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Laura Bassi and Giuseppe Veratti: an electric couple during the Enlightenment*

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Resum. A partir de la meitat del segle XVIII, s'escampa per Itàlia una gran curiositat pels fenòmens elèctrics, posats en evidència per les primeres màquines productores d'electricitat electrostàtica. És un interès compartit pels ambients acadèmics i pels salons freqüentats per l'elit de la noblesa. L'Institut de les Ciències de Bolonya ès una de les primeres acadèmies científiques que dóna legitimitat a l'estudi de la natura del 'fluid elèctric' i dels seus efectes com a nou camp de recerca científica. Entre els especialistes bolonyesos en l'estudi de l'electricitat, destaquen el metge Giuseppe Veratti i la seva esposa Laura Bassi, professora de filosofia a la Universitat. Ambdós participen en recerca experimental i en debats teòrics sobre la natura i els efectes de l'electricitat. Aquestes activitats els posen en contacte amb destacats experts, com ara Jean-Antoine (Abbé) Nollet, Giovanni Battista Beccaria, Felice Fontana i Alessandro Volta. La recerca que fan Veratti i Bassi segueix camins diferents, però comparteixen espais i instruments, a més de les opcions teòriques i les relacions científiques. L'objectiu de la conferència és fer conèixer l'activitat científica d'aquesta parella, que al segle xviii representa un cas excepcional de col·laboració científica entre marit i muller.

Paraules clau: Laura Bassi · Giuseppe Veratti · història de la ciència · descobriment de l'electricitat

Abstract. From the first half of the 18th century onwards, tremendous curiosity about electrical phenomena spread throughout Europe. Machines producing electrostatic electricity were scattered over Italy, and lectures on electricity attracted members of academia as well as the ruling elite. The Institute of Science of Bologna was one of the first scientific academies to lend legitimacy to studies focused on the nature of "electric fluid," uniting them into a field of scientific research. Among the Bolognese specialists in the study of electricity, the physician Giuseppe Veratti and his wife, Laura Bassi, professor of philosophy at the university, stand out. As a couple and independently, they carried out experimental research in the field of electricity, even setting up research facilities within their own home, and were active participants in theoretical debates on the nature of electricity and its effects. These activities led to correspondence and collaborations with distinguished experts, such as Jean-Antoine (Abbé) Nollet, Giovanni Battista Beccaria, Felice Fontana, and Alessandro Volta. This text describes the couple's scientific activities, which in the 18th century represents an exceptional case of collaboration between husband and wife.

Keywords: Laura Bassi · Giuseppe Veratti · history of science · Enlightenment · discovery of electricity

Introduction

The highly original book Creative Couples in the Sciences, published several years ago, is a series of studies on researchers who, as husband and wife, obtained important scientific results in the 19th and 20th centuries. A few of these couples were even awarded the Nobel Prize. In the book's introduction, the editors (Helena Pycior, Nancy Slack, and Pnina Abir-Am) point out how the researchers' creativity was stimulated by their personal relationships. Moreover, they maintain that the collaboration, and even the competitiveness, that arises between members of a couple engaged in a common scientific task is different from that among researchers with merely professional ties, simply because the former are united both in their affections and in their professional lives [1].

If there were not many couples engaged in a common scientific field in the 19th and 20th centuries, there were obviously even fewer in the 18th century, the main reason being that women were generally excluded from higher education. In fact, however, because many of the activities associated with scientific enquiry were carried out at the investigator's home, his wives, daughters, and sisters often served as invaluable assistants, illustrators, or translators, but their names were destined not to appear in the books or articles of their husbands, fathers, and brothers. This was not the case of Laura Bassi, since she was far more in the public eye than her husband Giuseppe Veratti, as is also made clear by the fact that there are several oil paintings, prints, and medals repre-

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Fig. 1. Portrait of Laura Bassi from 1732.

senting her and her work, while not a single portrait of Veratti exists [2].

Unlike other learned women of her time, Laura Bassi was not indebted to her husband, who had a degree in medicine, for her philosophical and scientific education or indeed for her career. On the contrary, when they married, her knowledge of mathematics was far greater and much more contemporary than his, since she had acquired it from the school of Gabriele Manfredi, one of the Italian pioneers of infinitesimal calculus. There are, moreover, several hints indicating her support of Newton's theory of color as early as 1732, the year in which she graduated. Her knowledge of literary culture, i.e., Greek, Latin, and French, in addition to Italian, was also greater than his and she composed highly appreciated occasional verse in the Arcadian fashion [3]. Thus, all the conditions necessary for a relationship between equal partners, in terms of family life and scientific collaboration, were present in the life of the Bassi-Veratti couple. This was not only unusual but almost inconceivable in the social, juridical, and cultural context of the 18th century, much less in the Pontifical State.

