Physics in Pisa in the first half of the XX century: a reappraisal

Paolo Rossi – Dipartimento di Fisica "E. Fermi" dell'Università di Pisa and Centro Fermi – Museo Storico della Fisica e Centro Studi e Ricerche "Enrico Fermi" - Roma

Abstract
In the first half of the XX century Physics in Pisa was characterized by the strong personalities of the two full professors of Experimental Physics who kept in turn the (only) chair in the Institute, directed by Battelli from 1893 to 1916 and by Puccianti from 1917 to 1947. Both were ingenious and expert experimentalists, but both showed only limited interest towards the most recent developments of theoretical physics.
As a consequence, while being undoubtedly able to form new generations of well trained and high quality scientists (from Occhialini père, Perucca and Brunetti to Polvani, Ronchi, Carrara, Bolla, Bernardini, Gentile jr, Budinich, Borsellino, Gozzini, Verde and Castagnoli, not to mention Fermi and Rasetti), they never really favored the birth of a local school of Theoretical Physics, thus opening a hiatus in the local culture, to be filled (with some pain) only in the second half of the century.

At the beginning of the twentieth century, Pisa was one of the main Italian seats for the study of physics. In the fundamental study of B.J. Reeves [Reeves 1980] Pisa is, together with Rome, Padua and Turin, one of the few locations to which a whole specific and detailed chapter is dedicated.
The tradition of Pisan research in the field of Physics began around 1840, by the will of Grand Duke Leopold II, with the simultaneous arrival of Ottaviano Fabrizio Mossotti (1791-1863) and Carlo Matteucci (1811-1868) and continued with the activity of their pupil Riccardo Felici (1819-1902), author of fundamental contributions in the study of electromagnetic induction phenomena (Neumann-Felici law). Some discontinuity occurred in 1893, at the retirement of Felici, who had been keeping the chair of Experimental Physics for 34 years, because of the absence of a natural heir, as his students, although important (like Pacinotti, Roiti, Bartoli, just to mention the most famous ones) had already found a different location.
The direction of the Institute (and the only Physics chair) was then offered to Angelo Battelli (1862-1916), from Montefeltro, a pupil of Nàccari in Turin, who had already been a full professor in Cagliari (1889-91) and supernumerary professor in Padua (1891 -93) where, however, there was no possibility of further career as the share of chairs (fixed by Casati's law) had already been reached.
His volcanic temperament and his political commitment (he was several times a deputy at the national Parliament) made Battelli a great organizer, and in fact he obtained, in a very short time (1894-95), a first major enlargement of the building of Piazza San Simone (now Piazza Torricelli), a work costing 15 thousand lire, integrated by Battelli with 5 thousand lire of his own for the purchase of equipment. A further intervention of 1908 finally brought the building to the structure it would have kept until World War II, when it was partly demolished by the Germans [Occhialini 1914].
Also fundamental was his commitment to the foundation of the Italian Physical Society (1897) and to the relaunch of the *Nuovo Cimento*, which from 1900 became the property of the S.I.F.
In the present context, we would like to stress especially the contents and characteristics of his scientific work, which would condition, also through his students, an important part of the development of Pisan Physics, even beyond the temporal boundaries of this report.
Battelli was a skillful experimenter, and dedicated his commitment to a wide class of themes, chosen among those that most attracted the attention of the physicists of the time, always with the aim of checking with experience the theoretical hypotheses present in the literature , above all thanks to an improvement in the accuracy of the collected data. Prior to his arrival in Pisa he was mainly occupied with thermoelectric phenomena (Thomson and Peltier phenomena), of earth physics (though with little results) and above all, starting from 1887, of thermal properties of the

