anti-Semitic decrees were enacted in quick succession: Measures for the Defense of Race in the Fascist School (*Provvedimenti per la difesa della razza nella scuola fascista*) on September 5; Measures Toward Foreign Jews (*Provvedimenti nei confronti degli ebrei stranieri*) on September 7; and Founding of Elementary Schools for Young People of the Jewish Race (*Istituzione di*

scuole elementari per fanciulli di razza ebraica) on September 23. Her husband Bruno recalled that all of them,

> one by one, deprived the Jews of their rights as Italian citizens. Eventually, in September of 1938, I learned that I no longer was a citizen of my country, and that, in Italy, my activity as a teacher and as a scientist had come to an end.[50]

Testimony to the rapid crescendo of these terrible and threatening events is preserved in Rossi's papers in the Massachusetts Institute of Technology Archives, which contain newspaper clippings listing Jews who were expelled from universities, specifying their institutional affiliations and disciplines. He underlined his own name and the main points in these articles in blue or red pencil, thus tracking the increasing horror of the coming tragedy.

Nora Rossi had "a clear perception of the serious danger, which loomed in the future," and insisted that they leave Italy as soon as possible. For Bruno it was not easy to accept the idea that he had to leave "his" Institute.* Along with Rossi, a number of his students and collaborators also had to leave, in particular, Eugenio Curiel, Leo Pincherle, who was a student of Fermi and who taught theoretical and mathematical physics in Padua, and Rossi's assistant Sergio De Benedetti, who left to work with the Frédéric and Irène Joliot-Curie in Paris and then, when the German army occupied France in 1940, immigrated to the United States. To Edoardo Amaldi, this was the "destruction" of the Paduan group of physicists.[51]

It was nearly impossible for Italian Jews to obtain a passport at this time. The infamous Munich Agreement that dismembered Czechoslovakia was signed on September 30, 1938. Thanks, however, to the balance of a fellowship that Rossi had received from the Royal Academy of Italy (*Reale Accademia d'Italia*) in 1932,** Rossi received a sum of money from the Volta Foundation, and an official letter from the Italian Ministry of National Education (*Ministero dell'Educazione*

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* When Bruno Rossi was invited to the celebrations commemorating the 50th anniversary of the inauguration of the Physical Institute of the University of Padua, he still was deeply aggrieved over what he had suffered five decades earlier, and agreed to participate in a ceremony that took place in the Rectorate Great Hall, but refused to enter the Physics Institute. His wife Nora agreed with and deeply respected his decision, even after his death. Thus, in 2005, at the celebrations in Padua of the centenary of her husband's birth, she too did not want to enter the Physics Institute and only agreed to do so following the gentle insistence of Massimilla Baldo Ceolin, who showed her the interior of the Physics Institute and her husband's old chair in Ceolin's room, in which their youngest daughter Linda, full of emotion, sat for some time.

** Rossi wrote to Giancarlo Vallauri, who had succeeded Guglielmo Marconi as President of the Royal Academy of Italy, and on September 1 Rossi received a letter from the Chancellor of the Academy declaring that the Volta Foundation had granted him the fellowship to be used for a "mission" at Bohr's Institute in Copenhagen, Denmark. On October 25 Rossi received a second letter declaring that he would receive its second part of 1,000 lire after the Foundation had received a report on his activity. Rossi used the first part, of 1,840 lire, to leave Italy.

Nazionale) on October 4 saying that the renewal of his passport had been approved, while Nora received one with the help by some old friends in Sicily.[52]

Meanwhile, Rossi had written to Niels Bohr, telling him that he would like to spend some time at his Institute in Copenhagen. Bohr responded immediately with an invitation. He and his brother Harald (figure 10) had been instrumental in establishing the Danish Committee for the Support of Refugee Intellectuals, and Bohr's Institute had become a haven for refugee Jewish physicists. In September 1938, at one of its seminars,

> almost none of the German alumni dared attend. But Enrico Fermi, the leading physicist of Italy, was there. Bohr confidentially told him that he [Fermi] was under consideration for the Nobel Prize…. Fermi then told Bohr that he wanted to leave Italy. Mrs. Fermi was in jeopardy under the racial laws, and Fermi had long disliked Fascism. Fermi said that, if he should receive the prize, he would seek a position in the United States. Bohr at once invited him and his family to

Fig. 10. Harald Bohr (1887–1951) and his older brother Niels Bohr (1885–1962). *Credit*: Niels Bohr Archive; courtesy of American Institute of Physics Emilio Segrè Visual Archives.