A few years ago, Paula Findlen initiated a new chapter in the studies on Laura Bassi when she described Bassi's strategies for creating a career and a public role for herself, two aspects of a woman's life that were completely novel in the 18th century. It seems clear that for Bassi these strategies also extended to the invention of new roles and relationships within her marriage, with her husband's approval and complicity. One might then ask whether the couple's novel arrangement also determined the way in which they carried out their scientific and didactic activities and their interactions with the scientific community. The following discussion seeks to answer this question by concentrating, above all, on the roles they played, individually and as a couple, in the early community of Italian scholars of electricity. This is not a completely new theme, as Beate Ceranski dedicated a paragraph to it in her monograph on Bassi. That work is taken into account here and is integrated with the results of others.

As an introduction to this story, it is necessary to introduce Bassi and Veratti as well as to provide the reader with information about the two main cultural institutions of 18th century Bologna: the University and the Institute of Sciences. The University had a glorious past, but by the middle of the 17th century was in a state of decline, with modern ideas and methods finding no room in its curricula. The Institute of Sciences had been founded at the beginning of the 18th century with the aim of integrating the traditional teachings of the University. It was conceived as a Baconian House of Solomon, a place designed for research and experimentation, complete with a specialized library, a museum of natural history, physics and chemistry laboratories, and an astronomical observatory. It incorporated two academies, that of the sciences and that of the arts. The work of Bologna's academicians was quite well-known throughout Europe, thanks to the ten volumes of Latin transactions, the Commentarii, published from 1731 to 1791 [4].

Bassi and Veratti: a scholary couple

Laura Maria Caterina Bassi (1711–1778) was the only woman in Europe who at the age of 20 had graduated in Philosophy and been awarded a chair in the same subject; this was at the University of Bologna in 1732. In that same year, she became the first woman member of the Academy of Sciences.

Giuseppe Veratti (1707–1793) received a degree in Philosophy and Medicine in 1734. Although trained as a physician, he was strongly interested in physics, a matter which was part of the philosophical curriculum. In 1737, he was given a university position to teach it, and some years later a second position in the field of anatomy. In the second half of the 18th century he was promoted, serving as the assistant to Iacopo Bartolomeo Beccari, an experimental physicist at the Institute of Science. Veratti, like his master, Iacopo Bartolomeo Beccari, was one of the many Bolognese physicists of the Settecento who tried to apply the principles of the new Newtonian physics to the study of organisms. By the end of the century, the most famous practitioner of this approach was Luigi Galvani, the discoverer of electricity in animals. Galvani had been a pupil of Veratti and Laura Bassi [5].

Fig. 2. Laura Bassi defends her thesis for her degree in Philosophy (1732), Archivio di Stato di Bologna, Anziani Consoli, vol. 13, c. 94a, miniature on parchment (Authorization n. 908, 27.10.2009 of the Ministerio per i Beni e le Attività Culturali).

The following citation shows the close interaction among scientific interests and private feelings in the life of Veratti and Bassi. In ending a letter to his wife during one of the rare periods he spent away from Bologna, Veratti writes: "Remember the electrical Machine, the love I feel for my Children and to Yourself, who are the greatest wealth I possess on this Earth" [6].

This letter was written at the end of the year 1746; their married life had begun 8 years before. It offers evidence of the couple's affectionate solidarity and scientific collaboration. In 1738, the marriage between the first woman to obtain both a university degree and a lectureship, and a young physician, her colleague at the University and at the Academy of Science, had not been well regarded by society. It was considered a blemish on the image of the virgin Minerva, the symbol of learned Bologna, with whom the young Bassi, with her education and dialectic ability, had been identified. By marrying, she had transgressed the confines assigned by nature and society to her gender. However, at the same time, the very public exhibition of such a "prodigy," which drew to Bologna the attention of European men of culture as well as travelers on their grand tour, had aroused the ire of the townspeople, who found it scandalous that a young, unmarried woman was frequenting places of mixed company, such as aristocrats' salons and exclusively male gatherings, such as the Academy's meetings [7]. In order to escape this dually complex situation, Bassi decided to marry and, as we know from one of her letters, chose Veratti only after he had promised that he would not hinder her in her studies [8]. In fact, her new marital status increased Laura's chances of taking part in social and scientific life, despite her pregnancies and numerous children. In 1746, when the abovementioned letter was written, she had already had five children, three of whom had survived, and there would be a further three in the years to come. The couple's home became a seat for literary salons, frequented not only by scholars of science but also by poets, amateurs, and travelers.

