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Electricity in Portugal in Volta's Times

In this article I try to give some insight on what was the state of the art about electricity in the Portuguese University of Coimbra in Volta's times. Reference will be made to the Italian influence in what concerns the establishment of the new experimental physics teaching and to the impact produced by Volta's invention of the electrical battery.

The reform of secondary and university studies began in the middle of the 18th century in Portugal. After the expulsion of the Jesuits, in 1759, the Prime Minister of D. José, King of Portugal – the Marquis of Pombal, tried to develop those studies in a modern context. Before him, others tried the same, namely the priests of Oratorio Congregation to whom the previous King conceded the privilege of opening their house to public sessions of modern philosophy. We are concerned with the Marquis' reform and mainly with what happened in the University of Coimbra after 1772. Before this date, by 1760, the Marquis of Pombal was concerned with the education of noblemen and tried to get a new secondary institution that could give them a new knowledge in sciences. It was the College of Nobles or "Colégio dos Nobres". This was the first Portuguese official school to include the teaching of experimental philosophy in its curriculum. For this purpose, we know that the Marquis developed contacts with the University of Padua in order to get the best teachers he could, to teach physics, chemistry, natural history, mathematics and astronomy. The Marquis and an Italian engineer, named Michele Ciera that came formerly to Portugal to participate in the geodesic work the Portuguese Crown intended to undertake in South America, made the contacts. The Marquis even had the intention of getting the well-known professor Jacopo Facciolati (1682-1769) from the University of Padua to be the director of the College of Nobles.[1]

Then from Italy came Giovanni Antonio Dalla Bella, professor of experimental physics (formerly it was appointed Angelo Falier), Giovanni Angelo Brunelli to teach mathematics, Michel Franzini, professor of geometry and Michele Ciera became the tutor of studies. Many instruments were acquired then for the College of Nobles; some of them were made in Portugal, namely those that do not require special techniques. However, a few years later, in 1772, the teaching of science was transferred from the College to the reformed University of Coimbra. It seems that

[1] See CARVALHO (1954; 1997), p. 52.

the curriculum proposed was too hard for the young noblemen of eleven years old and so the Marquis ordered that all the equipment and the teachers should be transferred from Lisbon to Coimbra.

It is interesting to point out this Italian influence on the teaching of new science in our oldest university. Why did the Marquis use Italian teachers for his reform? Was it only because of the language? Perhaps we can find some reasons in the fact that we had Italian contacts already before this date or century, in the Jesuits' time, as Lisbon was a world centre for the sending of missions to the Far East and South America.

We can register, for instance, that in 1559, Clavius observed a solar eclipse in Coimbra.[2] There were also many concerns with the delimitation of frontiers in Portuguese Brazil and for this reason there came some Genovese Jesuits to give support to these missions. Giovanni Battista Carbone and Domenico Capassi made several observations of the closest satellite of Jupiter and of a lunar eclipse, before leaving for the geodetic mission in Brazil (first half of 18th century).

Another interesting fact we can consider is the way the spreading of the scientific revolution in the southern countries took place. There was an Italian influence in what concerns the teaching of new ideas, although the mentors were Dutch (namely through the books used) or British (through instruments) and the general way of acceptance was Cartesian. This Italian influence seems to have points in common with the introduction of Newtonian physics in Greece, in the same period. As was pointed out by Vlahakis[3] the first person to do this in that country was a certain Theotokis Nikiphoros (1731-1800) who studied in Bologna and Padua Universities. The teacher that came from Italy to Portugal to teach experimental physics was G.A. Dalla Bella, as we have already mentioned, who was born in Padua on 30.8.1730. In his own town University, Dalla Bella studied Philosophy and Medicine and, in 1748, he took a degree in both areas. He was a disciple of Poleni Marquis, whom he replaced after his death in the teaching of physics in the University of Padua until the time he came to Portugal – by the end of 1766.

