THE 18TH CENT. CONTROVERSY ABOUT THE SHAPE OF THE EARTH: TEXTUAL AND TRANSLATION ISSUES

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ABSTRACT

The controversy about the shape of the Earth that occurred in France at the beginning of the18th century is an interesting and thought-provoking case of scientific controversy which might interest students of various ages and school levels. The first part contains a quick reminder about the controversy, its context, the main questions at stake and its pedagogical interest. With these ideas in mind, one of us conceived a pedagogical scenario meant for a historical course at middle school level. The workshop was intended to go through the historical material we used for it, for reasons we explain in the second part. In the course of this research, we find out several interesting texts, for which we needed English translations. Looking for the latter confronted us with two unexpected but interrelated challenges: one related to the quality of the translation, the other to the choice of our texts. We present this material and explain the issue in the next part. We conclude with the new ideas that came out of this discussion.

1 The controversy about the Shape of the Earth and its pedagogical interest

This controversy occurred in France during the first decades of the 18th century and reached its climax in the 1730's. On the scientific side, it was part of a long-lasting scientific debate beginning within the Royal Academy of Science. It originated in two conflicting theories and experimental data. According to Newton's and Huygens's theories, the Earth would be flattened on the poles with an equatorial bulge —that is an oblate spheroid or "melon". This were essentially astronomical theories presented with great mathematical rigor and buttressed by Richer's pendulum's observations (1672). On the other hand, according to the French astronomer Jacques Cassini, also director of Paris Observatory, the Earth would be bulged to the poles and flattened at the level of the equator — a prolate spheroid or "lemon". The Cassini (father and son) thought they have demonstrated this fact after several reliable campaigns of survey and measure of the meridian arc in 1700, 1718, and 173. Their surveying measures were reputed to be made with the greatest rigor and seemed to invalidate Newton's mathematical theory. Furthermore, Jacques Cassini had thought he could justify these results with a cartesian like interpretation recalling the vortex theory, a theory that became mainstream among several prominent academicians and mainly Fontenelle.

On the mundane and "philosophical" side, the debate evolved in the 1730's into a heated dispute opposing famous figures of the enlightenment movement, mainly Voltaire and Maupertuis. Maupertuis' defense of Newton's theory published in 1732 launched the controversy for it directly contradicted the Cassini's measurements and theories. At stake was also the very conception of the universe: Newton's principle of attraction and an empty universe on the one hand, Descartes' mechanistic theory of vortices accounting for a matter-packed universe, on the other. Maupertuis was by then recognized as a brilliant scientist but was also an ambitious intellectual looking for glory and public recognition. In this regard, he succeeded in gaining the support of Voltaire (and conversely) in those years and generally convinced the French public opinion (with its strong tendency to Anglomania), up to the high aristocracy – including the ministers. Partly due to his complex and egocentric personality, Maupertuis did a lot to make this scientific controversy into a public event, discussed much beyond the walls of Académie des Sciences (Voltaire 1738, 1752).

What strongly contributed both to the scientific and mundane debate was the decision, taken by French minister Maurepas (and largely inspired by Maupertuis, to whom he was very close) to finance two expeditions, one to the equator lead by Godin, La Condamine and Bouguer and the other led by Maupertuis himself to the pole in 1737. One of the purposes was to check whether the length of one degree of meridian significantly decreased (in the "lemon" case) or increased (in the "melon" view) when going from the equator to the north.

The northern expedition, of which two detailed accounts were made with all the calculations, one by Maupertuis (1738) and the other by Abbé Outhier (1744), was highly publicized and served as a powerful means to advance Maupertuis's ambitions. But this did not put an end to the scientific controversy. The use of instruments was disputed: for example, the use of an English sector (more precise according to all the members of the expedition) rather than a French instrument (of the type used by the Cassinis) outraged some academicians. Most of all, the incoherency of all measurements made of arcs of meridians in various parts of the world soon became a matter of perplexity.

Moreover, many academicians as well as the general public, were actually unable to follow the complex astronomical calculations and sophisticated theories developed, for example, by Clairaut in his 1743 masterpiece. As a result, the success of the "Newtonian" point of view, buttressed by the successes of the analytical mathematical approach of which Maupertuis, Clairaut, or, later, D'Alembert were representative, took several years to become dominant at the Academy of Sciences, partly for ideological reasons and partly for scientific ones. Ironically, the incoherency of measurements remained a subject of concern for many scholars, like D'Alembert, and it was only at the end of the 18th century that it was discovered that the measurements made in the North were indeed highly problematics and miscalculated owing to a careless use of the sector.

This interesting affair with its many facets is one of the first cases of scientific controversy reaching a relatively large public audience. It soon became part of an ideological fight to defend Newtonian theories against others, as part of the French Enlightenment movement. For the same reason, it constitutes one of the major steps in the penetration of Newtonian ideas in France in this period (Badinter 1999, Schank 2008).