> come to Copenhagen following the Nobel ceremonies and there await their transportation.[53]

Bohr was equally thoughtful and helpful in Rossi's case.

On October 10, 1938, the Rector of the University of Padua informed Rossi that his services were no longer needed:

> Prof. Bruno Rossi
> Subject: Defense of race in the fascist school
> In compliance with art. 3 of the king's decree of law n. 1390 dated September, 1938, which deals with measures for the defense of race in the fascist school, it is my duty to advise you that, as of October 16, you are suspended from service.
>
> The Rector
> (signed [Carlo] Anti)[54]

Nora recalled their departure, remembering

> the rushed goodbye to "my" Giotto in the Cappella degli Scrovegni* and the rage I felt against Bruno, who did not want to leave "his" laboratory, which was no longer his. For him, it was like a cord he could not cut….
>
> The last day in Padova I joined Bruno in the laboratory in order to pull him away. I remember the wide staircase as we, melancholy, descended slowly. At the bottom of the stairs stood Mario, the janitor, in tears. "Professor, don't leave. Why? Why? It's not fair. It's not fair." It was the most moving goodbye that we received from the people of our native land.[55]

The Great Fascist Council (*Gran Consiglio Fascista*) enacted the Declaration on Race (*Dichiarazione sulla Razza*) on October 6, which was published on October 26, and became law on November 17. By that time Bruno and Nora Rossi had left Italy. An exodus of Italian Jews comparable to that of German Jews was underway. Edoardo Amaldi and a small group of physicists remained in Italy to face the catastrophe. Thanks to the seeds that were sown by Orso Mario Corbino, Antonio Garbasso, Enrico Fermi, Bruno Rossi, Franco Rasetti, and their pupils, and thanks especially to the extraordinary courage of Edoardo Amaldi and Gilberto Bernardini in assuming the enormous responsibility of reconstruction—actually, of *construction*—modern physics would blossom again in Italy after the war.

Copenhagen

On October 12, 1938, Bruno Rossi and his young wife Nora left Padua for Copenhagen, crossing Germany by train. In leaving Italy Rossi felt that he no

* The Cappella degli Scrovegni in Padua contains a fresco cycle that Giotto (*ca.* 1276–1337) completed around 1305. It is one of the most important and moving masterpieces of Western art. Today, to preserve it, the Cappella is carefully climate-controlled and tourists can enter it only in small groups and stay only for around fifteen minutes.

longer was a citizen of his country, and that his career "as a teacher and as a scientist had come to an end."[56] On reflection, however, he later remarked that, "To describe this event as a tragedy would be a gross exaggeration; at that time truly tragic was the fate of so many people in Europe." Still, his loss "was a hard blow," which to some degree was mitigated by

> the warm welcome we received from Niels and Margarete Bohr, and from the people around them…. The human interests, the lively intellectual climate, the sane view of political events that were the essence of the "spirit of Copenhagen" went a long way toward clearing our minds and strengthening our confidence in the future.[57]

Rossi never forgot the precious help they received in those dark days, which he recalled on the occasion of Bohr's seventieth birthday in 1955:

> [My] memory goes back to that fall of 1938, when the weeks spent in your Institute renewed my faith in the brotherhood of men, and gave me strength and inspiration to resume my work in a new country.[58]

In Copenhagen Rossi experienced at first hand the international character of physics and physicists, and their deep concern for the plight of the refugees from Nazi Germany and Fascist Italy. His correspondence at the end of 1938 and beginning of 1939 illuminates the tragedy of his forced emigration from Italy—as well as the strength he drew from the support of his extraordinary wife Nora and from his physics research. He recalled that:

