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Science Communication and the "via Panisperna boys": the Role of Ettore Majorana

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Enrico Fermi's work gave birth to a real cultural revolution in the Italian scientific scenario. His scientific studies concerned almost every field in physics and had far-reaching effects of which virtually everybody, above all in Italy, is still taking advantage.
Two important "by-products" of Fermi's ideas and initiatives will be here taken into consideration: the new way of carrying out research and communicating science invented by Fermi and his group and his publications for the general public, which often stood for high examples of scientific popularisation.
Then the focus will shift on Ettore Majorana's role to try to understand why his work in the field of communication within the School of Physics of Rome was basically non-existent despite the excellent communicative skills he demonstrated both during his university lectures – also published in this magazine – and in his article "*Il valore delle leggi statistiche nella fisica e nelle scienze sociali*" [20], the only one which does not deal with pure physics issues and which will be also taken into account in this paper

Fermi's Cultural Revolution

In the first thirty years of the 1900s, two important innovations were introduced in the field of modern physics: the theory of relativity and quantum mechanics. The promoters of both these changes were born or worked in Central Europe, except Gregorio Ricci Curbastro and Tullio Levi Civita (Italy), Satyendra Nath Bose (India), Arthur Holly Compton and Alfred Landè (USA, but the latter was of German origin). Their names recur in virtually every textbook of modern physics: Max Planck, Albert Einstein, Arnold Sommerfeld, Werner Heisenberg, Max Born, Pascual Jordan, Otto Stern, David Hilbert, Karl Schwarzschild (Germany); Marcel Grossmann, Hermann Minkowski (Switzerland); Wolfgang Pauli, Erwin Schrödinger (Austria); Niels Bohr (Denmark); Hendrik Antoon Lorentz, Paul Ehrenfest, Pieter Zeeman, Peter Debye (The Netherlands); J. J. Thomson, Ernest Rutherford, Paul Adrien Maurice Dirac (Great Britain); Henri Poincaré, Louis De Broglie (France).

While these people were changing the whole vision of the world, in Italy where everything had begun with Galileo's work, physicists had stopped to lead the way. Central Europe actually started to excel in physics immediately after Galileo's discovery, thanks to the commitment of great minds such as Isaac Newton, Hans Cristiaan Huygens and afterwards Joseph Louis Lagrange (of Italian origin!) and James Clerk Maxwell, to quote but a few eminent names. At that time, the sole Italian contribution to scientific progress came from Alessandro Volta and few other researchers. In Italy, in the first part of the 20th century, nobody carried out theoretical research; theoretical physics, as a subject of teaching, was even absent from the country's universities.

Theoretical lectures were mainly held by mathematicians and consisted of a sort of mathematical physics or advanced rational mechanics based on the study of the properties of the equations of mathematical physics and their solutions, with very few or no physical applications.

In the early twenties, one of the few Italian physicists who could understand what was going on beyond Italian borders defined this attitude as "the theoretical physics of 1830". These words were pronounced by Orso Mario Corbino, the mighty and brilliant director of the Physics Department of the University of Rome, located in via Panisperna. The direction of the Physics Department with its political and economic implications kept Corbino very busy and, despite he was an excellent experimental physicist, he ceased conducting advanced research. He was, however, also an extraordinary "talent scout" and when he met a brilliant young man who had just come out of Pisa's Scuola Normale Superiore (1922), he could not help acknowledging his talent. The name of this gifted young man in his early twenties was Enrico Fermi and he was already well-known outside the academic environment for his excellent acquaintance with relativity and quantum theory.

In few years, Corbino created the best Italian school of physics: in 1926 Fermi was appointed to a chair in theoretical physics and, at the age of 25, he became the first professor of theoretical physics in Italy. In 1927, Corbino asked Franco Rasetti, Fermi’s friend and former university mate, to join his group since he was perhaps the best Italian experimental physicist at that time.

In the same period, Corbino enrolled among his students some promising men, whose passion and inclination towards physics and mathematics could not be completely satisfied by a degree in engineering. Corbino invited them to take the extraordinary chance to develop their skills under Fermi’s competent guidance. Ettore Majorana, Emilio Segrè and Edoardo Amaldi became the pupils of Fermi and Rasetti and, even in old age, they would always be remembered as the “via Panisperna boys”.