All this make it an excellent subject for both historical and scientific activities for students, leading them to understand the role played by mathematicians in one of the most spectacular changes in modern worldviews, and also developing their critical thinking. But this depends on one crucial condition: for the mere authority of luminaries of the French enlightenment like Voltaire, Maupertuis, or D'Alembert, is not enough to convince anyone of the value of what happened then. Studying this episode requires gaining a minimum understanding of what was at stake, why it was controversial or disputed, and what were the concrete means used to tackle the issue.

This, in turn, brings with it important challenges, given the complexity of the controversy in question. To take a single but significant example, the alternative theories above crucially depend on the understanding that the shape of the Earth can be detected through observations such as (O1) the changing period of pendulums or (O2) the increasing length of one degree of meridian. Both the mode of measuring these phenomena and (C) their exact connection to the shape of the earth are not at all obvious. This subject, on the other hand, could thus be put at the core of an interdisciplinary approach to the question, as we have tried to imagine and implement.

2 Getting students to understand the controversy: looking for the "right" textual material

One of us (Catherine) construed a pedagogical scenario for middle school students in the framework of a history course whose subject was *The Enlightenment and its relation to sciences*. Students were given an overview of the intellectual and technical progresses characteristic of the 18th century, with a focus on the new instruments and calculation techniques that progressively permitted a systematic topographical survey of France. At one point they were given a basic explanation about the nature of the controversy (an adapted version of the explanation given in §1) and documents about the Maupertuis expedition to the North, some maps as well as images of various instruments. The key idea was to submit them the following question: *how did the scholars in the Age of Enlightenment manage to establish with certitude who was right about the form of the Earth, Newton or the Cassinis?*

We do not need to enter here the details of the scenario of the interesting attempts of the students, which are explained elsewhere (Darley 2018). The important point for us is that in order for the scenario to achieve its goals, the contribution of a science or mathematics teacher is essential. We should note, by the way, that this perspective basically amounts to say that we have a case of a history teacher looking for mathematics and a mathematics teacher, not mathematics teachers looking for history and historians, which is the usual premise of ESU encounters.

While the circumstances have not hitherto permitted such cooperation, we decided to prepare for it by looking for historical material that would sustain such a pedagogical construct. The Salerno workshop presented preliminary results of this search, leading us to focus on two series of texts:

1. Excerpts from one of the diaries of Maupertuis's voyage to the North, namely Abbé Outhier's journal (1737). While the French text is easily available and readable to nowadays students, several excerpts of key episodes were chosen from the English version published in (Pinkerton 1808).

2. Excerpts from two important articles written by D'Alembert for the French Encyclopedia edited several decades later: one on the notion of degree

(in any sense: degree or arc, of angle, and of meridian), and the other, D'Alembert's famous article on the shape of the earth.

The first series was meant to help students explore the concrete procedure used to determinate the length of a degree of meridian near the North pole (observation O1) and understand the difficulties implied as well as the human means and intelligence involved. The second series was meant to tackle the difficult connection between the variation of the length of one meridian degree at various latitudes, and the focus problem about the shape of the earth. As in the workshop, we will only pay attention here to the challenges arising from the exploration and use of the first series from Outhier's journal.

3 Lost in translation: what the English version of Outhier's travel led us to understand

3.1 Maupertuis' and Outhier's diaries

The two narratives of the expedition to the North, Maupertuis' and Outhier's, share a basic purpose: to represent the reader with the basic details of the expedition, showing all measurements were made with enough care and seriousness so that the result could be trusted. They implied a complex procedure of triangulation between two points having latitudes differing from approximately one degree. The two points in questions are the location of Kittis and Tornea in the two illustrating maps (Fig.1 and 2) taken from Maupertuis (1) and Outhier (2). The two locations differ from nearly 1° of latitude, as shown in Fig 1.

Fig.2 shows in outline what is figured out in Fig.1 with the cartographic details: the latter gives an idea of the difficulty of the operation. The two locations are some 130km apart from each other, and the ten locations marked by letters (K for Kittis, T for Tornea, etc.) correspond to submits that were very difficult to access, especially under very hard climatic conditions. This ten locations approximately form a heptagon KPACT*k*N, which, added to the reference length B*B* measured on Torneas' river during the winter, could enable the scientists to determinate the length of the arc of meridian KM, separating the positions of Kittis and Tornea.

Maupertuis gives a quick account of the travel conditions and mainly insists on the great difficulties of each operation; he gives, above all, many details about the calculations and verification of measurements. Outhier, by contrast, gives less explanation on the overall purpose of the expedition and a lot more details about the concrete conditions of the various steps of the whole procedures. In particular, he explains in some details the decisions that had to be made at every stage of the trip, and the difficulties related to the use of the embarked instruments, especially the zenith sector constructed for them by Graham. The latter is needed to determinate the difference of latitude between two locations by measuring zenith distances and was used by Maupertuis and his colleagues to evaluate the difference of latitude between Kittis and Tornea. It is a huge instrument, the transportation and installation of which is difficult and needs a whole construction, which is detailed in Outhier. The famous illustration (Fig 3) taken from Cassini de Thury later book on the Parisian meridian line gives an idea both of the size of such an instrument and the difficulty of its use.