It is relevant to note that Theotokis Nikiphoros was also connected with Poleni as

> he first met the Newtonian spirit and found out the value of experiment under the teaching of Professor Poleni, who was one of the most distinguished Italian physicists of the period.[4]

We can also remember that the University of Padua, as well as the University of Coimbra, are two of the oldest universities in Europe (they were established at the beginning of the 13th century), so it seems natural that there have been contacts between them, namely because of language affinity.

Nevertheless we cannot forget that there were many other influences on the spreading of the new scientific ideas.

[2] See ANDRADE, DE (1944), pp. 481-96.
[3] See VLAHAKIS (1993).
[4] *Ibid.*, p. 648.

Turning back to Dalla Bella we have his own testimony about the philosophical equipment that was made and bought for the College of Nobles and after that went to the reformed university.[5]

As for Experimental Physics, Pombal's *Statutes* for the University of Coimbra were very detailed and imperative. He recommended the teaching of several topics of Physics in the program and for all the matters the use of experiments in order that students could find the true laws of Nature. For him, the progress of Physics should be found in experience and only there. So, all speculations that could not be demonstrated experimentally should be avoided. In the same devised program, attention was given to Electricity, both natural and artificial. He refers to it as one of the other enigmas of Nature:

> Electricity, both natural as well as artificial, is until the present another Enigma of Physics, similar to Magnetism. But for this reason the Teacher will not give up showing his Disciples a series of chosen Experiments, by which the facts are proved, that until now have been discovered in this matter, explaining the ways the electrical virtue is born, the signals, by which it expresses itself, and the conclusions, that by analogy have been drawn or to explain the terrible phenomena, including lightning.[6]

It was also determined that the experimental classes should be undertaken in the "Casa das Máquinas" (Machine House) and that the students

> could not be simple spectators; but they do work and the Experiments for themselves; as is necessary for acquiring the habit and sagacity they need; and to form in themselves the taste of observing Nature.[7]

The first classes in Experimental Physics were theoretical and they occurred on May 18, 1772, but in a few days (May 22), Dalla Bella began the experimental part.

There are documents where part of what was done is described together with the euphoric state of all of those that attended the class. Dalla Bella began making a dissertation on the necessity and usefulness of making observations and experiments in physics and then he passed on to a few experiments on the divisibility of matter.[8]

Dalla Bella adopted Musschenbroek's Essai de Physique for his classes although he was working on his *Physices Elementa usui Academiae Conimbricensis Accommodata.* The first two volumes were published in 1789 and the last one in 1790. This third volume was concerned with Electricity, Meteors and Magnetism. It was also said in the *Statutes* of the University that every teacher should provide his students with a Memoir with all the subjects that were referred to in classes. As we can appreciate this purpose was not attained in a short time! However, Musschenbroek's treatise seemed to be perfect for giving a full account of the spirit of the new physics and the aims for the reformed university. Dalla Bella's treatise

[5] See MALAQUIAS (1997).
[6] CARVALHO (1978), p. 13.
[7] *Ibid.*, p. 14.
[8] *Ibid.*, p. 37.

appeared written in Latin as it was so determined by the rules that guided the reform, which seems a little anachronic when we appreciate the intentions there included.

We have not found details on the experimental classes, that is, on the way the experiments were performed and when. However, there still exist documents from which we know that usually there would be two classes[9] (sometimes three), during the week, with the performance of experiments. The others were used for lecturing on the subjects.[10] And in many of the experimental ones, one or even two demonstrators assisted the teacher.[11] Although we have not many details, as far as we can discover, on the electrical experiments and on the impact that the new theories aroused, we know that there was great interest in what was going on in modern Europe.

As an example, we found the register[12] of an aerostatic experiment made in Coimbra, on June 1784, and it is known that similar experiments took place in Paris, in November 1783, with Rozier and the marquis of Arlande.[13] Four students of Domenico Vandelli (professor of Chemistry and Natural History) performed that experiment, after his demand in January of that year. They had to wait for some months in order that the rector could be present at the demonstration.[14]

So people had recent information on what were the main subjects under discussion. We could not find the same kind of news on electricity in that periodical but we think the main reason is connected with the lower spectacularity that the new theories of electricity could have in the public, even though there exist one or two notes on electrical experiments made before the Queen when she visited Mafra.[15] There she took part in a physics class, where some experiments with the electrical as well as with the pneumatic machine were performed.

