Leopoldo Nobili: His Galvanometer and His Connections to the Faraday-Neuman-Lenz Law of Induction

Leonardo Possenti and Stefano Selleri

DINFO – University of Florence
via di S. Marta 3, 50139, Florence, Italy
E-mails: stefano.selleri@unifi.it, leonardo.Possenti@unifi.it

The discovery of the phenomenon of magnetic induction, or the Faraday-Neumann-Lenz law of induction, was something much expected, after Hans Christian Ørsted [Rudkøbing, Benmark, August 14, 1777 – Copenaghen, Denmark, March 9, 1851] discovered that electric currents had an effect on a magnetic needle. Many researchers, among whom the most notable was Michael Faraday [Southwark, London, UK, September 22, 1791 – Hampton Court, Middlesex, UK, August 25, 1867], actively sought such a phenomenon, yet the instrumentation then available was exceedingly crude [1]. For an electric phenomenon to be apparent, a spark should be observed for voltage, or a current strong enough for visible effects. Some more-sensitive device able to detect feeble currents was necessary. Indeed, Ørsted's discovery made possible the development of such an instrument: the galvanometer. In that same 1820, Johann Schweigger [Erlangen, Germany, April 8, 1779 – Halle, Germany, September 6, 1857] build a first galvanometer by winding a coil of wire around a magnetic needle free to rotate. This was later enhanced by "multiplying" the effect of the current by using several coils of wire.

Figure 1a. Leopoldo Nobili.

Figure 1b. Vincenzo Antinori.

However, it was only with the refinement of such instruments by Leopoldo Nobili [Trassilico, Lucca, Italy, July 5, 1784 – Florence, Italy, August 22, 1835] (Figure 1) that the reliable detection of feeble currents was feasible. Nobili, a preeminent Italian physicist and top scientific instrument maker in Europe, used two oppositely oriented needles on the same suspending wire, and a coil in the shape of a figure eight (1825). The double needle was insensitive to the strong, static, Earth's magnetic field, hence greatly increasing the sensitivity of the instrument [2] (Figure 2). He named his device the *astatic* galvanometer.

In the same period, in 1824 exactly, François Arago [Estagel, Perpignan, France, February 26, 1786 – Paris, France, October 2, 1853] found that a rotating magnetic needle was slowed down by the presence of nonmagnetic metals close to it [3, 4]. He also observed that a rotating copper disk caused a suspended magnet over and close to it to rotate if free, or else was slowed down by the presence of the magnet if this latter was fixed. However, this phenomenon remained inexplicable, and was not immediately connected to electricity (Figure 3, from [5], p. 38).

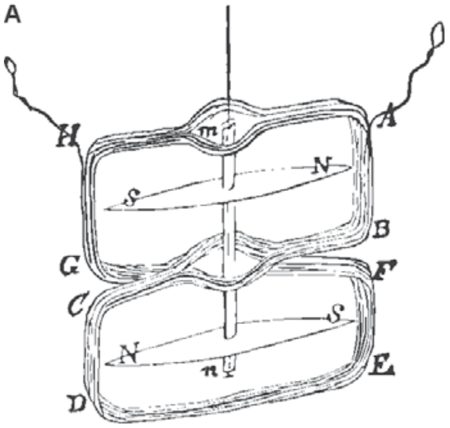


Figure 2a. The layout of the astatic galvanometer, from Nobili's original paper [2].

Eventually, in 1831, Faraday set up an experiment in which Nobili's astatic galvanometer showed a transient current in a coil when another coil connected to a generator, or a permanent magnet, was moved close to or away from it.

The point now is that Faraday devised his experiment in 1831, and read the results on November 24, 1831, at the Royal Society. However, he was quite slow in publishing a paper: a short note appeared only in April 1832 [6]. On the other hand, the news of his highly expected, successful induction experiment spawned at light speed through Europe. The experiment was described by Faraday himself to Jean Nicolas Pierre Hachette [Mézières, Ardennes, France, May 6, 1769 – Paris, France, January 16, 1834], who read a communication in French to the *Académie des Sciences* in Paris on December 26, 1831. Such a French communication, published in the journal *Le Temps* [7], reached Florence, where it was read by Vincenzo Antinori [Florence, Italy, 1792 – Florence, Italy, 1865] (Figure 1) and Leopoldo Nobili, who immediately duplicated the experiment and produced a paper.