It was only because of her marriage that Bassi managed to avoid the merely representative and ornamental role to which the authorities in Bologna had relegated her. Without the status of a marriage or the material and moral support of her husband, Bassi almost certainly could not have successfully attained the two goals that permitted her to effectively carry out her research and her teaching—if not exactly on the same terms as her male colleagues, then nearly the same. She obtained the first of these goals in 1745, when she and Veratti were able to convince Pope Benedict xiv to nominate her as a member of the new class of the Benedettini academics that he had created to stimulate the scientific output of the Academy. The Benedettini received a stipend but were expected to attend the sessions of the Academy assiduously and to present at least one original paper per year [9].

The second goal that Bassi managed to attain due to Veratti's collaboration was the opportunity to teach on a regular basis, albeit at home. In 1732, when the lectureship of Philosophia universa was assigned to her, the Senate had pointed out that, because of her gender (ratione sexus), Bassi could only hold lectures with the consensus of her superiors and on exceptional occasions. Bassi had tried to have this constraint removed so that she could teach under the same conditions as her fellow professors, but these efforts were in vain. Finally, in 1749, in her own home she set up a school of Experimental Physics that was highly successful as it filled a gap in the studies available in the city. The University offered only theoretical teachings, whereas the experimental courses of the Institute were too abridged and produced few results.

The main prerequisite of a school of this nature was the availability of a physics laboratory equipped with all the instruments, machines, and materials essential to meet all the needs of the discipline. If only because of the high costs involved, Veratti's agreement and collaboration were clearly critical to the success of Bassi's enterprise. Thus, at their home the couple had an impressive set of tools (among them, as referred to in the letter above, an electric machine) that they used for their research and also for the medical therapy proposed by Dr. Veratti. To open the school, it was necessary to expand this collection with new tools; in turn, over time, the school acquired a great deal of recognition. In 1820, a Bolognese aristocrat acquired the school's equipment from Paolo Veratti, the couple's son, and drew up an inventory of it. In this document credit was given only to Bassi, who by that time was part of the academic pantheon of Bologna [10].

The school also turned out to be a good investment because it attracted numerous students as well as the fact that in recognition of its benefits to the public the Senate awarded Bassi a considerable increase in salary, in 1759. Courses were held throughout the year and Bassi continued teaching them until shortly before her death in 1778. Thereafter, her husband assumed these responsibilities. One of the first students to attend the school was Lazzaro Spallanzani, who always referred to Laura Bassi as his "venerata maestra" [11].

The fact that Bassi's professional success also meant an increase in the family's income suggests that the couple's efforts were not wholly of an idealistic nature. In any case, their solidarity is apparent in their agreed-upon strategies for obtaining recognition in the scientific community and in the unanimous choice of which faction to support whenever there were divisions within the academic or political community. It was also manifested in their cultivation of shared scientific friendships. Moreover, their habit of working together, along with their reciprocal affection and respect, may have had an important influence on the evolution of their respective research interests. One example that seems to verify these statements is the roles that Bassi and Veratti played, individually and as a couple, within the early community of Italians studying electricity, in a period extending from the initial discussions on the subject (1747–1752) to the end of the 1770s, i.e., the years just prior to Galvani's theories on animal electricity [12]. The couple's research activity took place in their home laboratory, in the Physics department at the Institute of Sciences, and during the meetings held at the Academy of Sciences.

At the time of the aforementioned letter, the availability of an electrical machine at the Verattis' house made it the only private place in Bologna where it was possible to perform electrostatic experiments. Judging from what is known about the

equipment available at the house [13], the machine is likely to have been an improved version of the Hauksbee model invented at the beginning of the century. A description of the machine can be found in the travel diary of Jean Antoine Nollet, who visited the Bassi-Veratti laboratory in 1749. The machine is described as a multi-globe machine, similar to the one designed by the German professor Johann Heinrich Winkler around 1743–1745, which very quickly spread all over Italy. A number of details in Nollet's description suggest that some of the parts of Veratti's machine were made in Venice, where this model of electrical generator was well known due to the public demonstrations of the Saxon physician Christian Xavier Wabst and the Flemish experimenter Francisco Bossaert [14].

The Institute acquired an electrical machine only in 1743. It was a single-globe machine moved by a multiplying wheel (according to the Hauksbee and Gravesande models) and belonged to the extensive collection of experimental physics instruments that the Institute purchased from the Dutch instrument-maker Jan Van Musschenbroeck, made possible by the generous financial support of Pope Benedict XIV. Until then the Bolognese physicists had worked on pneumatics, fluid dynamics, mechanics, and Newtonian optics [15]. It was only towards the end of the 1740s, much later than other European centers of learning, that they began to show some interest in the phenomena of electricity. The role of the Bolognese Academy in expanding research on electricity in Italy was recently explored by Paola Bertucci, in a book focused on the travel across Italy of the Abbé Jean Antoine Nollet, in 1749 [16]. Nollet went to Italy in order to judge for himself the controversial experiments carried out by a number of Italians, who thought that electricity might act as a vehicle for introducing into the human body pharmaceutical products contained within sealed glass tubes for the treatment of certain illnesses. The Academy was directly involved in discussions about the use of electricity in medical therapy. These discussions, which took place in Italy in the years 1747–1749, became a matter of debate throughout Europe, thanks to Nollet. Some years ago, this episode was referred to by Simon Schaffer as an example in support of his theories on the social aspects of scientific evidence [17]. Controversy arose following publication of the book *Dell'elettricità medica*, by the Venetian Gianfrancesco Privati, who was a solicitor, writer, and cultivated self-made expert in physics. Pivati was a member of the Academy of Bologna, where his book was published in 1747 in the form of a letter addressed to the Secretary Francesco Maria Zanotti. The Academy entrusted to Veratti the task of experimental verification of the efficacy of the therapeutic method proposed by Privati. The experiments by which the latter maintained he had confirmed the therapeutic efficacy of electricity were presented at the Academy and made known to a wider public in a book published in Bologna in 1748, which was subsequently translated into French and printed in Geneva in 1750 [18].