> I spent long hours at the institute, talking with people and catching up with my reading, gradually rekindling my enthusiasm for science.
>
> While we were there, Bohr organized a conference [from October 25–29] that brought to Copenhagen many scientists, among them a number of cosmic-ray physicists. I strongly suspect that one of his motives was to give me the opportunity of meeting people who might be able to help me find a job. In any case, that is exactly what happened, because, shortly thereafter, Patrick Blackett* invited me to Manchester [where in 1937 he had succeeded William L. Bragg as Langworthy Professor of Physics] on a fellowship from the Society for the Protection of Science and Learning.[59]

The prospect of going to Manchester, however, was not Rossi's only potential opportunity. On October 7, 1938, the chemist Chaim Weizmann, President of the Zionist Organization and Chair of the Board of Governors of the Hebrew

* Rossi had met Blackett for the first time in Berlin in 1930, and since Blackett's wife was Italian, they "easily became quite friendly"; see P.M.S. Blackett interview by John L. Heilbron, December 7, 1962, Niels Bohr Library and Archives, American Institute of Physics, College Park, MD USA, website <www.aip.org/history/ohilist/4508.html>, Section IV.C.3.

University of Jerusalem, wrote to Rossi, inquiring if he would be interested in its chair of experimental physics,[60] an offer that meshed with Weizman's aim to appoint outstanding Jewish scientists to its faculty.[61] Rossi replied on November 2:

> I would consider an honour for me to obtain a chair at that University and, therefore, I am sorry not to be able to take, in this moment, an engagement for the future. But the situation in Italy has not yet sufficiently cleared up and also I have just accepted to go and work some time in Manchester with prof. Blackett….[62]

In fact, already two weeks earlier, on October 10, Blackett had written to Rossi expressing his hope that Rossi would come to Manchester:

> Dear Rossi,
> I am very sorry to hear your news and will do all I possibly can to be of use. In particular, I would be extremely honoured if you would care to work here for sometime in my laboratory. I do not, of course, know what your ultimate plans would be, but if you would care to come here and spend some time with us while fixing up your arrangements, I, and all my colleagues, would be very much delighted. I think I could manage to find enough money to make this possible for a short time at any rate. I hope you will let me know as soon as possible what your plans are so that if you wish to come here I can start making arrangements.
>
> With very best wishes,
> Yours sincerely,
> P.M.S. Blackett[63]

And on November 1, just after the close of the Copenhagen conference, David Cleghorn Thomson, General Secretary of the Society for the Protection of Science and Learning (SPSL),* wrote to Rossi that:

> [We] hope very much to be able to make a grant to you to enable you to work with Professor Blackett in this country for at least a year…. In the event of a research opening not turning up in America after you have been for one year in this country, would it be possible for you to return to live in Italy? We need to know this as otherwise questions are raised of an unconditional guarantee for your maintenance in this country. This matter would of course not arise were it still possible for you to return to Italy in a year's time.[64]

Prior to leaving Padua in September 1938, Rossi had sent out other feelers. Thus, on September 11 he had written to Manuel Vallarta at the Massachusetts Institute of Technology, who replied on November 1 after returning from trip out of town:

* The Academic Assistance Council was founded in London in 1933 and changed its name to the Society for the Protection of Science and Learning in 1936, continuing its mission of assisting refugee scholars with short-term grants and helping them find long-term employment.

Dear Dr. Rossi,
I am extremely sorry to learn that as a consequence of the application of the Italian racial laws you have been dispossessed of your position as a professor at the University of Padua. Of course you know that this country had received a great many refugees prior to the recent events in Austria and Czechoslovakia, and that since then the influx has tended to increase. As a result of this, the possibilities for absorption of these refugees, particularly in academic positions, has almost reached saturation. While personally nothing would please me more than to have you for a colleague in this part of the country, I must confess that the chances for securing anything seem at present very remote. However, I have mentioned your case to a few of my influential colleagues, and if anything should turn up, I shall certainly inform you at once….
M.S. Vallarta[65]

Vallarta wrote to Rossi again on January 17, 1939, stressing that "the chances at the moment do not appear any too good.[66]

Furthermore, one month after Rossi had arrived in Copenhagen, on November 12, 1938, Arthur H. Compton responded to a letter that Rossi had sent to Compton two months earlier,* from which it appears that Compton was one of the first people to whom Rossi wrote asking for help:

Dear Rossi:
I cannot tell you how keenly I feel the tragedy of your situation, being removed from your home and your work after so many good years of your life. Due to some mischance, the letter which you wrote me last September failed to reach me until today. I had just dictated, but not yet sent, an invitation for you to join a Cosmic Ray Symposium here in Chicago next summer. I enclose a program of our last summer's symposium. Next summer we hope to make it international in scope. We should like very much if you could join us.