vapors. The relative failure of earth physics research is very significant of the fundamental limit of Battelli's research, characterized by a substantial lack of theoretical bases of his own, so when he moved on relatively unexplored terrain, unable to verify the theories of others, he was struggling to obtain convincing results.
We keep this fact in mind, which will also reflect on the subsequent evolution of the Pisan Institute.
Shortly after his arrival in Pisa, Battelli was joined by Antonio Garbasso (1971-1933), a younger pupil of Nàccari's, who in 1895 was given the task teaching Mathematical Physics. The Battelli-Garbasso collaboration, which lasted a couple of years, was fundamental not so much for the specific results as for the fact that it helped to redirect research into the radiative phenomena that were discovered in those years. It is significant that, a few months after the announcement of the X-ray discovery by Röntgen, and even before its results were published, Battelli and Garbasso managed to reproduce the experiment and make it the subject of public conferences; but it is also symptomatic that their interpretation of the phenomenon was completely wrong, as they came to affirm that it could not possibly be a new type of electromagnetic radiation.
Starting from 1900, thanks to the collaboration with his young pupil Luigi Magri (1875-1911), Battelli directed his research on oscillatory discharges, realizing very sophisticated and very precise experimental apparatus, in particular with the rotating mirror method.
Another important object of investigation was radioactivity between 1906 and 1909, in collaboration with the assistants Occhialini (father) and Chella. The treatise *Radioactivity* published by them in 1909, had a good reputation for its completeness and was translated into French and German. Battelli also took care of synchronization between images and sound in film projections: the first experiment of projection with sound was made on 19 October 1906 in Pisa at the Cinema Lumière. In later years, Battelli has also dealt with the dynamics of air flight, but undoubtedly, because of his increasingly absorbing political commitment, in the course of time his scientific activity had strongly diminished in intensity and importance. In the meantime, however, the didactic commitment had never ceased, mainly taking the form of inserting the senior students into current laboratory practice, allowing them to refine the techniques while acquiring direct knowledge of the latest research results.
More than half of his 74 graduates published at least one communication in the *Nuovo Cimento*, many found a professional placement as teachers in the secondary schools, and some deserve to be remembered for their university career, like Ugo Panichi (1872-1966), mineralogist, professor in Cagliari and Pavia, Luigi Puccianti (1875-1952) professor in Genoa and Pisa, Augusto Raffaele Occhialini (1878-1951), professor in Sassari, Siena and Genoa, Virgilio Polara (1887-1974) in Catania and Messina, Eligio Perucca (1890-1965) at the Polytechnic of Turin, Rita Brunetti (1890-1942) in Ferrara, Cagliari and Pavia and Mariano Pierucci (1893-1976) in Modena. It should be noted that the above list includes more than a quarter of the holders of Experimental Physics in Italy in the 1930s.
In 1917 Luigi Puccianti, a Pisan by birth, and a pupil of Battelli and Garbasso, was called to succeed to Battelli. After graduating (1898) Puccianti had moved to Florence where he remained until 1915, when he got the chair and was called to Genoa. Puccianti proved to be a great experimenter since the time of the preparation of the thesis, focused on infrared spectroscopy studies, for which he had built the entire spectrograph piece by piece, and in particular the torsion system for the Crookes radiometer, a result of which he was particularly proud even many years later.
Following his many researches in the field of Puccianti spectroscopy even before he had obtained the chair, he achieved a notable reputation, even internationally. We must also include electrodynamics among his interests, and remember his strenuous opposition to Giorgi's system of measure units (which later became the International System) because in his opinion it obscured the substantial homogeneity of the fields **B** and **H** and the dimensionless nature of the coefficient μ. It was not a physically irrelevant issue, because Puccianti connected it to Ampère's hypothesis on the origin of magnetism and therefore to the substantial unity of the origin of the interactions between