Classical histories on electricity also mention the experiments on atmospheric electricity carried out by researchers in the Bolognese Academy in 1752, immediately after the French experiments in Marly. These experiments were among the first in Italy to confirm Franklin's hypotheses about the identity between atmospheric and artificial electricity. In this episode too, Veratti was one of the main protagonists, immediately making the results known to the public [19]. Both these experiments concerning atmospheric electricity and the lightning-rod, and those of 1748 on therapeutic electricity were widely reported in the 1755 edition of the Academy's *Commentarii* [20]. As a result of these works, Veratti gained a minor place in the history of electricity, although probably a smaller one than he deserved.

Laura Bassi, by contrast, has been almost totally ignored by historians of electricity, which is quite unjust considering that she presented no less than seven dissertations on electricity to the Academy, a number surpassed only by her husband's. That her contribution has been forgotten is, however, quite comprehensible, since the texts of these papers have been lost; only their titles and dates of presentation are known. This is the only time when Veratti's name is more prominent than his wife's, but this is true only historically because at the time she was well-respected by her colleagues. The example of Nollet serves to illustrate this point: after his return to Paris, he continued to correspond with her also about other areas of experimental physics. In particular, one long letter that he wrote is significant because of the description Nollet gives of one of his new inventions, a square in which it is possible to conduct "electrical fire" in order to create luminous designs at one's desire. The French experimentalist eventually included this letter in the 1767 edition of his *Lettres sur l'Électricité* [21].

The research program

As pointed out above, Bassi's training was different from Veratti's. Her best-known contributions, mainly because they were published in the *Commentarii*, dealt with problems of pneumatics, hydraulics, and mechanics, solved at times by analytical methods [22]. She did share with her husband, however, a passionate interest in electrical phenomena and, later, in studies on fixed and on inflammable air. Her presence can be clearly felt in all three of the major lines of research in electrical phenomena carried out at the Academy in Bologna from the 1750s to the 1770s. As clearly delineated by Veratti in his papers of 1748 and 1752, these three closely linked lines were:

1. The Newtonian epistemological approach, which, in the wake of the *Queries* in the *Opticks*, attempted to find principles capable of linking physical phenomena (light, heat, electricity, and magnetism) with organic phenomena (the effects of electricity on the growth of plants and on muscular movement, "electric" fish, and phosphorescent fish).
2. The study of the effects of "electrical fluid" on living organisms and on their functions. It was mainly Veratti, and then Galvani, who took research to the borders between physics and physiology. As mentioned above, despite holding a post in those years as a lecturer in physics at the University, Veratti was a physician, a pupil of Iacopo Bartolomeo Beccari, likewise a physician, but also a professor first of physics, then of chemistry, at the Institute and the University. Indeed, with very few exceptions,

among them Laura Bassi, all the Bolognese scholars of electricity had degrees in medicine.

3. The support of the single electrical fluid theory proposed by Franklin and systematized in a Newtonian framework by Giambattista Beccaria, with whom the Academy, through Beccari, Bassi, and Veratti, held a close and fruitful relationship. Even when most of the Italian electricians supported Symmer's "double fluid" theory, the Bologna Academy remained faithful to Franklin [23]. An official guide to the Institute published in 1780 stated that the machines and instruments in the room dedicated to electricity were intended to illustrate Franklin's and Beccaria's theories [24].

In the concluding section of his book on medical electricity, Veratti presented the results of a series of tests aimed at demonstrating the "physical qualities" of what he sometimes calls electrical "force," and other times electrical "virtue" or "matter." Among these, the first and best-known one was the capacity to attract certain bodies and repel others. Veratti rejected explanations of a mechanistic type, such as Nollet's (whom, however, he did not mention by name), and instead believed that electrical phenomena are a result of attraction, which he defined as the "general source, from which the principal phenomena of nature spring." He was of the opinion that, like attraction, "electrical virtue" was "scattered and spread universally throughout corporeal nature." Finally, he put forward a "conjecture" that "there may be much analogy and similarity between electrical fluid and light." Newton showed that light is attracted or repelled by bodies in different ways. The same was true for "electrical fluid." Why shouldn't one think that "these two marvelous fluids" are "one and the same thing"? [25].