Fermi’s arrival proved immediately beneficial not only in Rome: thanks to that post organised by Corbino expressly for Fermi, another two talented young men could embark on a new Italian adventure in the field of theoretical physics: Enrico Persico, Fermi’s friend, went initially to Ferrara and Aldo Pontremoli to Milan.

Another two important Institutes of Physics were created in Florence and Milan but the one in Rome remained the leader. Breaking with the tradition established by old mathematical physics, Fermi showed to his students, and consequently to the whole world, a new way to deal with physics. Fermi was the man who, at the age of 17, used to show the professors of Pisa’s Scuola Normale how he could solve partial differential equations and Fourier series with astonishing self-confidence. It was he who learned by himself more about physics and mathematics than any person with a bachelor’s degree in physics. That same man was now teaching his students/friends how to think by orders of magnitude, how to produce results resorting to simple physics rather than mathematics (although he was very competent also in this field, but preferred to leave it to the so-called “high ministers” as he would recount some years later).

As if all this were not enough, Fermi created a new additional teaching method for the Italian Universities based on informal seminars held in his office. It was particularly on those occasions, rather than during his official lectures, that he revealed his real, extraordinary teaching skills. He would ask the few people invited to his seminar to address any question about physics, any theoretical or experimental problem. Then he would flip through his notebooks – containing the papers he had been writing since he was a boy with the aid of very few reference books – to find those few crucial ideas he was looking for to improvise an exhaustive and solid lecture as if he had carefully prepared it. Sometimes he read with his students the articles of the foreign theoreticians who in Germany, Austria and Great Britain were actually transforming traditional physics into something new. During those unconventional lectures, students apprehended Schrödinger's mechanics and learned "how to work physics". Sometimes they wondered if Fermi was teaching them something he had discovered during his early morning, day-to-day research or if he himself was actually learning something new with them, or if he was just creating a theory or a new and original approach to a specific problem.

Those informal seminars, separated from official lectures were something totally new in Italy, but they were rather common abroad: also Born, Bohr, Sommerfeld, Heisenberg held famous seminars, sometimes even at their homes with some refreshments or after dinner. Fermi had taken part in some seminars when he was at Born's Institute in Gottingen but they had left him rather disappointed since it had seemed to him that the rigour of mathematical formalisms hid the real essence of physics. He was the one who used to "think out loud" and to make new physics at the blackboard during informal conversations.

Regarding pure physics, only Fermi's three main results of fundamental physics will be mentioned here. Fermi achieved them between 1926 and 1934 thanks to his almost complete and independently acquired knowledge of physics, and to his extraordinary intuition. First of all *Fermi statistics* (1926) which illustrates the distribution of half-integer spin particles (called fermions); then *Fermi beta-decay theory* (1933) which radically changed traditional physics by introducing the concept of the creation of particles and which gave birth to the study of weak interactions and to the modern approach to field theory. Finally, the effect of the slowing down of neutrons in artificial radioactivity which inaugurated the very controversial study of chain reactions, with its social and military implications which contributed to modify the scientist's role in society.

For the latter Fermi was awarded the Nobel Prize, but each of these discoveries would possibly have been awarded a Nobel Prize, had they been made by three different persons.

The "secondary" scientific production of Fermi's group

The scope of Fermi's research implied inevitable repercussions which overrode the mere study of the laws of natural physics and changed the way scientific research and communication had been carried out up to that moment. In Italy, Fermi introduced, with Corbino and Rasetti, the so-called "group research" which is currently routine procedure in every university and research centre. Also Oscar D'Agostino, chemist, and Bruno Pontecorvo, physicist, joined the group of Fermi, Rasetti, Amaldi and Segré to carry out experimental research. The articles published in the thirties concerning radioactivity from neutrons and the effect of slow neutrons, were among the first in the world signed by five or six persons.

On the occasion of those research studies, Fermi's group took another unprecedented initiative: since Ginestra Amaldi (Edoardo's wife) was on the editorial board of the magazine *Ricerca Scientifica*, they started to send the magazine regular brief letters or reports. The "via Panisperna boys" invented, sixty years ago, the so-called *preprint*, used to update reasonably quickly the main research laboratories abroad, on their progress in artificial radioactivity research.