Unfortunately, we are not in a position to pay all of the traveling costs. The University has, however, put at my disposal funds which enable us to offer $250.00 toward those costs.

I am immediately taking steps to see whether I can find something in this country which may serve as an adequate position for you; especially because of the recent emigration of capable physicists from Europe, this is rather difficult. However, I am hopeful that we may find something. Please keep me informed regarding your location. In any case, we should be very pleased if you could come to our symposium next summer. Would you let me know at your early convenience whether there would seem to be any chance of this and, if so, what you would probably want to talk about.

* Compton also sent a copy of his letter to Niels Bohr.

> Please give my kindest regards to your Mother and to your brothers. We were very pleased to hear of the award of the Nobel Prize to your compatriot, Professor Fermi.
>
> Yours sincerely,
> Arthur H. Compton[67]

Compton had met Rossi at the conference that Fermi had organized in Rome in October 1931, where Rossi's talk had stimulated Compton to undertake a research program in cosmic rays. The conference that Compton was now organizing was scheduled to take place in Chicago from June 27-30, 1939. On December 2, 1938, Compton also sent "a note of encouragement" to Rossi, replying to a letter that Rossi had written to Comption on November 10, which had crossed in the mails with Compton's letter to Rossi of November 12:

> Dear Professor Rossi,
> We should indeed welcome you to our Laboratory at the University of Chicago. I am making efforts in various directions to finance your work as a member of our organization. Although these efforts have not as yet been successful, I am hoping that before many months we shall be in a position to make you an invitation which you will find it possible to accept.
>
> In the meantime I have told a number of our American colleagues of your situation.
>
> With best personal regards.
> Your very truly
> Arthur H. Compton[68]

Rossi also had written another undated letter to Compton, the draft of which is preserved in his papers and is full of crossed-out words and lines that testify to the anguish he and his wife were feeling after leaving Italy. In it he recalled having already informed Compton about the grant he had received from the SPSL, but added that: "it is not my purpose to seek for a durable position in England or anywhere in Europe."[69] He asked Compton to help him to obtain a visa, since he could not obtain one from the Italian government. He also said that he did not want to leave his wife in Europe, so he had to find enough money "to make this possible." He closed by saying: "I cannot tell you what a pleasure I had in receiving your so kind and friendly letter. Thank you so much for the interest you are taking in my case and for your valuable help."

Meanwhile, Blackett was making arrangements for Rossi's stay in Manchester. He hoped to arrange a payment of £400 per annum: "I know this is not very much to one who has just had a big professorial position but I think you will find it enough to lead a comfortable existence in Manchester."[70] Then, on November 24, Blackett officially invited Rossi, saying that he had "already arranged financial support for you here for as long as you may wish to stay."[71] He hoped to see Rossi

in Manchester by December 15. Then, on December 22, David Cleghorn Thomson, General Secretary of SPSL, wrote to Rossi telling him that the Society was making a grant to enable him

> to carry out research work with Professor Blackett in Manchester, at the rate of £250 a year, in the first instance for six months. This amount as you also know is to be supplemented by funds collected by Professor Blackett himself.[72]

Rossi also corresponded with other physicists during this period, informing them of his and his wife's uncertain situation. Thus, on November 29, Felix Bloch, who in 1933 had decided not to return to Heisenberg's institute in Leipzig after a visit to his home in Switzerland, wrote to Rossi, recalling his pessimistic views about the situation in Europe and telling Rossi that he had sent Rossi's curriculum vitae to Carl Anderson at Caltech, hoping that Anderson would be able to help Rossi in some way.[73] In fact, however, owing to Millikan's hostility (he had never forgiven Rossi for opposing his theory of the nature of cosmic rays at the 1931 Rome conference), it was doubtful that Rossi would be invited to Caltech.

