

The Mysterious Disappearance of Ettore Majorana

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Abstract. We review the short but interesting life of Ettore Majorana.

1. Introduction

I would like to add my voice today to those honoring Frank Avignone and Ettore Fiorini. I am only ten years away from *my* seventy-fifth birthday and it is an inspiration to me to see their level of activity in the field has scarcely diminished. I also wish to eulogize Peter Rosen. Not only did he and I share an interest in much of the same physics, but we also shared a job! Thirty years ago I was a program officer in theoretical physics at the National Science Foundation, and Peter took that position after I left.

Deciding what to speak about this afternoon was difficult, since I have not done any recent neutrino work. Instead I thought it would be interesting to review the life of one whose name has been oft-mentioned at this meeting — Ettore Majorana — for his is an interesting story. I have extracted much of the material below from two books — one by the Sicilian writer Leonardo Sciascia[1] and the second a volume produced by the Italian Physical Society to honor the centennial of his birth, which includes a retrospective by Edoardo Amaldi[2]. I have also used material given by Amand Faessler in interesting talks about Majorana's life.

2. Majorana as a Youth

Ettore Majorana was born 5 August 1906 in Catania, which is a province on the eastern side of the island of Sicily. His family was highly respected and quite well to do, and owned homes in Catania, in Palermo, in Rome, etc. His father Fabio Majorana (b. Catania 1875-d. Rome 1934) was an engineer and for many years served as the Director of the Catania telephone company. The family “moved” to Rome in 1921 and in 1928 Fabio was appointed to the position of General Inspector of the Italian Ministry of Communication in Rome. (Interestingly his father had an older brother Quirino Majorana (1871-1957) who was an experimental physicist at the University of Bologna). His mother Dorina Corso Majorana (b. Catania 1876-d. Rome 1965), was said to be somewhat overbearing. The union produced five children — Rosina, who later married Werner Schultze, Salvatore, who became a Doctor of Law, Luciano, who became a civil engineer, Ettore, and Maria, who became a musician and piano instructor[2].

Ettore was very shy as a child and stories are told by his family of him being able to multiply three-digit numbers or to extract square or cube roots in his head. However, an indication of this shyness is that when presented with such a problem, he would disappear underneath a table

in order to do the calculation and later would call out the answer. (I wonder whether today we might classify him as autistic.) He was also cited in the local newspaper for his chess prowess.

Ettore was schooled in Catania for his first few years, but then was sent to Rome first as a boarding student in classical studies at the Jesuit Istituto Parificato Massimiliano Massimo. Above I mentioned that his family “moved” to Rome in 1921, when Ettore was fifteen, so that he finished his studies as a day student. I put the word “moved” in quotes because this is not how you or I would move our family — putting our house for sale, hiring some movers, buying a house in a new city. Rather for the Majoranas, it was a matter of telling the servants in Catania and Palermo to close up the house for a while and notifying the servants in Rome to open up the apartment[3]. In any case, Majorana earned his final diploma “licenz Lciale” at the Liceo Statale Torquato Tasso in 1923.

Apparently Ettore intended to follow in his father’s engineering footsteps, for on November 3, 1923 he entered the two year preparatory course for engineers, held at the Faculty of Sciences at the University of Rome, and he earned his final diploma in the autumn of 1925. He then took the next step, entering the three year School of Applications for Engineers. His work was fine, except for his study of hydraulics — he passed the hydraulics exam 7 December 1927 with a grade of only 75/100 — but he did not graduate. That is because he had befriended a young student Emilio Segre, who convinced him that his future lay in the field of physics. Segre himself had begun his studies as an engineer, but in the summer of 1927 followed the advice of Franco Rasetti, who was a lecturer in Physics at Florence, and transferred to the Institute of Physics where he studied under the direction of the young (27 year old) Enrico Fermi, who had just been appointed as extraordinary Professor of Theoretical Physics at the University of Rome in in a 1926 national competition. The board of examiners had met in November of that year and chose Fermi for this position in Rome, Enrico Persico for a professorship in Florence and Aldo Potremoli for a position in Milan.