As for Dalla Bella's *Physices Elementa* and after such a delayed publication, we can find in the third volume some pages dedicated to electricity. The index of this part is presented in the table below and it is divided in seven articles.

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[9] During a week there will be a total amount of five lessons dedicated to Experimental Philosophy.

[10] See ARQUIVO DA UNIVERSIDADE DE COIMBRA (1782-1803). This is a manuscript book that reports the periodicity and kind of classes given by the teachers in the Faculty of Philosophy during the period from Jul. 30, 1781 to March 28, 1803. In fact it begins on Dec. 9, 1782.

[11] Somewhere it is also referred that some hundred people saw the experiments, more than the few number of students of Experimental Philosophy.

[12] *Gazeta de Lisboa*, segundo suplemento, N. XXVIII, 17 de Julho de 1784.

[13] DA COSTA (1984), p. 104.

[14] *Ibid.*, note 4.

[15] See *Gazeta de Lisboa*, Setembro de 1790, cited by CARVALHO (1982), p. 86.

As we can see, the subjects were classical for the period. The book extends itself for 66 pages dedicated to Electricity. We don't know how far Dalla Bella took the impact of the two electrical theories or even if they caused any special point of quarrel. But from the textbook it is known that he presented both theories – Nollet

and Franklin's, with some preference for the latter (Art. V – *De Hypothesibus Electricitatis*). He begins to talk about the electrical properties of amber, the substances that can be electrified and the ones that do not and ends with some reference to sulphur, sealing wax and tourmaline (Art. I); in Art. II he mentions the communication of electricity when conductors are in contact with the electrical machines; he makes reference to Coulomb's laws of attraction and repulsion[16] as well as to the production and effects of the two kinds of electricity and electrostatic induction. In Art. III, he presents electrical condensation, Franklin's magic squares and describes the discovery of condensation in Leyden (*Lugdunun Batavorum*). It is in this part that he makes reference to Nollet and Franklin's interpretations and seems to be more inclined to the latter. After this, he presents capacitors with armatures of different nature as well as of different areas. In his Art. IV, he presents some hypotheses about the nature of "electrical matter". Is it a fluid that emanates from the bodies or is it fire, light, Newton's aether or Priestley's phlogiston? Dalla Bella seems to admire Tiberio Cavallo and the simplicity of his French edition of the *Traité complete d'Electricité* (1782). In Art. VI he presents the new instrument Volta invented – the electrophorus and he ends with the description of Franklin's experiments on the nature of thunder and lightning while connecting these with what occurs in the discharges with electrical machines.[17]

It is worth noting that when Dalla Bella came to Coimbra, and after a short stay in his homeland, he published a small book entitled *Noticias historicas, e praticas ácerca do modo de defender os edificios dos estragos dos raios / compiladas pelo doutor João António Dalla Bella.* – Lisboa: na Régia Officina, Typografica, 1773 (Historical notes, and practices about the way to preserve buildings from the damage of thunder, compiled by João António Dalla Bella). He had the intention of spreading this news in Portugal and that is the reason why he says that he asked a Portuguese man to translate it into Portuguese. From the index we can know the subjects he referred to:

> Art I – The matter that produces thunder/lightning is nothing but Electrical Matter.
> Art. II – What part of the fulminant matter can electrical conductors attract from clouds.
> Art. III – Metallic conductors can defend factories from thunder/ lightning.
> Art. IV – Method, that one must observe in the application of metallic conductors, in order to preserve any kind of building from thunder/ lightning.
> Art. V – Main objections, that it is use to make against the use of metallic conductors, and answers to them.