The various excerpts chosen for the workshop refer to several key stages in Outhier's diary: (1) on the 2nd of July, Outhier explains the intensive discussion among the group after their arrival in Tornea ten days before: where are they to find the right locations for the requested sequel of triangles? (p.51-52); (2) one month and a half later, on the 21st of Aug, they have to reconstruct one signal left in Horrakilero and that had been entirely burnt (p.90); (3) on the 2nd of Sept, Outhier describes the trick they used to make observations in Tornea in the bell tower of the church, just after the office, taking opportunity of the clear weather (p.96); (4) finally on the 9th of sept (p.102-103) the construction of the observatory in Pello, near the northern point of Kittis. This episode is nicely illustrated by a detailed map of the impressive constructions made on this occasion. Generally speaking, Outhier's journal abounds in nice maps of the region, representations of buildings, and vivid scenes capturing special episodes.

We will not enter into any more detail here, rather we need to focus now onissues connected with the translations.

3.2 The problems with our choice of English translations

As explained above, the main purpose of the two diaries was to account for the scientific reliability of the expedition. This explains why, beyond the narrative itself, they contain a host of figures and calculations for each station and observation either of distances or elevation angles. These figures and maps are contained in the thirty last pages of Outhier (203-234, around one tenth of the entire work); as for Maupertuis's book, the narrative is contained in a lengthy preface of 80 pages while the main part of the book is devoted to observations (100 pages) completed by nine maps and schemas of the triangles.

By contrast, Pinkerton's 1808 edition kept the two narratives only, with no mention of calculations and charts. The reader, therefore, has no way of grasping the general situation of the explored region nor the scientific strategy used for charting the region and determining the relevant distances and latitudes. The same neglect for the scientific dimension of Maupertuis' enterprise is evident in the mistranslation for the word "sextant", standing for the huge zenith-sector constructed by Graham, as mentioned above.

All this might appear somewhat surprising given that Pinkerton himself was a geographer and had announced in the preface to his gigantic edition of travel narratives that he would follow the ordering adopted for his Geography. While we do not know exactly who translated the text (his collection mainly consist in a newly edited compilation of already published narratives in Green or elsewhere, but Maupertuis's and Outhier's texts are presented as "newly translated"), Pinkerton for sure arranged the texts and, together with the publishers, was responsible for the main choices of presentation. His choice might be explained by the general meaning that geography writing had at the beginning of the 19th century: according to Sitwell's analysis (1972), geography then emphasized the comparison of nations according to their level of power and idiosyncrasies rather than universal physical characteristics like their topographical situation.

Whatever the case, we were progressively and led to recognize that this translation was quite inadequate for our purpose. This leads us back to the main conclusions of our workshop.

4 Main conclusions

Putting together the various elements needed to fully understand the scientific nature of the 18th cent. controversy about the shape of the Earth, and also to make it clear to our audience, we came to several conclusions.

The first is that explaining both observations O1 and O2 (from Outhier's journal) and the connection to the issue of the shape of the earth (C, from D'Alembert's *a posteriori* reflections) is not only overambitious at middle school level but unnecessary for our most basic purpose. Indeed, getting into the meaning and purpose of the expedition is far enough to understand not only the difficulties of such an enterprise, but also, and above all, its scientific character: Outhier is very clear about the fact that big and small questions appeared all along the trip and were constantly motivated by the overall purpose[66].

The second conclusion bears on the perception of this purpose: contrarily to what Pinkerton's edition seems to suggest, it is not really possible to understand the special tension inherent in Outhier's narrative, without getting a sense of the overall strategic schemas they had in mind from the outset: what are the means "to form a sequence of triangles" is the obsessive idea that guides the travelers and help to clarify their basic purpose. And this idea is made clear through the maps and observation data consigned to the end of the French version. In other words, the textual material needed should include, at least in part, such maps. Reading the excerpts could then become an exercise of making sense of their questions, by taking into account the overall purpose, which can be done by simultaneously looking at the narrative and the underlying schemas.

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[66] As for problem C, it should really be the subject of an in-depth reflection on the very notions of angle and curvature, that should be in principle the purpose of the mathematics course and not reducible to an isolated activity.

[67] [*] signals texts that can be downloaded on the web site of Bibliothèque Nationale de France (Gallica), [A] at the site archives.org, and [E] on the ENCCRE website for the collaborative edition of Diderot and D'Alembert *Encyclopédie*, cf. . http://enccre.academie-sciences.fr/encyclopedie/

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