3. Majorana at the University of Rome

Majorana was admitted to the physics program at the beginning of 1928. How he joined the program involves an interesting story by his friend Edoardo Amaldi. Amaldi, Segre, and others had urged him to set up a meeting with Fermi about transferring to physics and when this came about and he discussed this possibility with Fermi, Ettore was given presentations concerning the various activities in the institute[12]. One such activity had to do with what we now call the Thomas-Fermi statistical model of the atom and Fermi showed him a numerical table which he had developed in this regard using a simple hand calculator. Majorana listened without comment and left, but returned the next day with his own sheet of paper on which he had generated his own figures. He asked to look at Fermi’s table and, after comparing them, announced Fermi’s work to be correct. He then left the Institute for the day and within a week had begun his study thesis work with Fermi. He submitted his thesis “On the Quantum Mechanics of Radioactive Nuclei” on July 7, 1929 and it was accepted with a grade of 110/110 with distinction. The subject of the work was a generalization of the Gamow and Houterman theory of alpha decay to the case of particles in excited states and with higher angular momentum.

After obtaining his degree, Majorana continued to attend the Institute and on 12 November 1932 he obtained his university teaching diploma in theoretical physics. The examination board, consisting of Fermi, Antonino Lo Surdo and Enrico Persico, was unanimous in their recommendation and reported that the candidate possessed a “complete mastery of theoretical physics.” During this period he generated a modest output of publications involving quantum mechanics. His papers included work

i,ii) on the Thomas-Fermi model of atomic structure[4],[5]:

G. Gentile and E. Majorana, "On the splitting of Röntgen and optical terms due to the rotating electron, and on the intensities of Cesium lines," *Rend. dell'Acc. dei Lincei* **8**, 229-33 (1928).

E. Majorana, "Search for a general expression of Rydberg corrections, valid for neutral atoms or positive ions," *Nuovo. Cim* **6**, 16-16 (1929).

iii,iv) on chemical bonding:

E. Majorana, "On the formation of the molecular helium ion," *Nuovo Cim.* **8**, 22-28 (1931).

E. Majorana, "Pseudopolar reaction between hydrogen atoms," *Rend. dell'Acc. dei Lincei* **13**, 58-61 (1931).

v,vi) on spectroscopic lines:

E. Majorana, "The possible anomalous terms of helium", *Nuovo Cim.* **8**, 78-83 (1931).

E. Majorana, "Theory of incomplete P'triplets," *Nuovo Cim.* **8**, 107-113 (1931).

vii) on polarized atoms in the presence of changing magnetic fields (a phenomenon which is now called "Majorana flip")

E. Majorana, "Oriented atoms in a variable magnetic field," *Nuovo Cim.* **9**, 43-50 (1932).

viii) on the form of the relativistic wave equation for arbitrary spin[6] (infinite dimensional unitary representations for the relativistic Lorentz group):

E. Majorana, "Relativistic theory of particles with arbitrary intrinsic angular momentum," *Nuovo Cim.* **9**, 335-344 (1932).

ix) and on nuclear theory:

E. Majorana, "On the theory of nuclei," *Zeit. für Physik* **82**, 137-45 (1933).

(As an aside, I should mention that after his death his brother found an unpublished manuscript "The value of statistical laws in physics and social sciences" which was subsequently published in *Scientia* **36**, 58 (1942) through the influence of Majorana's friend Giovanni Gentile, Jr. This paper was recently republished in *Quantitative Finance* **5**, 133 (2005).)

Then in January of 1933 he received a grant from the Italian National Research Council in the amount of 12,000 Lire, which allowed him to travel to Leipzig to work with Heisenberg. His application was supported by Fermi. Leipzig at this time was a center for theoretical physics and besides Heisenberg the theory group included Hund, Peierls, and Bloch. He arrived in Germany during January of 1933 and stayed until the beginning of the summer, when he went to Copenhagen for a three month visit with Bohr at the Institute. After a brief time back in Leipzig, he returned to Rome in the autumn of 1933.