The "boys" seemed unconcerned about disclosing the provisional results of their work and about the risk that someone else could steal their discoveries (what the group actually missed was the first nuclear fission which they obtained inadvertently in 1938, despite Ida Noddack's indications) and published about 50 articles – some of them also have an English version – including simple updating and more exhaustive reports on their experiments and theories. Regarding science communication, however, something else is worth mentioning:

“In the second half of the twenties, after the changes in the Italian political situation and the complete transformation of fascism into a single-party totalitarian regime, the Italian cultural scenario also changed with the institution of the *Accademia d’Italia* (1926), the reform of the CNR [National Research Council] (1928) and the SIPS [National Board for the Development of Sciences], the introduction of the racial laws (1938), the ban on, among others, Jewish books and the suppression of the Lincei Academy (1939)” [11].

However, some positive signs were also recorded, above all in publishing:

“Traditional scientific publications, such as ‘Nuovo Cimento’ – the scientific magazine of Italian physicists -, ‘Scientia’ […], the minutes of the SIPS and some famous academic publications went on circulating while some new others appeared such as the magazine of the CNR, ‘La Ricerca Scientifica’ (since 1930) and ‘Memorie’ edited by the physics class of the Accademia d’Italia (since 1931), in addition to some informative and popular publications such as ‘Sapere’ (since 1934), ‘Scienza e Tecnica’ (published by the SIPS since 1937), ‘Il Saggiatore’ (1940)” [11].

Fermi and his friend Persico[1] began to update the catalogue of books published by Zanichelli and to write some new textbooks for both schools and universities: *I principi della nuova meccanica ondulatoria* (Persico, 1927); *Introduzione alla fisica atomica* (Fermi, 1928); *Fisica ad uso dei licei scientifici* (Fermi, 1929), and *Fisica ad uso dei licei* (1931); *Fisica ad uso degli istituti magistrali* (Persico, 1932); *L’atomo e le sue radiazioni* (Rita Brunetti, one of Garbasso’s pupils, 1932); *Elementi di fisica e chimica ad uso delle scuole di avviamento professionale* (Persico, 1933).

[1] Persico also helped the diffusion of the principles of quantum mechanics and the creation of a new, efficient and modern research group in Florence - similar to the group in Rome - directed by Antonio Garbasso, in collaboration with other important names in Italian physics such as Beppo Occhialini, Bruno Rossi, Gilberto Bernardini.

In 1933, Fermi had the brilliant idea to write in collaboration with other experts, an exhaustive treatise of nuclear physics and then to publish it with the funds of the newly-created CNR. Three volumes were produced: *Molecole e cristalli* (Fermi, 1934); *Il nucleo atomico* (Rasetti, 1936); *Fondamenti della meccanica atomica* (Persico, 1936). Similar studies on theoretical physics would be produced by the Russian School about forty years later: the famous multi-volume treatise by Landau and Lifšits.

And that is not the end of the story. In 1926, Fermi became a worldwide celebrity thanks to his article on quantum mechanics and he also became member of the editorial staff of the *Enciclopedia Italiana* (Italian Encyclopaedia) funded in 1925. A few years later, in 1932, Fermi became the director of the section on Physics: "he edited a whole range of entries concerning physics in the *Enciclopedia Italiana* and wrote the definitions of "Atom", "Electron" and "Statistical mechanics". He also chose the most suitable experts to write some other strategic entries". [11] Thus other members of the group contributed to the *Enciclopedia*: Segré provided the definitions of 'neutron' and 'nucleus'; Persico of 'quantum' and 'quantum mechanics'; Occhialini of 'positron'; Rossi of 'cosmic rays'; Guido Castelnuovo, famous mathematician, of 'relativity'; Garbasso of the general term 'physics' and Gentile of the entry 'radiation'.

At that time, Fermi also wrote for some politically-oriented press: for *Gerarchia* (Hierarchy) he wrote an article entitled *Nuclei ed elettroni* (Nuclei and Electrons) (*Gerarchia*, XI, 1931); for *Gioventù Fascista* (Fascist Youth) the articles *Religione e Fascismo* (Religion and Fascism) (*Gioventù Fascista*, January 1931) and *Fede in Dio. La sapienza dei semplici* (Faith in God. The wisdom of simple people) (*Gioventù Fascista*, II: 5). The thought of Fermi's acute, perceptive and lay mind managing to deal with the ridiculous, pseudo-political and pseudo-religious topics imposed by these publications may actually arouse amusement, but some of his brilliant remarks are always worth noticing such as "It is a pity that, in traditional school programs, an important subject is still missing: how to study".