The path in search of analogies that made it possible to link different phenomena was followed uninterruptedly at the Academy in Bologna, first by Veratti, who in academic meetings of 1758 and 1759 proposed an analogy between "magnetic virtue," "electrical virtue," and fire; second by Laura Bassi, who in 1777 maintained that there was an affinity between bodies that retain heat and those that retain electricity; and third by Galvani, who in 1786 hypothesized that there is a similarity among flame, respiration, and "electrical vapor", and in 1791 finally publicized the results of experiments proving the existence of electricity in animals and its identity with common electrical fluid [26].

This research program was undoubtedly also fueled by the great influence Beccaria had on the Bolognese scholars [27]. Originally, however, as Beate Ceranski suggests, there might well have been discussions and exchanges of opinions between Bassi and Veratti. In the years 1747/1748 and after, the couple was engaged in different fields, and, in fact, Laura's notes on electricity date from after 1761. Ceranski is of the opinion that Bassi deliberately remained in the background in order not to harm the fame of her husband as an expert electrician, whose book she promoted forcefully by means of her own personal network of relationships [28]. However, that she was in fact already profoundly interested in the debates about electricity is proved by a paper entitled '*De aere in fluidis contento*', which she presented at the Academy in 1748 [29]. The subject discussed was the cause of air bubbles that are formed in different liquids contained in vases when air-pressure is eliminated. Bassi felt that the cause was the attraction carried out on the air within by the walls of a jar and the liquids contained therein, which were of different densities. She began the paper by establishing an analogy between the behavior of air and that of light. She then observed that "both these fine fluids," in crossing different barriers, "obey the laws of attraction and repulsion," exactly like electricity, whose tendency to accumulate in the extremities of bodies and corners she recalled [30].

It is therefore clear that even if the two partners were focused on different topics, they still shared a model of interpretation. This no doubt arose from their habit of exchanging ideas, encouraged both by the fact of living together and by their experimental activities, which, while concerned with different subjects, were carried out side by side in the same laboratory. Ceranski wonders which of the two had more influence on the other. She tends to favor Laura, who had first appreciated Newton many years before and who had on several occasions publicly repeated his experiments on the composition of white light as explained in the *Opticks* [31].

The physics laboratory in the Veratti house, in which there was a considerable quantity of electrical instruments, was in the mid-1750s an essential point of reference for some young physicians and physicists, the supporters of Haller's physiological doctrines, including Leopoldo Caldani and Felice Fontana. Haller's distinction between sensitivity, a nerve property, and irritability, an independent property of the muscles, was attacked in Bologna by Tommaso Laghi, who, at a session of the Academy in 1756, defended the traditional doctrine of animal spirits circulating in the nerves as the only cause of muscular movement. He also proposed the hypothesis that nervous fluid was of an electrical nature and that muscular contraction was caused by electricity passing from the nerve to the muscle. In a later session, Caldani defended Haller's theories. The latter had not carried out his experiments at the Institute but privately, in the presence, besides that of Fontana and other young friends, of more authoritative figures, such as Francesco Algarotti and Bassi and Veratti themselves. The experiments, which required the electrical stimulation of various organs, and hence an electrical machine, had been carried out in the laboratory of the couple. It was Fontana rather than Caldani who performed the experiments, using cats, calves, and, above all, a great number of frogs as test animals. Electricity was considered by the two researchers to be the most powerful stimulus, capable of arousing reactions in tissues and irritable organs, even when any other stimuli were ineffective. They both, however, rejected the idea that nervous fluid was of the same nature as the electrical one [32].

One of the first epistemological objections to their acceptance of this theory was that it would have questioned Haller's system, which they supported, and the idea that there was a force within muscles that was independent of nerves and sensitivity. Moreover, as R.W. Home explained, in an article published in 1970, Laghi's analogy was unacceptable on the basis of Franklin's and Beccaria's theories about electricity, with which Caldani and Fontana agreed [33]. It may well have been

Bassi and Veratti who were behind their conclusions, since they were the first supporters of these theories in Bologna. Both Caldani and Fontana were regular visitors to the couple's house, where Fontana also carried out his first experiments, described in his book about the iris, in addition to those on irritability [34]. Veratti's agreement with the hypothesis of a single electrical fluid had been reached after reading Beccaria's 1753 work *Artificial and Natural Electricity*. We know that he repeated those experiments there shortly thereafter. It was probably on the basis of his recommendation that Beccaria was elected a member of the Academy in the spring of 1755. He came to Bologna in October and repeated the experiments described in the book in the physics laboratory at the Institute, also availing himself of Bassi's and Veratti's collaboration. The latter eventually presented Franklin's *Experiments and Letters on Electricity* to the academics on November 6th of the same year [35].