After coming back from this trip, however, his publications ceased. It is not clear why this was the case, but it is known that he developed a serious case of gastritis while in Germany, which his family doctors attributed to nervous exhaustion. Whatever the cause, this illness stayed with him and Majorana became a very reluctant author. Once he had discovered something, he considered his own work to be commonplace, so that he was very disinclined to write anything about it. An example is the work by Joliot and Curie in France, which had discovered a neutral particle that could enter matter and expel a proton. The experimenters assumed that the particle must be a photon, since that was the only neutral particle known at the time. However, Majorana immediately saw that it must be a particle with a mass near that of the proton, in order to move something as heavy as the proton. When he heard this Fermi urged him to write it up immediately, but nothing happened and soon thereafter Chadwick was (properly) given the credit for the discovery of the neutron for his work using Beryllium[9].

4. Majorana at the University of Naples

Because of this writer's block, very little is known about Majorana's career during this time except that he ceased his regular presence at the physics institute and took up an interest

in philosophy, especially the work of Schopenhauer. During this period he also developed an interest in economics and politics. In 1937, however, a new competition for physics chairs was announced — the first which had been held since 1926. Fermi was appointed chair of the examination committee, which consisted on himself, O. Lazzarino, E. Persico, G. Polvani, and A. Carelli. The committee met on October 25, 1937 and they selected

- a) Gian Carlo Wick, who went to Palermo, then to Padova in 1938 and then to Rome in 1940
- b) G. Racah, who went to Pisa but lost the chair in 1938 due to the fact that he was Jewish. He moved from there to Jerusalem.
- c) G. Gentile, Jr., who was the son of the politician G. Gentile, Sr. obtained a position in Milan, but died there in 1942 from what is described as a “minor” infection.

Fermi had urged Majorana to apply for this position, and in addition to the list of publications given above the candidate was asked to supply a new research paper. The paper which is the genesis of the two-component neutrino (the “Majorana” neutrino)

E. Majorana, “Symmetrical theory of the electron and the positron,” *Nuovo Cim.* **5**, 171-184 (1937).

was written for this competition. It is said that when Fermi approached him, Majorana pulled some research notes from a drawer in his desk but that possibly Fermi helped to write the paper. In any case, his application for a position was considered by the committee, but they did not offer him any of the three positions. Instead, at the recommendation of Senator Giovanni Gentile, Sr. (who perhaps saw that Ettore’s presence on the list would push his son to fourth position and out of the running) Majorana was considered above comparison with any in this group and was recommended for a position at Naples on the grounds of “alta fama di singolare perizia cui e pervenuto nel campo degli studi de Fisica teorica” (high fame of singular expertise reached in the field of theoretical physics). He thus began his career in January 1938 teaching quantum mechanics at an annual salary of 26,000 Lire. Some notes from these lectures are available[7],[8],[13] and there are some like N. Cabibbo who say that Majorana was on track to discover the Feynman path integral. However, having read these notes, I think that this is a bit of a stretch.

Obviously, Fermi had a very high opinion of his former thesis student in order to justify the award of this special position. In this regard, speaking to Guiseppi Cocconi, Fermi has been quoted as stating that[11] “Because you see, in the world there are various categories of scientists: people of a secondary or tertiary standing, who do their best but never go very far. There are also those of high standing, who come to discoveries of great importance, fundamental for the development of science [Fermi considered himself to be in this category.] But then there are the geniuses, like Galileo and Newton. Well, Ettore was one of these. Majorana had what no one else in the world had ...”

Also during the Manhattan project, Oppenheimer recalled that at one time a critical issue arose, whereupon Fermi turned to Wigner and said “If only Ettore were here.” Another time he said “This calls for Ettore.” After hearing this General Groves asked Fermi who this “Ettore” was and was told that it was Majorana. Groves asked where he was so that they could bring him to work on the project. Wigner replied “Unfortunately he disappeared many years ago.”

For several months things went well with his teaching career. In Naples, Majorana moved first into the Hotel Terminus and then in February to the fancier Hotel Bologna. He began his lectures on quantum theory 13 January 1938 to a group of students.¹ However, the level of these lectures was very high, and there were only a few who showed much understanding.

¹ Note that ten of these lectures have been already published[13].