currents and currents, between magnets and magnets, and between magnets and currents. His memory on this subject was discussed in 1914-15 at the *Accademia dei Lincei*.
After returning to Pisa Puccianti significantly slowed down its research activity: its most important result in the Pisan season was the proposal of a direct method for measuring the X-ray wavelength, based on Compton's findings and on the use of a large-angle diffraction pattern of incidence.
Having abandoned in fact the experimental research, Puccianti nevertheless continued to devote himself with passion to teaching and high dissemination, and was full of ideas and suggestions for his students and colleagues. Prosecuting a model of experimental research largely inspired by that of Battelli, he was also a true teacher for a school of physics that left important traces not only in Pisa, where spectroscopy, especially thanks to Adriano Gozzini (1917-1994), remained one of the central themes of the research activity, evolving then into the physics of lasers, but also in other locations, and in particular in Florence, where thanks to his pupil Vasco Ronchi (1897-1988) the National Institute of Optics was born, and at the Naval Academy of Leghorn where Nello Carrara (1900-1993) began the study of microwaves and, with the engineer Tiberio, created a prototype of radar.
One must certainly add to this list a seminal contribution of Puccianti to the new physics that was developing in locations other than Pisa. We refer to the physics of cosmic rays, which made important progress with Bruno Rossi also thanks to the use of magnetic lenses suggested by Puccianti. In the years 1930-32 in Florence, Rossi's collaborators included a young student of Puccianti, destined to a brilliant career: Gilberto Bernardini. And this is not the end of the story, because the same magnetic lenses played an essential role in the 1944 experiment by Conversi, Pancini and Piccioni, which can in many ways be considered as the start of the physics of elementary particles (Alvarez)
But let's not forget that among his students we must also include Fermi and Rasetti, and if the genius of Fermi as a theorist certainly does not owe anything to Puccianti's teaching, it is however difficult to doubt that in the laboratory practice, although hated at the time but required for the preparation of the thesis, Puccianti had an important training role for the one who would later become one of the greatest experimental physicists of the century.
Puccianti's graduates were at least 120 (it is difficult to estimate exactly their number because the practice of requesting theses in different institutions had already started), and once again it is impressive to list how many of them obtained later a university chair or an important institutional role; we remember among the graduates of the period 1917-1947
Giovanni Polvani (1892-1970), full professor in Bari (1927-1929) and in Milan (1929-1969)
Vasco Ronchi (1897-1988), founder and director of the National Institute of Optics (1927)
Mentore Maggini (1890-1941), director of the astronomical Observatory of Collurania since 1926
Nello Carrara (1900-1993) professor at the Naval Academy from 1924 to 1954, director in charge in Pisa from 1947 to 1950, professor in Florence from 1956 to 1975
Enrico Fermi (1901-1954), full professor in Rome (1927-1938), Nobel Prize in Physics (1938)
Franco Rasetti (1901-2001) full professor in Rome (1930-1939) and in Canada from 1939
Francesco Vecchiacchi (1902-1955), full professor of Electrical Communications at the Polytechnic of Milan (1937-1955)
Giuseppe Bolla (1901-1980) full professor in Milan (1942-1972)
Amedeo Giacomini (1905-1979), full professor in Trieste (1949-1955) and in Perugia (1955-1975)
Giovanni Gentile (1906-1942) full professor in Milan (1937-1942)
Gilberto Bernardini (1906-1995) full professor in Bologna (1938-1946), Rome (1946-1964), Scuola Normale Superiore (1964-1977)
Cosimo Pistoia (1901-?) (Radiotecnica E.I.A.R.)
Luigi Solaini (1909-1989), full professor of Topography at the Polytechnic of Milan (since 1950)
Nestore Bernardo Cacciapuoti (1913-1979), full professor in Trieste (1949-1962) and Pisa (1962-1979)