A life of scientific success

The experiments repeated by Beccaria in Bologna included one on the motor effects of electrical stimuli, also quoted by Laghi in his dissertation against Haller: using Franklin's magic square, he conducted electricity through two copper wires joined to the tendons and muscle in the thigh of a live chicken: the spark that was set off made the muscle contract. It has been said of this experiment that "it recalls surprisingly Galvani's first tests" [36]. However, neither Caldani, nor Fontana, nor Veratti evidently interpreted the results as a proof of the analogy between nervous and electrical fluids, and thus in opposition to Haller's principles of physiology. Veratti would return once again to the theme of the effects of electric shock on animals in a series of experiments also using Franklin's square; these were presented at the Academy in 1769 and 1770. In his opinion, the shock caused an upset in the functions of nerves and the destruction of the gluten in the muscles and, consequently, of the irritability of the fibers [37]. This conjecture, therefore, can still be seen within a Hallerian framework. In the following years, Veratti changed his mind; however, in the 1791 volume of the *Commentarii* the account of these experiments is placed alongside Galvani's *De viribus electricitatis*, in which Haller's doctrine of irritability was rejected and muscular contractions were explained as the effect of a flow of animal electricity from the nerve to the muscle [38]. In fact, in his innovative research, Galvani could always count on the advice of Veratti, who proposed some experiments to him, as autographed documents at the Academy prove. In those documents Galvani highly praises not only Veratti but his wife as well [39].

Veratti's lasting appreciation of Haller can also be explained by the friendship that continued to tie him and his wife to the two foremost Italian followers of Haller, Caldani and Fontana. In 1761, after moving to Padua, the former even offered to take on the task of obtaining two vacant chairs for the couple at that University, one in experimental physics and the other in mathematics [40]. Here, however, the relationship between the couple and Fontana is of greater interest to us. In 1758, Fontana had moved to Tuscany, where he had been entrusted by the Grand Duke's government with setting up a large public physics museum [41]. If his letters to Veratti were mainly concerned with matters pertaining to his works on irritability and the iris, those addressed to Bassi, greater in number and to a large extent unpublished, are extremely interesting from the point of view of the history of electricity. The first reason concerns the history of instruments: Fontana often speaks to his correspondent, whom he refers to as "an honor to women and the envy of men," about the machines acquired or constructed for the museum. Among the former was a Nairne electrical machine, which was a novelty for Italy, while the latter included an enormous machine, constructed by the museum's mechanics, which could produce violent sparks like those obtained with the Leyden jar. Fontana also describes a "little electrical machine" constructed in Florence under the guidance of its inventor, the Dutchman Ingenhousz, to whom he had first been introduced by Bassi. One such "little machine" had been constructed for a nobleman in Milan, but had first been sent to Bologna so that Bassi might have a copy made of it [42].

But Fontana does not only discuss instruments with Laura Bassi; he also confides to her that he is not fully convinced by Franklin's system because it does not explain all phenomena. On the one hand, Franklin's work is confirmed by "irresistible experiments," which he has carried out personally. On the other hand, he says that he has found several proofs that "restrict the over-generic propositions of Franklin's followers," although they are not such as to prove the single fluid theory wrong. This letter is dated 1768. As is known, like most Italian scholars of electricity, Fontana would later publicly support Symmer's double fluid hypothesis. We do not have Bassi's replies to these letters, but in a letter of 1775 Fontana attributes to her an "ingenious" defense of Franklin's system, which, nonetheless, does not convince him. She had, in fact, accepted the corrected version of the single fluid theory proposed by Beccaria, who in 1767 had introduced the concept of "vindicating electricity" to explain the phenomena of repulsion between bodies with a negative charge. On June 7, 1771, Bassi presented a paper to the Academy entitled *Sopra l'elettricità vindice*, the text of which, unfortunately, has been lost. Veratti was not converted to the double fluid theory either, so much so that in the years 1778–1780 he dedicated his courses at the Institute to the demonstration "with experiments" of "Beccaria's and Franklin's system" [43].