Figure 2b. One of the original astatic galvanometers, built by L. Nobili in 1826 and preserved at the "Museo Galileo," the museum of the History of Science, in Florence, which owns several of Nobili's devices.

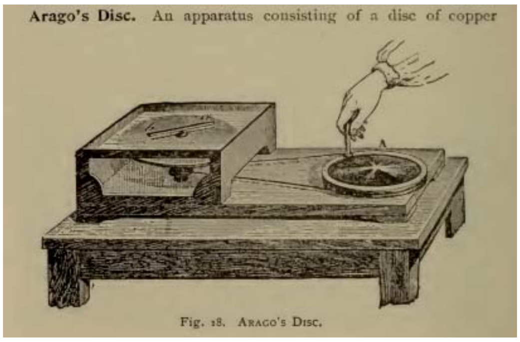
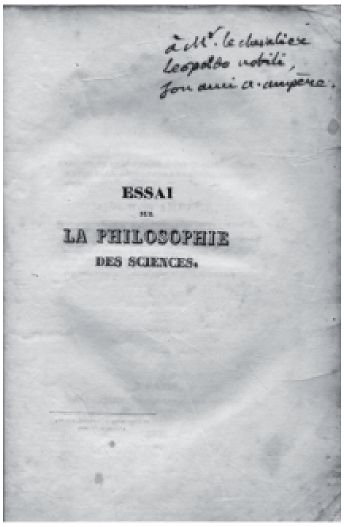


Figure 3a. Arago's disk, from [5].

In Antinori and Nobili's paper, the authors fully acknowledged Faraday's priority. They regretted that Faraday had not yet published his results, and thanked Hachette for having spread the news [8]. Such a paper was dated January 3, 1832, but appeared in an issue of a Journal dated November 1831 (vol. XLIV). Nobili and Antinori quickly wrote a second paper on the subject [9], dedicated to the currents induced on a rotating disk in a magnetic field, hence solving the problem of the rotation observed by Arago [3, 4].

The problem is that Antinori and Nobili's paper was the only item available in the open literature for a few months. As was common practice in that period, it was submitted in French, German, and even English, to the *Philosophical Magazine*, in an annotated translation performed by Faraday himself [10]. It was thus the only well-organized paper on the subject up to Faraday's paper [11], where Faraday himself summarized these events. The priority issue, never claimed by Antinori and Nobili, was nicely settled.


à Mr. le chevalier
Leopoldo nobili,
son ami A. Ampère.

ESSAI
SUR
LA PHILOSOPHIE
DES SCIENCES.

Figure 3b. The first page of the book *Essai sur la Philosophie des Sciences* by A. Ampére (1834), with a friendly dedication of the author to Leopoldo Nobili [private collection, courtesy of Fausto Barbagli, Natural History Museum, University of Florence].

Yet in the *Literary Gazette* there appeared a series of columns publicizing Faraday's discovery [12], and later announcing [13] that Faraday intended to explain the Arago rotation phenomenon on the basis of this new discovery. This in turn upset Giuseppe Gazzeri [Florence, Italy, November 9, 1771 – Florence, Italy, June 22, 1847], a renowned chemist, who attacked the *Literary Gazette* and its journalists (not Faraday!) from the pages of the *Antologia Fiorentina* [14]. Faraday replied in a letter to the *Literary Gazette*, and a discussion on the Arago phenomenon arose. The notes by Faraday in [10] mainly point to his previous work, and say that "I am criticizing Sig. Nobili and Antinori for not understanding my views. It was impossible that I could put forth in a brief letter, matter which, though I have condensed it as much as possible, still occupies seventy *quarto* pages of the Philosophical Transaction." It was true: Nobili and Antinori only had available [7], not [11]. As a result, a misunderstanding was highly possible.