Giulio Gregoretti (1915-?) full professor of Electronic Measurements at the Polytechnic of Turin (since 1973)
Paolo Budinich (1916-2013), full professor in Trieste (since 1954)
Antonino Mura (1916-1957), researcher in Milan
Antonio Borsellino (1915-1992), full professor in Genoa (1950-1984) and later in Trieste since 1984
Aldo Vespi (1917-2014), principal of the Liceo of Pontedera
Adriano Gozzini (1917-1994), full professor in Pisa (1959) and at the SNS
Guido Tagliaferri (1920-2000) full professor in Bari (1960) and Milan (1960-1996)
Mario Verde (1920-1983), full professor in Turin (1950-1983)
Donato Palumbo (1921-2011), full professor in Palermo, director of the fusion program of EURATOM (1961-1986)
Carlo Castagnoli (1924-2005), full professor in Parma (1959) and then in Turin from 1961 to 1995
Alfonso Merlini (1926-2014), director of the Physics Division at EURATOM in Ispra until 1991
Also in this case, the professors present in the previous list represent about a quarter of the full professors of Physics in service in 1960 and entered into the post-war role.
However, we would be scarcely objective if, in addition to the undeniable successes of a school that, thanks to the constant supply of bright young people constituted by the recruitment of the students of the Scuola Normale Superiore, we did not highlight some limitations, both in the method and in the choice of topics, that an analysis of the Pisan scientific production before the arrival in Pisa of Conversi in 1950 clearly reveals.
We have already talked about the lack of attention to the theoretical foundations of the phenomenological models that had characterized Battelli's research and teaching. Puccianti, who as mentioned above also was not totally devoid of theoretical interests, and who had also bothered to refute the anti-relativistic interpretation of Sagnac's experiment, must however be criticized for a lack of attention to the evolution that was taking place in physics, on the one hand with the birth of the quantum mechanics of Schrödinger and Heisenberg and on the other with the extraordinary and rapid development of nuclear physics, in which also Italy was playing a very important role thanks to the work of Fermi and collaborators . Not to mention the research in general relativity, which also, thanks to the work of the young Fermi, had seen in Pisa a first and extraordinary flowering.
It is worth noticing that this is a cultural attitude, and not a lack of updating, as can be verified by an examination of the programs of university courses held since the second half of the twenties: in 1927/28 Puccianti in the course of Superior Physics discussed de Broglie's ideas and the Schrödinger equation, as did Lazzarino in the course of Mathematical Physics of 1928/29 (but the names of Heisenberg and Dirac appear for the first time only in the 1930/31 program). It is significant that the first theoretical thesis, discussed in Pisa in 1927, was that of Giovanni Gentile jr (1906-1942), and this happened only for reasons of *force majeure*, because the original referee, the experimentalist Polvani, had meanwhile gone to Bari.
The first chairs of Theoretical Physics (1927) went to Rome, Milan, Florence and shortly after to Turin, and only in 1937 was asked for a chair for Pisa, who went to Giulio Racah (1909-1965), but soon expelled (1938) because of the racial laws. The course, which had previously been held by Gentile for four years, after Racah was entrusted, always by appointment, to Tullio Derenzini (1906-1988), who held it for many years, until 1955, but never made research and always limited itself to an introduction to the basics.
The choice not to cover the teaching of theoretical physics with a full professor active in the field, unlike what was happening in the immediate post-war period in all the most important locations, from Padua to Bologna and Pavia (1947) and then also to Naples and Genoa (1950) speaks loud about a "philosophy" of research in physics that only with the arrival in Pisa of Radicati in 1955 whould radically change, adapting to a model that was now taken for granted throughout the rest of the country.

Basic references:

A. Occhialini, "*Notizie sull'Istituto di fisica sperimentale dello Studio pisano"*, Pisa 1914
L. Puccianti, *"Il contributo della scuola di Pisa alla fisica italiana",* SIPS (1939)
G. Polvani, "*Fisica"* in "Cento anni di ricerca scientifica", SIPS (1939)
G. Polvani, *"In memoria di Luigi Puccianti*", Pisa 1955
B. Reeves, "*Italian Physicists and their Institutions 1861-1911"* Harvard thesis 1980
G. Dragoni, *"per una storia della fisica italiana tra la seconda metà dell'Ottocento e la prima Guerra mondiale",* in "La storia delle scienze" Vol.5 t.II pp.306-353, Milano 1989
L. Gorgolini (ed.), *"Angelo Battelli (1892-1916). L'uomo, lo scienziato, il politico"* San Leo 2004
C. Romeni, *"Storia della fisica in Italia: 1915-1955"* in "La storia delle scienze" Vol.5 t.II pp.354-374, Milano 1989
L. Bonolis, "*Fuga dall'Italia fascista: il caso Bruno Rossi*", Sapere, dicembre 2010, pp. 52-61