[16] Coulomb wrote an important memoir on torsion in 1784: "Récherches théoriques et expérimentales sur la force de torsion et sur l'élasticité des fils de métal". In 1785 he published a "Premier Mémoire sur l'Électricité et le Magnetisme. Construction & usage d'une Balance électrique, fondée sur la propriété qu'ont les Fils de métal, d'avoir une force de réaction de Torsion proportionnelle à l'angle de Torsion", followed by another on the same subject and "Où l'on détermine, suivant quelles loix le Fluide magnétique, ainsi que le Fluide électrique, agissent, soit par répulsion, soit par attraction" *(Mémoires de l'Académie des Sciences*, Paris, 1787).

[17] CARVALHO (1978), p. 624.

Art. VI – Some warnings for anyone in order to prevent himself from thunder/ lightning.

While describing this subject, Dalla Bella refers to some experiments that he had already performed in the College of Nobles and gives instructions for others that can be performed. It seems that this memory was taken in consideration when, some time later, Assumpção Velho, professor of Physics in the Royal College of Mafra, wrote another one on the way of defending the convent and palace of Mafra with lightning rods.[18]

After this publication Dalla Bella published another one on physics matters, this time about his claimed discovery of the inverse square law of magnetism.

Dalla Bella also composed an *Index Instrumentorum* where he registered all the machines that were in use, by 1788, in the Physical Cabinet. There still exists a manuscript version of this *Index* as well as a printed version, dated 1790. After comparing these two versions we find, in the first one, a total of 582 machines and in the other 592, corresponding to a few other new items in the field of Electricity. However, regarding this last subject – Electricity, and in the first manuscript version we have the following classification of devices:[19]

[…] 8 electrostatic machines;
1 Lane electrometer;
2 sets of electrical bells;
28 Leyden jars (of which 24 in battery);
8 Franklin's squares;
1 battery of the same squares;
1 exciter;
1 Volta's electrophorus.

These machines seem to testify the kind of experiments that could be performed following the new attention paid to the subject of "Electricity". Although Dalla Bella's 3rd volume on physics appeared only when he retired (1790),[20] we can have an idea of what the subjects he presented there were from the index shown in the table above.

Concerning the subject of "Electricity", a comparison has been made between the electrical material that came from the College of Nobles in Lisbon (54 instruments), the one that could be used in 1788 (62) and the material that could be performed in 1790 (74 machines). Some of these instruments were bought in London and the names of Edward Nairne and Benjamin Martin appear engraved on six of the electrical machines known. However, other material came from other parts in Europe. For instance, in a document dated June 8, 1782, one reads the following remarks:

[18] VELHO (1797).
[19] *Ibid.*, p. 49.
[20] Dalla Bella retired from classes sooner. In fact, his last academic year was 1785-86 and Constantino Botelho de Lacerda, Teotónio Brandão and Ribeiro de Paiva substituted him. Botelho de Lacerda became the first professor of Experimental Physics after the official retirement of Dalla Bella, which occurred in December 1790. He stayed there as full professor till 1820.

> For a new electrical Machine named electroforo that came to me from Italy, it cost 7 Zecchino from Venice that performs in this money 12$320 Reis. I have paid for the Machine that it is now in the Cabinet.[21]

We don't know for now if the electrophorus was already known in Portugal before this date, as it was first devised in 1775. It was certainly known by Magellan (1720-1790), a Portuguese man then settled in England.[22] He travelled with Volta during his trip to England in 1781 and before this date there are a few letters[23] they exchanged where some philosophical matters and news are discussed. Magellan, as is known, supervised many orders of the Portuguese Crown concerned with philosophical and mathematical instruments. Some of them came to the University of Coimbra, but we do not have notice that he ever wrote directly to Dalla Bella. The known letters of Dalla Bella do not give us information about the contacts he maintained abroad, namely in Italy, but we think that they should exist. After he retired, in 1790, he returned to Padua where he died in 1823, aged ninety-three.