At the beginning of December, Lorenzo Emo Capodilista, one of Rossi's former students at Arcetri, also had discouraging news from California, writing to Rossi that it was impossible for Ernest O. Lawrence to offer him a position in his Radiation Laboratory in Berkeley.[74] Even Robert B. Brode, who had been awarded a Guggenheim Fellowship to work with Blackett in Manchester in 1934–1935, would be unable to help him, but he had promised to submit Rossi's case to his friends at Caltech. Meanwhile, Capodilista suggested that Rossi "ask Compton, who is very influential," since he controlled the funds of several laboratories, and was "president of a society founded in these days for victims of political and religious persecution."

Hans Bethe, who had visited Rossi in Florence while he was working in Fermi's institute in Rome, sent an undated letter to Rossi, commenting "how sad was everything, even if it was certainly to be awaited."[75] He also said that Rossi had made a sensible decision in leaving Italy, without waiting for things to get worse. He promised to write to Jabez C. Street at Harvard, Compton, Thomas H. Johnson at the Bartol Research Foundation, and Isidor I. Rabi at Columbia, inquiring about the possibility of finding a position for him in the United States.

On December 7, 1938, the Italian National Fascist Party (*Partito Nazionale Fascista*) informed Rossi (who must have received this letter some time later) that

> according to orders given by the Great Council of Fascism and to the P.N.F. Provision n° 1174, from today you are no more part of the P.N.F. on the following grounds: "being of the Jewish race." You must consign to the Disciplinary Office of this Federation the card and the P.N.F. button in your possession….[76]

According to a document released by the Ministry of National Education, Rossi was eventually "expulsed from service" on December 14, 1938.[77]

Manchester

By late 1938 Rossi had become deeply interested in mesotrons, the penetrating cosmic-ray component of mass intermediate between that of the electron and the proton, a particle that was connected tentatively to the heavy particle that Hideki Yukawa had predicted in his theory of nuclear forces, and that Homi Bhabha had proposed, in analogy to radioactive decay, is unstable and will disintegrate spontaneously into an electron and a neutrino with a lifetime on the order of 10^{-6} second. Rossi now focused on the difference in their absorption in air and lead, and recalled that according to special relativity the *apparent* lifetime of a mesotron moving at a velocity approaching that of the velocity of light is considerably larger than its *proper* lifetime, that is, its lifetime at rest. Mesotrons therefore might disintegrate before being brought to rest by losing energy in a gas, but not in a liquid or solid, because in these substances they would be stopped in a time considerably shorter than their relativistic lifetime. In other words, by "traversing a gas absorber, the intensity of the hard component would therefore be more reduced than by traversing a liquid of a solid absorber of the same stopping power."[78] He thus saw that he now could reinterpret similar results he had obtained earlier on his and Sergio De Benedetti's expedition to Eritrea at the end of 1933. Rossi calculated that the lifetime of mesotrons was 2×10^{-6} second, of the same order of magnitude given by theory.

Three weeks earlier on November 10, 1938, Enrico Fermi received a telephone call from Stockholm,[79] informing him that he had been awarded the Nobel Prize in Physics for 1938 "for his demonstrations of the existence of new radioactive elements produced by neutron irradiation, and for his related discovery of nuclear reactions brought about by slow neutrons."[80] On December 24, following the Nobel Prize ceremony in Stockholm, Fermi and his family boarded the *Franconia* at Southhampton, England, and on January 2, 1939, they arrived in New York.[81]

As the Fermis were wending their way from Sweden to America, Bruno and Nora Rossi crossed the North Sea and arrived in England, heading for Manchester, where they established a warm relationship with Blackett and his wife Constance. In Blackett's laboratory Rossi met A.C. Bernard Lovell, George D. Rochester, J.C. Wilson, and the refugee Hungarian physicist Lajos Jánossy. Blackett and his colleagues had already carried out several experiments on cosmic rays, so for Rossi this now was an opportunity for getting his hands "dirty again by doing some experimental work."[82]

On March 22, 1939, Rossi wrote to Esther Simpson, Assistant Secretary of the SPSL, describing his personal financial resources:

> I have no source of income which I can use abroad other than the grant from the S.P.S.L. and from Professor Blackett, which amounts to £400 a year. The latter grant will stop at the same time as the former. There is the possibility that I will receive a very small pension from the Italian Government, perhaps some £60-£90 a year, but this is by no means sure and besides it is very unlikely that I could have it abroad.[83]

German troops had invaded Czechoslovakia less than two weeks earlier on March 10, Italian troops were preparing to invade Albania, Germany and Italy would announce their alliance, the Berlin-Rome Axis, on May 7, and Hitler and Mussolini would sign their Pact of Steel on May 22. In light of these ominous events in Europe and because of his increasingly uncertain situation in England, Rossi left Manchester to give a talk at Compton's symposium on cosmic rays in Chicago with the clear intent of seeking a position in America. Blackett too was worried and quite pessimistic about the situation in Europe, so he urged the Rossis to leave. They were very sorry to do so, since they had found such human warmth and hospitality with the Blacketts.[84] In the event, Blacket's group dispersed in the summer of 1939, its British members leaving for a secret radar station on the east coast of England.

In early June 1939, about six months after the Fermis had left Europe, Bruno Rossi and his wife Nora Lombroso boarded a French liner bound for the United States of America.*

The New World

When Bruno and Nora arrived in New York on June 12, 1939, they remained there for around ten days, where they met Enrico and Laura Fermi and Hans Bethe, Rossi's old friend whom he had met on his way to Rome when he stopped off in Florence where he had learned "to appreciate Italian cuisine" at Rossi's mother's home.[85] The couple now felt "the need to reestablish contact with some old friends in order to overcome the shock of the transition from one continent to another." Bethe was about to drive to Chicago to attend Compton's cosmic-ray symposium, and he invited the Rossis to go along with him, an offer they accepted "with great pleasure." This was the first major international conference on cosmic rays; it took place from June 27–30, 1939, and some sixty active researchers from most of the leading groups participated in it, including Blackett, Lovell, Wilson, and Jánossy from Manchester, all of whom gave talks,[86] and Walter Bothe from Berlin,** with the number of interested people raising the total attendance to about three

* Rossi recalled that the name of the French liner was the SS *Liberté*, but in 1939 this actually was the Norddeutsche Lloyd liner *Europa*, which in 1946 was ceded to France as a war reparation, was renamed the SS *Liberté*, and was operated by the Companie Générale Transatlantique. Moreover, in 1939 the *Europa* sailed from Bremerhaven, Germany, to New York, thus making it unlikely that the Rossis crossed the Atlantic on this ship. Much more likely is that they boarded the French liner *Normandie*, which in 1939 sailed from Southampton, England, to New York. See Rossi Papers, Box 28, Folder "Letters and Documents 1938–1939," MIT Archives.

** Bothe was disturbed that Rossi would not speak German with him, but Rossi claimed that this was not a sign of his hostility to Germany but only because his effort in learning English had erased the German language from his memory; see Rossi, *Moments* (ref. 1), p. 46.

hundred. An entire day of the symposium "was devoted to the problem of the radioactive instability of mesotrons…. The consensus was that the evidence for this phenomenon could not yet be regarded as decisive."[87]

In Manchester Blackett and Rossi had carefully examined experimentally the evidence for the anomalous absorption of mesotrons and had concluded that there was no proof of the instability of mesotrons.[88] At the Chicago symposium Rossi reported on recent experiments at Manchester, and immediately thereafter, now as a recognized expert in the field, he published an article on the disintegration of mesotrons in the *Reviews of Modern Physics*, signing it as a "Fellow of the Society of the Protection of Science and Learning, now at the University of Chicago."[89] The participants at the Chicago symposium had agreed that there was no conclusive experimental evidence for the decay of mesotrons, and Rossi recognized that to obtain such evidence their absorption with increasing altitude in the atmosphere should be investigated. Compton, impressed with Rossi's work, invited Rossi and his wife to spend a few days with him and his wife Betty after the symposium in their summer cottage on Otsego Lake in Upper Michigan, where Rossi explained his ideas more fully to Compton, who immediately pointed out that Mount Evans in the Colorado Rocky Mountains, at over 4,000 meters above sea level, would be an ideal site for such an experiment: It was one of the highest mountains in the United States,* and had a road to its top where a small cabin had been built for earlier scientific experiments. He told Rossi that he should organize an expedition immediately. Rossi was "taken aback," since it already was the middle of July and snow might begin to fall in the Colorado mountains by the end of August. Rossi, however, could not but accept the challenge:

> Compton's well-meaning suggestion had placed me in a difficult spot. But, of course, I did not draw back; and, immediately after my return to Chicago, I began working with a sense of urgency.[90]

On July 18 Blackett replied to an earlier letter from Rossi, writing that:

> I must say I am not at all surprised at your decision not to return to this country as I really thought that your decision to buy a return ticket was dictated by politeness as much as anything! I think you are perfectly right to stay in the U.S.A. as obviously chances of absorption are far greater and chances of war negligible. I only want to say how extremely glad we all are here that you were able to spend these months with us and how delighted we are too that you found them useful and that they enabled you to get back to cosmic ray research so energetically after your long period in Italy building your new institute….[91]

* On an official list, Mount Evans, at a height of 4,334 meters (14,222 feet), is given as the forty-second highest mountain in the United States and the sixteenth highest mountain in Colorado. It does, however, have the highest paved road in the United States, which was constructed from 1917–1927.

A few days earlier, Rossi had received an offer of a research associateship from the University of Chicago at a salary of $2,500 per annum paid by the Committee in Aid of Displaced Foreign Scholars, and by accepting this position Rossi had made "a final decision to remain in the United States."[92] Bruno and Nora later recalled that the "friendly and intellectually stimulating atmosphere" they had found in Chicago was largely responsible for adopting America as their "new home."[93] Rossi thus became one of about one-hundred physicists who immigrated to the United States between 1933 and 1941 fleeing Nazi Germany and Fascist Italy,[94] the majority of Italians immigrating after the promulgation of the Italian racial laws in 1938. Thus, Bruno and Nora, like their compatriots, arrived at a time when the devastating effects of the Great Depression were still evident, with unemployment in America still at an estimated 17.2 percent.[95]

Prior to leaving Chicago for Colorado on August 26, Rossi, with the help of two of Compton's physicist friends, Norman Hilberry from New York University and Barton Hoag from the University of Chicago, built the three Geiger-Müller counters and coincidence circuit he would need, and loaded everything into an old bus that Compton borrowed from the Zoology Department that was used for field trips during the academic year. Rossi recalled:

> The memory of that trip, through the limitless midwestern plains, among unending fields of corn and wheat—our first contact with the very heart of America—is still alive in our minds.[96]

After arriving in Denver, at 1,600 meters above sea level, they stopped for a couple of days to take some measurements, went on to Echo Lake at 3,200 meters above sea level (figure 11) where they took more measurements, and finally, on September 1—the same day on which Germany invaded Poland—they drove to the top of Mount Evans at 4,300 meters, transporting themselves and tons of lead and graphite on a rocky, steep, and narrow road. One month later, on September 30, Rossi sent a Letter to the Editor of the *Physical Review* reporting that they had found "definite evidence for the disintegration of the mesotrons."[97] It had been an exhilarating, if at times a perilous adventure for Bruno and Nora Rossi in their new world.

Epilogue

In the fall of 1940, Rossi left the University of Chicago for Cornell University in Ithaca, New York, where Bethe had recommended that he be appointed to fill a vacant associate professorship. Three years later, in July 1943, after traveling often to Cambridge, Massachusetts, to work on problems of radar instrumentation at the MIT Radiation Laboratory, what Rossi called the "Age of Innocence of the Physics of Elementary Particles" ended when Bethe called him to work on the development of an atomic bomb at Los Alamos, New Mexico.[98] Rossi recalled:

Fig. 11. Nora and Bruno Rossi at Echo Lake, Colorado, in September 1939. *Credit:* Reproduced by permission of Nora Lombroso Rossi.