Such fidelity is not surprising, as after Beccaria's visit to Bologna in 1755 his ties with the scientific community in the city had grown even stronger. Beccaria obviously saw in the favor shown him by the most authoritative Italian scientific academy a shield against the attacks made on him in his own city, Turin, first by the Cartesians and then by the opponents of Franklin. In 1758, he published in Bologna a work whose title (translated) was *Atmospheric Electricity* in the form of letters to Beccari, the President of the Institute. The letters contain a theoretical and experimental defense of the Franklin system. Most of the experiments described had been carried out in Turin, but Beccaria also recalls that some had been done in Bologna, in the presence of Beccari, and with the participation of Bassi and Veratti. One in particular, aimed at "establishing the universal

diffusion of electrical vapor," and indirectly "the contradictions of electricities," had been suggested to him by Laura Bassi, a woman who, Beccaria wrote "does not dislike good reasons but never tires of experiments." The test was enormously successful. Another experiment is described in detail, this one proposed by Veratti, whose aim was to counter any objections to the "contradictions of the two electricities," and his considerations about this topic are reported [44].

Beccaria's collaboration with the Bolognese couple, especially with Laura, continued in the following years by means of letters. Some of hers have survived and she is often the bearer of messages from her husband or speaks of scientific experiments they have performed together, for example, tests on atmospheric electricity conducted in their country house, since these had been banned in Bologna after terrified public reactions to lightning-rod experiments carried out there in 1752 and 1753. Perhaps under the influence of Fontana, Bassi admits in 1769 that she had previously had "various doubts about the contrary nature of electricity," adding that she would like to speak to Beccaria personally about it. In their correspondence, they often spoke of another trip on the part of the latter to Bologna, and hence another chance to carry out experiments together, but this journey was never to take place. Beccaria expresses his gratitude for his Bolognese friends' support and on more than one occasion promises Laura that he will dedicate one of his papers to her. Like Caldani and Fontana, he frequently sends the couple people anxious to meet them and be introduced into the Institute. Like Fontana, who considered their home to be the most open and welcoming in Bologna [45], he was sure that they would be at these people's disposal. As his points of reference in Bologna, he also sends the couple copies of his books for distribution among other scholars at the Institute.

This role as intermediaries among researchers in other cities and the Academy was valued by both of them, but especially by Laura Bassi. In the 1770s, above all, various scholars, especially young ones, sent her their publications, described their discoveries to her, or offered to dedicate their next work to her. Three such scholars were not simply by chance connected to the Franklin's supporters' group. One of them was Giuseppe Campi, who sent her a collection of Franklin's works, the first to be translated into Italian, which he edited in 1774 [46]. The second one, Marsilio Landriani, also engaged in a defense of Franklin, asked her for her opinion about a new type of portable barometer he had invented, but the main topic of this letter was more concerned with debates about various types of air, which at that time was of great interest among those studying electricity, including Bassi and Veratti [47]. The third, and most famous, of Bassi's correspondents was also interested in electricity and in inflammable air. This was Alessandro Volta, who sent her a short work in 1771 containing a description of a series of new electrical experiments, and in 1776 his first two letters about inflammable air in marshlands and, in the following year, the complete work. In 1777, when he sent her his pamphlet describing a pistol that works with inflammable air, he announced in advance a new invention, the lantern using inflammable air, and his intention of dedicating its description to her, whom he defines as the "beautiful ornament of natural sciences, and the light and glory of her sex in our Italy" [48]. In these letters by Volta, and in the only reply of Bassi's that is extant, we are struck by the now-aging Bassi's enthusiasm for the young Volta's inventions. This enthusiasm was obviously shared by Veratti, who even after his wife's death would continue to acquire all the new instruments invented by Volta for the laboratory that the couple had built up together over the course of so many years [49].

Public recognition of a woman scientist

The competence and merits of the Bassi-Veratti couple in spreading knowledge about electrical phenomena, through their research and especially through their teaching, were officially recognized in Bologna. In 1776, the Senate decided to reorganize the teaching of physics at the Institute. Various proposals were made, including separation of the course on electricity from the rest of experimental physics. Bassi and Veratti were asked to organize the new course together, but they replied that this division would have caused several problems of a practical nature. The Senate accepted these comments and decided that the course would indeed be divided, but into one on general physics and the other on experimental physics. The latter was entrusted to Laura Bassi as chief professor and Veratti as her assistant. However, since he had already assumed this role in previous years he this time expected to become the professor. The solution adopted, which was granted in response to Bassi's insistent applications in the previous years—and in recognition of her merits and fame "throughout the Republic of Letters"—obviously had to be approved of and accepted by Veratti, who would become first professor only two years later, that is, after his wife's death [50].

The situation that arose was undoubtedly paradoxical for the time, yet significant in the equally paradoxical way in which Laura Bassi and Giuseppe Veratti were seen by their contemporaries, i.e., as a couple engaged in the same work albeit not a truly equal couple, because one of the two members enjoyed public recognition and social esteem that were far greater than the other's. The greater honor was paid not to the man, the husband, as was to be expected then, and even to some extent nowadays, but to the woman, the wife.