Perhaps we would suspect that Dalla Bella wrote many articles on physics or on electricity, but it was not the case. In fact, he wrote mainly on agriculture.[24] Nevertheless Dalla Bella was well acquainted with the science of his time after the copious bibliography he got to the physical cabinet**,** and that should be one of the reasons why the Marquis brought him from abroad. However, it does not seem that he had developed his art in an advantageous way as only after great insistence from the Portuguese Royal Academy of Sciences he could write a memoir where he presented his pretended discovery of the inverse square law of the magnetic actions.[25]

In fact, it has been proved by Rómulo de Carvalho[26] that this was not a fair memory by Dalla Bella as he refers to something that was already known then without making reference to it. In addition, he should be aware of the work of Michell as his treatise (*Treatise on Artificial Magnets*), already existed in the University Library.

What happened to the students that took the philosophical course? These were only four and they entered the teaching staff of the university as demonstrators in Natural Science as well as in Physics and Chemistry. One of them became well known as he published a treatise on chemistry – *Elementos de Chimica* (Coimbra, 1788-9, 2 vols.) – that put forward Lavoisier's *Éléments de Chimie*. He was Vicente Coelho Seabra da Silva Telles. He performed several experiments on gases and especially on hydrogen. He also took part in the aerostatic presentation referred to above.

The other question we tried to answer was: when was the pile Volta discovered known in Portugal? The exact date is difficult to obtain. Perhaps it was known not

[21] CARVALHO (1978), p. 101.
[22] MALAQUIAS and THOMAZ (1994).
[23] At least since 1776 there are known letters between Magellan and Volta, see *VE*, I.
[24] DALLA BELLA (1784), (1786), (1805).
[25] *Memorias da Academia Real das Sciencias de Lisboa*, Tomo I, Lisboa, 1797, pp. 85-199.
[26] CARVALHO (1954; 1997), p. 322.

long after his presentation of the device to Napoleon. But, as far as we could find in the main official periodical *Gazeta de Lisboa* for the years of 1800 and 1801, nothing exists. The main concern then was with the news on Napoleon's invasions and war in Europe and nothing is recorded about this subject.
In the Archives of the University, we could find a simple note telling this:

> I ordered from Joze Joaquim de Miranda a Device for a Galvanic pile, which is very well and even better made than the one that came from Paris. Coimbra. 16 August 1805
> [Signed] The second professor of the Faculty of Philosophy
> Constantino Botelho de Lacerda
> (*Laboratório Químico*, Arquivo de Universidade de Coimbra, 1° macete).

This means that the new discovery by Volta was known before 1805, but we cannot affirm exactly when. Perhaps it was announced by someone who came from France, England or Italy, or it was simply known through the *Philosophical Transactions*, where Volta's letter to Sir Joseph Banks was published, in which he presented his new device for producing an electrical current.

By the beginning of 19th century, the *Jornal Enciclopédico*, a Portuguese periodic dedicated to the spreading of scientific news, became well known. There we can find, for the year 1820, some articles containing news on electricity: a note on "The electrical properties of metals and about the positive and negative electrical forces, claimed to be absolute, of several bodies", by a certain Mr. Tatum, that was a translation from the General Annals of Physical Sciences of Brussels, as well as an article "On illumination by electric light", by Meinecke from Saxony; another one "On Galvanism, and on Calorimotor, a new Galvanic instrument" or even another "On an improvement on the construction of lightning rods".[27] This periodical began only in 1820 and so we lack information regarding the period in between.

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[27] *Jornal Enciclopédico de Lisboa* (1820): "Sobre as propriedades electricas dos metaes, e sobre as forças electricas positivas e negativas, pretendidamente absolutas, de varios corpos", por Mr. Tatum (*Artigo dos Annaes Geraes das Sciencias Fysicas*, de Bruxellas.)", nº 1, Janeiro de 1820, pp. 38-9; *Ibid*., "Sobre a illuminação pela luz electrica". Por Mr. Meinecke, Professor em Halle, na Saxónia, pp. 40-3; *Ibid.,* "Do Galvanismo, e do Calorimotor, novo apparelho Galvanico"., nº VIII, Agosto de 1820, pp. 78-9. "Melhoramento na construcção dos guarda-raios", *ibid*., nº VIII, Agosto de 1820, pp. 79-80.

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