Nobili and Antinori replied, stating that their interpretation was analogous to that made by Ampére of Arago's discoveries [15]. Ampére was the most renowned physicist at the time, and Nobili was Italy's greatest physicist. Faraday bitterly replied, and a long discussion started. This was quite unusual for Faraday, usually extremely polite with other physicists. A possible explanation is that Faraday was worried that Nobili and Ampére, two of the greatest physicists and friends (Figure 3), were interpreting the induction phenomenon he discovered in terms of actions at a distance, whereas Faraday was figuring those lines of force that would have later opened the road to Maxwell. Faraday could have been afraid that a mathematical theory of induction in terms of actions at a distance could be produced, whereas he, self-taught experimenter, could never come up with one. He might then have thought of indirectly attacking Ampére through Nobili [17].

Surprisingly enough, Nobili, close to the end of his life, denied any claim of explaining induction via action at a distance, and espoused Faraday's concepts [18]. However, he claimed that he had developed a similar yet less refined concept earlier, too [19].

References

1. M. Faraday, "Electro-Magnetic Current," *The Quarterly Journal of Science, Literature and the Arts*, **XIX,** 1825, p. 338.

2. C. L. Nobili, "Ueber einen neuen Galvanometer," *Journal für Chemie und Physik*, **XXXXV,** 1 825, pp. 249-256.

3. F. Arago, "On Rotation Magnetism." Proces verbal, Academy of Sciences, 22 November 1824, in *F. Arago Meteorological Essays*, London, Longman, Brown, Green and Logmans, 1855.

4. F. Arago, "Séance du lundi 7 mars,"*Annales de Chimie et de Physique*, **XXVIII,** 1825, pp. 325-326.

5. T. O'Conor Sloane, *The Standard Electrical Dictionary*, Second Edition, New York, Norman W. Henley & Co., 1897.

6. No author, "Proceedings at the Friday-Evening Meetings of the Royal Institution of Great Britain," *Philosophical Magazine,* 11, April 1832, pp. 299-301.

7. No author, *Le Temps,* 28 December 1831.

8. L. Nobili, V. Antinori, "Sopra la forza elettromotrice del magnetismo [On the magnetic electromotive force]," A*ntologia, giornale di Scienze Lettere e Arti,* **XLIV,** November 1831, pp. 149-161.

9. L. Nobili, V. Antinori, "Nuove esperienze elettromagnetiche e Teoria Fisica del magnetismo di rotazione [New electromagnetic experiments, and Physical Theory of rotational magnetic field]," Antologia, *giornale di Scienze Lettere e Arti,* **XLV,** January 1832, pp. 107-122.

10. M. Faraday (translation and notes), "*On the Electro-motive Force of Magnetism*. By Signori Nobili and Antinori; (from the Antologia, No. 131): with notes by Michael Faraday," *Philosophical Magazine*, 11, June 1832, pp. 401-413.

11. M. Faraday, "Experimental Researches in Electricity," Philosophical Transactions of the Royal Society of London, 122, 1832, pp. 125-162.

12. No author, *Literary Gazette*, N, 788, February 25, 1832, p. 119.

13. No author, *Literary Gazette*, N, 791, March 17, 1832, p. 169.

14. G. Gazzeri, "Sulla priorità delle ultime scoperte elettro-magnetiche, in risposta ad alcuni articoli della Litterary Gazette di Londra [On the priority of the latest discovery in electromagnetism, in response to some articles of the Litteray Gazette of London]," *Antologia, giornale di Scienze Lettere e Arti*, **XLV,** March 1832, pp. 173-176.

15. L. Nobili, V. Antinori, "Sopra vari punti di Magneto-elettricismo," *Antologia, giornale di Scienze Lettere e Arti,* **XLVI,** June 1832, pp. 142-143.

16. J.C: Maxwell, "On Faraday's Lines of Force," *Transactions of the Cambridge Philosophical Society,* X, part I, 1955, pp. 155-229.

17. S. Sbrighi, "La controversia Nobili-Faraday sull'induzione elettromagnetica," in G. Tarozzi [ed.] *Leopoldo Nobili e la cultura scientifica del suo tempo,* Bologna, Nuova Alfa Ed., 1985, pp. 69-95.

18. L. Nobili "Teoria fisica delle Induzioni Elettrodinamiche," in *Memorie ed Osservazioni Edite ed Inedite del Cavalier Leopoldo Nobili*, Vol. 1, Firenze, David Passigei & Co., 1834, pp. 257-279.

19. L. Nobili, Questioni sul Magnetismo, Modena, Eredi Soliani, 1824.