During this period he did not touch any of his salary money, which was deposited into an account in a bank in Naples. In late March, however, he took all of this money out of the bank and on March 23, 1938 took the night boat to Palermo. While in Palermo he sent a note to the Director of the Naples Physics Institute, Antonio Carrelli, hinting at dramatic plans. However, as soon as he had posted it he apparently changed his mind and so telegraphed a message to Carrelli telling him to disregard his previous note. The original note that had been dispatched to Carrelli states

March 25 1938

Dear Carrelli, I made a decision that has become unavoidable. There isn't a bit of selfishness in it, but I realize what trouble my sudden disappearance will cause you and the students. For this as well, I beg your forgiveness, but especially for betraying the trust, the sincere friendship and the sympathy you gave me over the past months. I ask you to remind me to all those I learned to know and appreciate in your Institute, especially Sciuti: I will keep a fond memory of them all at least until 11 pm tonight, possibly later too. E. Majorana

and Carrelli was naturally concerned when he received it. Later he received a second letter from Palermo

March 26, 1938

Dear Carrelli, I hope you got my telegram and my letter at the same time. The sea rejected me and I'll be back tomorrow at the Hotel Bologna traveling perhaps with this letter. However, I have the intention of giving up teaching. Don't think I'm like an Ibsen heroine, because the case is different. I'm at your disposal for further details. E. Majorana

In any case, Carrelli was concerned enough by these events to contact the Majorana family in Rome, and Ettore's brother Luciano was dispatched to Naples to scope out what had happened. It was determined that Majorana had traveled back to Naples on the steamer on the night of March 25, 1938, and he had shared a compartment with Professor Michele Strazzeri of the University of Palermo. However, after this no trace was found, even after a reward of 30,000 Lire was offered by the family.

On December 6, 1938 the minister issued a decree where Majorana was considered as having resigned from his public office, starting on March 25, 1938 because he "abandoned the duty of his office for more than ten days, without any justified reason."

Fermi wrote a letter to Mussolini to undertake a search, saying "I have no hesitation to state to you, and I am not saying this as an hyperbolic statement, that of all Italian and foreign scholars that I have had the opportunity to meet, Majorana is among all of them the one that has most struck with for his deep brilliance." The family also entreated Mussolini to find Ettore but despite a police search, nothing was turned up.

5. Majorana's Fate

So what happened? There have been many speculations.

- i) The most common theory is suicide, jumping into the Mediterranean on the boat trip from Palermo. His note to Carrelli can certainly be read in this way. Also, Sciascia reports that Majorana left a note at the hotel in Palermo for his family stating[1]:

I have only one wish: do not wear black. If you must conform to custom just wear some emblem of mourning, but not for more than three days. After that remember me in your hearts, if you can, and forgive me.

On the other hand, why would he take all his money out of the bank? Also, his family insisted that he had a very strong Catholic faith and would certainly *not* have taken his own life.

- ii) After examining all the evidence, Leonardo Sciascia became convinced that Majorana decided to disappear because he foresaw that nuclear forces would lead to nuclear weapons[1]. In this regard, Laura Fermi said that her husband had said that “Ettore was too intelligent. If he has decided to disappear, no one will be able to find him.”
- iii) Some (including his family) say he had a crisis of spiritual faith and retreated into a monastery. Monsignor Riccieri, who was Bishop of Trapani after serving in Catania, said that Majorana had experienced “mystical crises,” and agreed that suicide was to be discounted. He cited the sanctity of the confessional to say no more[9].
The monastery theory is given some additional traction by reports that a few days before Majorana sailed for Palermo a young man who looked like him and appeared upset had shown up at the Chiesa del Gesu Nuovo near the Hotel Bologna in Naples and asked to go into retreat. Upon being informed that a long term accomodation would be required before he could join the novitiate, he thanked the brothers and left.
- iv) Others say that he became a beggar in Naples and report a disheveled person helping local students with their mathematics.
- v) There was a report that he went to South America and that a “Majorana” had checked into a hotel in Buenos Aires. Detectives were dispatched but found the registration page missing from hotel register.
- vi) Finally, the Sicilian writer Salerno says “A theory of suicide has always been advanced, but the politics of the Fascist and Nazi years leading up to the Second World War suggest homicide. As some of Majorana’s work might have facilitated development of an atomic bomb, a project with which Heisenberg was eventually involved for Nazi Germany, there exists a strong possibility that he was murdered, probably by Nazi agents[10].”

So what really happened? Since I am a theorist, I will present my theory this afternoon as to Majorana’s fate, which is that we shall never know.

Acknowledgements

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