Ettore Majorana: a communicator manqué?

From the point of view of science communication, Ettore Majorana adopted a completely different attitude as opposed to that of the “via Panisperna boys”. If Fermi’s group published about fifty articles on induced radioactivity only, Majorana published only ten in his whole life! If he was not totally satisfied with the exhaustiveness and rigour of his study, he refused to publish it. At least that is what he seemed to suggest. His attitude derived also from a certain form of self-punishment, from a low self-esteem and a low esteem in Fermi’s judgement when he dealt with Majorana’s work.

Majorana’s retiring behaviour was partly due to the fact that Fermi’s group was carrying out research on induced radioactivity at an experimental level and consequently he could not participate in it; and partly to the fact that this research took place in 1934, when Majorana no longer attended the Institute. He, in fact, had already opted for voluntary seclusion after a journey abroad. He temporarily abandoned his seclusion in 1937 when he became professor of theoretical physics at the University of Naples but he was to pass away soon afterwards.

In 1937, Fermi and other friends of Majorana, including Amaldi and Giovannino Gentile who shared most of Majorana’s scientific interests, had once again to implore him to produce a new publication with a view to the forthcoming appointment, the second in ten years, to the chair of Theoretical Physics. Initially Majorana was reluctant, but eventually resumed an article that he had started to write five years earlier entitled “*Teoria simmetrica dell’elettrone e del positrone*”.

But something had already changed in group researching; the shift from atomic physics to the physics “of the future” had happened in 1929 and it was directed towards a field in which Majorana was very interested: nuclear physics. Corbino, Fermi and Rasetti were convinced that atomic physics was actually “overstocked” despite wave mechanics had been discovered just three years earlier. Thus, on the occasion of a speech Corbino delivered at the SIPS, they traced the main principles of a new politics of research, a real innovation at that time. These new guidelines implied, among the various subjects, the creation of scholarships for students to improve their skills abroad, the increase of funds for the new sector of nuclear physics, the updating of technical procedures and the renewal of laboratories. [10]

The clear speech Majorana addressed in the opening lecture of his course on Theoretical Physics and his article [20] show that Ettore Majorana did not lack the clarity and concision which would have allowed him to write for the *Enciclopedia* and for other popular publications. Majorana's article was written for a sociology review, but it would never be published. Although he had not yet begun his four-year seclusion, science communication and publishing held no attraction for him.

In the following extract from a letter addressed to his friend Gentile (who translated James Jeans' book *The New Background of Science* into Italian), Majorana revealed, however, some interest in science communication and his concern about the distance between Italian readers and the world of science:

"Dear Gentile, thank you very much for sending me your beautiful edition and translation of Jeans' book which opportunely came to occupy my country leisure. I admired the exhaustive preface and I think it will certainly suit the Italian audience because it hints at our country's main schools of thought. Anyway, I think that the main quality of this book is that it foresees people's psychological reaction regarding the consequences of recent progress in physics when it will be clear to everybody that science can no longer be considered as a justification for mere materialism. Thus, I believe that your translation will certainly help to increase the Italians' interest in scientific issues." [7]

They shared many interests and ideas:

"It is clear that they shared a common cultural background the boundaries of which can be marked by their similar way of working, their common interest in certain subjects such as the group theory. All this possibly led them to be excluded from the "via Panisperna" cohesive group" [7].

Other causes outside the scientific context, also contributed to their exclusion: Giovannino's father, Giovanni Gentile, was the philosopher of the

Fascist regime. Franco Rasetti, despite the vast number of interests he had outside the scientific environment, said in an interview with Godstein:

“We, the members of the “via Panisperna” group, sincerely despised philosophy and its representatives, above all Gentile. We actually despised both Gentile, who was fascist, and Croce who was against fascism, that was because we held philosophers in very low esteem regardless of their political beliefs. I think philosophy is nonsense” [7].