> The days that followed this invitation were among the hardest of my life; without being told, I could easily imagine what the Los Alamos project was about, and I was loath to have any part in the development of such a deadly device as the fission bomb was expected to be. On the other hand, I like many others, was terribly worried by the likelihood that in Germany, where fission had been discovered, work on the bomb might be advancing at a fast pace. Finally, having resigned myself to the fact that neither by accepting nor rejecting the Los Alamos request could I escape a heavy responsibility, I decided that my choice could not be based on anything else but the need to fight the immediate danger.
>
> I clearly remember my feelings when I decided to go to Los Alamos. I was hoping that our work would prove that the fission bomb was not feasible. However, I had also reached the conclusion that if, on the contrary, the bomb was feasible we must make sure, at all costs, that Hitler did not have it before we did.[99]

Rossi was among those at Los Alamos and at other sites of the Manhattan Project who were shocked by the bombing of Hiroshima and Nagasaki in August 1945, and on February 6, 1946, he and Nora and their two young children left Los Alamos, "with a mixed feeling of relief and nostalgia,"[100] to take up an appointment as Professor of Physics at MIT, taking with him four young physicists who had worked with him at Los Alamos.[101]

In stark contrast to its devastated state in Europe, physics prospered in the United States after the war. As Enrico Fermi wrote to Edoardo Amaldi and Gian Carlo Wick from Chicago on January 24, 1946:

> [Now] that people have become convinced that physics can do atomic bombs everyone is talking about figures of several million dollars with ostensible indifference. The impression is that from the financial point of view the greatest difficulty will consist in imagining enough things to spend on….[102]

As did other physicists at other institutions in America, Rossi and his group at MIT flourished, becoming internationally renowned and attracting researchers from all over the world. With the advent of new and powerful accelerators in the 1950s, many cosmic-ray physicists switched to work on experiments using them, but not Rossi, who devoted more and more of his researches to elucidating the nature and origin of the primary cosmic rays, and to their sources, means of propagation, transformations in interstellar space, and acceleration mechanism. At the same time, studies of the showers generated by high-energy cosmic-ray particles at energies far above those obtainable with accelerators gradually transformed the field of cosmic-ray research into two new fields, high-energy elementary-particle physics and cosmic-ray astrophysics.

Rossi too, with his keen intuition that new technological windows open up new views of the universe, transformed himself from a cosmic-ray physicist into a cosmic-ray astronomer. The opening up of the space era, dramatically inaugurated with the launching of the Russian Sputnik, stimulated in Rossi a scientific enthusiasm comparable to what he had experienced three decades earlier at Arcetri. Moreover, now as one of the most influential scientists in the United States, he also became involved in its science policy, especially in connection with the establishment of the National Aeronautics and Space Administration (NASA). He began to think of the outer space in practical terms, culminating in the early 1960s when he and his group at MIT demonstrated the existence of the solar wind and when he promoted the search for extra-solar sources of X rays,[103] an idea that eventually led to the discovery of Scorpius X-1, an unexpectedly bright X-ray source some 9,000 light-years away in the constellation Scorpius, as well as the existence of diffuse X-ray emission from the deep sky.[104] These achievements, the culmination of research he had begun three decades earlier in Arcetri, inaugurated two new fields of research, the study of the magnetospheres of other planets in the solar system and in the interplanetary plasma, and cosmic X-ray astronomy, which today focuses on the investigation of astrophysical processes and the celestial bodies that produce them.*

* Riccardo Giacconi shared the Nobel Prize in Physics for 2002 “for pioneering contributions to astrophysics, which have led to the discovery of cosmic X-ray sources”; see website <http://nobelprize.org/nobel_prizes/physics/laureates/2002/>. His mentor, Bruno Rossi, was also deserving of that Nobel Prize but had died ten years earlier.

After the war, Bruno and Nora Rossi resumed their strong bonds to Italy. They visited Italy every year, where Rossi guided many young Italian physicists who were learning new techniques and thus contributing to the development of physics in Italy. Bruno Rossi died in Cambridge, Massachusetts, on November 21, 1993. In accordance with his wishes, his ashes were buried in Florence, in the Cemetery of Porte Sante, which extends along the side of his favorite church, the Basilica of San Miniato al Monte, on the way to the Arcetri hill, where he had begun his extraordinary lifelong scientific adventure.

Acknowledgments

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Via Cavalese 13
00135 Rome, Italy
e-mail: luisa.bonolis@roma1.infn.it