The paradoxical aspect of this situation can only be understood if it is considered within the context of gender relationships of the time. The extraordinary fact in the daily relationship of the couple Bassi-Veratti is that it was based on reciprocity, as established in the agreement made before they married. One of its consequences was that it allowed for a gender role division and a hierarchy that were absolutely new and against the laws and customs of the time. By respecting this agreement, Veratti allowed Bassi to pursue her scientific studies and intellectual profession while maintaining her role as wife and mother and thus a harmonious family life. The conciliation of these two roles showed that the access of women to knowledge was not a danger capable of destroying the family and of generating social chaos—as was claimed by moralists, philos-

ophers, and the lay public, and not only by adherents of Catholic conservatism.

Even in a town like Bologna, where in the *Settecento* a handful of women received public recognition for their knowledge, Laura Bassi was unique. One of the other prominent women of that time was Anna Morandi, whose fame was similar to that of Bassi but was achieved after the death of her husband, the ceroplastic sculptor Giovanni Manzolini. It was only then that Morandi's contribution to the field of anatomic ceroplastics was recognized, which freed her to carry out original research. This work resulted in her being placed in charge of the practical anatomy courses in the university [51]. Without doubt, the fame of Bassi and of Morandi was due to their research and their didactic abilities but also to their extraordinary positions in society. The *ancien régime* was neither able to accept the idea of all women's right to education and to participation in public life, nor to admit a conjugal agreement based on equality. In such a cultural context, the Bologna's episodes of celebration and recognition of the learning of a number of women were possible only because they were functional to the strategies of power and propaganda of male political and religious authorities, who counted on the exceptionality of such women and of the public posts appointed to them in the academy or in the university in order to gain fame for themselves or their town.

The imbalance in the public recognition granted to Bassi and to Veratti was not due to a lower appraisal of the value of his contributions; but it accounts for the role of icon of cultivated Bologna assigned to her. The city's prestige in part arose because of the wide dissemination of her case, unique in Europe. Veratti not only consented to this situation, even when he was not benefited but disadvantaged by it as in 1776, but on many occasions supported the efforts of his wife to effectively improve her conditions as a teacher and researcher.

A true change in the role of women in society and in the family necessarily implies a contemporary change in the role of men and in the prevailing gender hierarchy. In 18th century Italy, Laura Bassi and Giuseppe Veratti invented a model of gender relationships that remained novel for a very long period of time.

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[8] Bassi to Giovanni Bianchi, Bologna, 26 Aprile 1738, in B. Ceranski, 'Il carteggio tra Giovanni Bianchi e Laura Bassi, 1733-1745', *Nuncius*, IX, 1994, 1, pp 207-231.; on Bassi-Veratti's wedding, see also Ead., «*Und sie fürchtet sich vor niemandem*», cit., pp 86-94

[9] Cavazza, M, 'Una donna nella Repubblica degli scienziati', cit., pp 68-70. Pope Benedetto XIV (Prospero Lambertini) is considered to be the refounder of the Science Institute of Bologna, which was in a grave crisis during the 1730s. The institution of the new academic class was part of his strategy to promote the institute's activity and increase its scientific productivity. There were 24 *Benedettini* academies and they received an annual budget, but members were obliged to participate assiduously in the academy and to present at least one original annual report each year

[10] *Inventario delle macchine componenti il Gabinetto una volta della fù Sig.ra Dottoressa Laura Bassi Veratti, ora di ragione del N.U: Sig. Cav. e Conte Carlo Filipp. o Aldrovandi Marescotti*, in Archivio di Stato di Bologna, Archivio Aldrovandi Marescotti, n. 430, pp 24. The inventory is published in Marta Cavazza, 'Laura Bassi e il suo gabinetto di Fisica sperimentale: realtà e mito', *Nuncius*, X, 1995/2, pp 715-753: 741-753

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[14] "La Mach.[ine] Electrique de Mr. Verati a une Roüe de 3 pieds et demi de diametre, deux poupées assez solide set des cylindres dont les uns sont de cristal de Venise, les autres de verre blanc fait a Boulogne, ont environ 21 pouces de diam., et 8 a 10 pouces de longueur" (J. A. Nollet, *Journal du voyage de Piémont et d'Italie en 1749*, Soisson, Bibliothèque Municipale, MS 150, p. 229; Hackmann, *Electricity from glass*, pp. 73-82, 267. I was able to read Nollet's *Journal*, thanks to the kindness of Paola Bertucci (see reference). The crystal bells (*poupées)* of Veratti's machine resemble those of the electrical machine portrayed in G. Pivati, *Nuovo dizionario scientifico e curioso, sacro e profano*, Venezia, Milocco, 10 vols., 1746-1751. On Wabst's and Bossaert's electrical performances in Venice, and on the quick spread of Winkler's electrical machine in Italy, see Paola Bertucci, *Viaggio nel paese delle meraviglie. Scienza e curiosità nell'Italia del Settecento*, Torino, Bollati Boringhieri, 2007, pp 126-129

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