Majorana, on the contrary, did not share this opinion as witnessed by his interest in Pirandello and Schopenhauer and his friendship with Giovannino Gentile.

Majorana also owned Gentile’s book entitled *Fisica Nucleare* (Nuclear Physics) which he held in high esteem. “It is a very remarkable informative publication […] we have not seen anything of this kind in Italy for some time, nor are we likely to see it in the immediate future. It should be at anyone’s disposal”. Majorana’s collection of books included, as well as some classics, Dirac’s *Principles of Quantum Mechanics* and Sommerfeld’s *Atombau und Spektrallinien*, some works on atomic physics by Fermi and Persico (Persico’s *Fondamenti della meccanica atomica* would become a modern classic for many generations of Italian physicists), some important publications on nuclear physics such as *Radioactive Substances* by Rutherford, Chadwick and Ellis and Gamow’s *Constitution of Atomic Nuclei and Radioactivity* [7]. Since Majorana was also close to Heisenberg, he presumably read also the Italian translation of his *Die Physikalischen Prinzipien der Quantentheorie*, [17].

Regarding group theory, Majorana’s real passion, he owned Weyl’s *Gruppentheorie und Quantenmechanik*, and the book *Lezioni sulla teoria dei gruppi continui finiti di trasformazioni* by Luigi Bianchi – Gentile’s teacher in Pisa – and A. Speiser’s *Theorie der Gruppen von Endlicher Ordnung*.

Amaldi traced a picture of the situation in 1929: “After his degree, Majorana went on attending the Institute where he spent quite regularly a couple of hours every morning [...] and every afternoon [...]. He spent that time in the library, reading the publications by Dirac, Heisenberg, Pauli, Weyl and Wigner. But Weyl and Wigner were the only two people for whom he felt unconditional admiration resulting from Majorana's lively and almost prophetic interest in group theory and its applications to physics." It seems that Majorana often declared he intended to write a book on this subject and Segrè even remembered that he heard him saying that he had already written a few chapters. Though nothing was ever found among his papers" [7]

It seems also that Majorana wanted to write a book out of his university lectures. Nicola Cabibbo shares this hypothesis because Majorana used to order and arrange carefully every formula and table in his papers:

"The amazing thing in Majorana's papers is their neat layout: text and tables co-exist on the same page: the text shrinks beside a table to become a column and then it increases its length once again to occupy the whole page. The first impression is clear: these papers [...] are likely to be the draft of a book. The publication of a textbook or at least of some lecture notes was part of the academic tradition of that time" [9].

A comparison between Majorana's papers and Fermi's *Notes on Quantum Mechanics* published in their original handwritten form in [15], sheds some light on Majorana's style which would perfectly suit a textbook form. Cabibbo said about Fermi's notes that:

"The small amount of written text is their main characteristic. It is kept to the smallest amount of text necessary to introduce and explain his equations. Fermi provided his students with some fast-reading notes, similar to those students themselves take during lectures" [9].

Furthermore, Fermi would never express some epistemological or philosophical remark on the quantum theory; he used to explain a theory regardless of any difficulty the subject could cause, letting his encyclopaedic vision of physics lead his speech as can be also inferred from his notes[2] of 1926.

[2] They were collected by Dei and Martinozzi and are available at the library of the Physics Department of the Sapienza University in Roma.

On the contrary, Majorana let words exceed figures (except in a few cases) and, as his former pupil Gilda Senatore recollects, sometimes, during his lessons, he would slow down, turn towards his students and then start again to speak more slowly to let the students get their breath back. He could not help adding some personal remarks on the epistemological aspects of theory, especially concerning Heisenberg's theory on quantum mechanics.

Majorana's article on statistics and social sciences: an excellent example of science communication

Majorana's article *Il valore delle scienze statistiche nella fisica e nelle scienze sociali* [20], [5] is an excellent example of science popularization, multiplicity of interests and open-mindedness. Majorana first and one of his brothers afterwards, refrained from publishing the article. Only in 1942, four years after Majorana's disappearance, was it eventually published on *Scientia* thanks to Giovannino Gentile's commitment.

Both Erasmo Recami, who analysed Majorana's main studies in [29], and Amaldi, who dealt with the whole of Majorana's works in [5], wrote about it but using very few words. This article, originally written to be published in a review of sociology, is certainly less important than Majorana's other nine articles, all marked by a high degree of precision and innovation. In this specific context, however, it takes on a new meaning since it shows Majorana's skill in science popularisation.

There is an evident similarity between the opening lecture of Majorana's course of Theoretical Physics and this article. It is also possible that Majorana actually developed it from the papers he, as usual, had refrained from publishing. On both occasions Majorana expressed, for example, some criticism against the excessive trust in mechanicism which, due to the fact that it allows to calculate with extreme precision the dynamics of the solar system, had fostered a tendency to apply the deterministic approach of celestial mechanics to virtually every discipline, including "the most complicated phenomena of everyday experiencing". Another similarity was the description of the two main differences introduced by this new physics: the absence of determinism and the absence of objectivity. Majorana used even the same expression: the *statistical complex* of the microscopic states which determine globally a macroscopic state and which may somehow anticipate Feynman's path-integral method in quantum mechanics[3].

Majorana's criticism against determinism was obviously one of his favourite topics and sometimes it implied also some criticism against his beloved philosophy: "When effective, philosophical reasoning would not trespass its own borders and would leave the scientific questions basically unchanged, although carefully circumscribed" [20]. This is not an article on social sciences but on the method of statistical mechanics. In the following beautiful passage, Majorana himself explained this concept (a more careful analysis of Majorana's papers will certainly arouse some consideration on his excellent use of language):

"Determinism, when it leaves no room for human freedom and forces us to consider all phenomena in life as illusory, because of their presumed finalism, shows its main element of weakness: the stark and irreparable contrast with our conscience's strongest certainties. [...] our final objective is to illustrate how traditional statistical laws must be improved as a result of the new direction taken by contemporary physics" [20]

Thus it was not a matter of finding an improbable way of applying the new statistics to social sciences, but rather of revising and improving the statistical method in the light of contemporary physics.

His considerations on the social sciences seem almost a pretext to expatiate, without being verbose, on the difference between traditional physics and quantum physics. The reference to social sciences appears twice: when Majorana illustrates the formal analogy with statistical mechanics and when he deals with the so-called indeterminism (the probabilistic approach) in statistics. In the first case, the analogy results from an example which takes into account a certain figure from a global sample (i. e. the yearly coefficient of weddings in

[3] It is actually only a faint similarity: Feynman's paths are real trajectories, non-existent in quantum mechanics; Majorana's "statistical complex", on the contrary, is based on the solutions of the Schrödinger equation.

European society). Studying the properties of a gas does not imply studying the dynamics of individual components – this would mean fixing the initial position and velocity of billions of molecules and then solving (at least in principle) billions of Newton's equations to calculate billions of trajectories for each molecule – but studying the global properties of the gas (pressure, temperature, entropy, etc.) which is (also in principle) more convenient. Similarly the study of populations basically concerns global trends "deliberately overlooking individual data (such as the biography of each member of the society under scrutiny) the knowledge of which would undoubtedly be useful for a more accurate and safe forecast of trends" [20].

Regarding indeterminism (in the last lines of Majorana's article) he basically proposed *"to reconsider the grounds of the analogy [...] in the light of the social statistical laws"*, after the introduction of the probability. To clarify his idea, Majorana used another effective example: the radioactive decay of an atom. The absolute casualness and unpredictability of the event is likely to exclude any similarity with social phenomena (thousands or even billions of years may elapse before decay takes place). Indeed, radioactive decay can be measured by means of a specific device equipped with an amplifier that records its mechanical effects. Thus, a chain of predictable events is based on a very casual event. So, Majorana wrote at the end that:

"So, nothing prevents considering, from a scientific point of view, as plausible the theory that the very origin of human events might be a simple, vital fact, totally invisible and unpredictable. If it is so, as we think it actually is, the statistical laws of the social sciences are expected to acquire increasing importance since their function is not only to define empirically the overall result of a great amount of unknown causes, but above all to provide an immediate and reliable picture of reality, the interpretation of which requires a special ability, which is also a major help to the "ability to govern". [20]

That "special ability" would be really helpful to interpret Majorana's reality, to find that "simple, invisible and unpredictable vital fact" which deprived science and the whole world of such a deep-thinking, of such a special person like Ettore Majorana.

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