Mathematics Meets Cinema: *La Figure de la Terre*

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Abstract

The French mathematician and explorer Pierre Louis Moreau de Maupertuis (1698–1759) travelled to Finnish Lapland in 1736–1737 to measure the shape of the Earth. He wrote the book *La Figure de la Terre* which has recently been turned into a movie with the same title. The screenings of the movie in various countries (Finland, France, Argentina), accompanied with scholarly lectures, books and papers, have created an interesting bridge between mathematics and the seventh art. For the present paper, the Argentinian director Axel Straschnoy (AS) interviewed Osmo Pekonen (OP), a Finnish mathematician who besides being a scholarly expert on Maupertuis also played the lead role – in French. His double performance thus testifies of a double competence in Science and Art.

An Interview

AS: *Can you introduce us to the subject? Who was Maupertuis?*

OP: Pierre Louis Moreau de Maupertuis was born in Saint-Malo in 1698. He was a son of a privateer captain ennobled by the King of France. He started a military career as a Royal Musketeer but was soon won over to mathematics. He became a member of the Royal French Academy of Sciences where he was an early supporter of Newtonian science in France. On a study trip to England he became convinced of the flattening of the Earth near the poles as predicted by Newton. He led a famous expedition to Finnish Lapland in 1736–1737 to measure the shape of our planet, and succeeded in establishing its flattening ratio, thereby providing a major experimental proof of the Newtonian theory of gravity at large.

AS: *Why did he go to Lapland?*

OP: In the 18th century, cartographers of the leading naval powers, England and France, began suspecting that there was some systematical error in the atlases based on the hypothesis of a spherical Earth. Indeed, Isaac Newton had predicted in his foundational work *Principia* (1687) that the Earth is slightly flattened at poles, and bulges at the Equator, due to its rotational movement which diminishes the effect of gravitation as a function of the distance from the Equator. A flattened Earth has an oblate shape which in everyday language can be compared with a mandarin orange. In France, on the other hand, the leading geometers of the time, father and son Cassini, had come to a different conclusion based on their extensive field work done within the boundaries of France: the Earth should rather have a prolate shape like a lemon. Dubious arguments supporting this view were conjured up by appealing to the obsolete "vortex theory" due to René Descartes. As for the "fruity" images of 'mandarin orange' and 'lemon', they were actually in use in contemporary debate.

The French Royal Academy of Sciences endeavored to settle the issue once and for all by practical measurements on a global scale. For this purpose, two expeditions were launched. One expedition, under the leadership of Charles Marie de La Condamine, should sail to the Equator, the other one, that of Maupertuis, as far North as possible, to perform the same task which was the precise measuring of the length of a one-degree arc of meridian. By a comparison of the results obtained, the shape of the Earth could be deduced. For an oblate spheroid, the arc lengths should increase when approaching the poles.

Maupertuis first thought of traveling to Iceland but was soon convinced that the conditions there would be overwhelmingly harsh. No scientific expedition had spent a winter in Arctic conditions before! Happily enough, the Swedish scientist Anders Celsius was sojourning on a study trip in Paris, and he could recommend the Tornio river valley in Northern Sweden as a promising venue for the measurements. The Tornio river could serve as a means of transportation through the wilderness while its frozen surface might provide a perfect Euclidean plane for the measurement of the base line. There was also the small town of Tornio, founded in 1621, at the mouth of the river to guarantee hospitality and infrastructure.

So Maupertuis came to what is today Finnish Lapland with a team of four other members of the Royal French Academy of Sciences (Charles Étienne Louis Camus, Alexis-Claude Clairaut, Pierre-Charles Le Monnier, abbé Réginald Outhier). Celsius joined in as a representative of Swedish science. As we know, Finland was not an independent nation in the 18th century but a part of the kingdom of Sweden. The role of Celsius, as a supporting character in the movie, was played by the historian of science Johan Stén.

AS: How did the expedition go?

OP: Celsius's original idea was to execute the measurements on the islands in the Gulf of Bothnia in front of Tornio but these were too low to be of any use. They were, however, able to take advantage of the orientation of the Tornio river, almost north-south, and measure the arc along the river valley itself. The king of Sweden provided them with a regiment of Finnish soldiers which they used to clear the tops of the fells and build markers on them. The fog and the mosquitoes were a constant nuisance, and at one point they accidentally ignited a forest fire. Nonetheless at the end of the summer 1736, they had their suite of triangles ready. Field work was to be combined with mathematics and astronomy. The next step was to measure the zenith distance of certain stars (α and δ of Dragon's constellation) relative to the beginning and end of their triangulation, in order to calculate the latitude difference between those points.

The last practical task was to measure a base line on the frozen river, a task that was hampered by the intense cold. To warm up, they consumed spirits brought from France as they were the only beverage that would not freeze. Even then, Le Monnier, the expedition's chief astronomer, got his tongue stuck to the silver flask that held his drink, and it was impossible to remove it without leaving part of its skin on it! By Christmas the field work was done. They stayed in Tornio, executing their calculations and waiting for the spring to turn the Gulf of Bothnia navigable again, so that they could return home.

Maupertuis, and one of his companions, seem nonetheless to have had time to seduce two Lappish girls who, to their surprise, later followed them to Paris causing a lot of embarrassment.

AS: *What happened after his return?*

OP: Maupertuis was immediately received by the King at Versailles and acclaimed at the Academy as "the man who flattened the Earth". Even so, doubts lingered on among his adversaries, led by the Cassini dynasty of geometers, until renewed measurements within France finally settled the issue.

He wrote a book on the expedition entitled *La Figure de la Terre* (1738); a great success, soon translated into English and with numerous reprints. Maupertuis became one of the first scientists to have his portrait

painted like a nobleman. He appears in it wearing a Lappish costume, flattening the Earth with one hand. He ordered engravings out of his portrait, which he distributed throughout Europe. Frederick the Great invited him to be the president of the Prussian Academy of Sciences, founded in 1700 by Leibniz.

Maupertuis really was one of the great figures of the French Enlightenment but, hitherto, he has remained somewhat forgotten in his home country. As a mathematician, his main contribution was the formulation of the *Principle of Least Action* in Calculus of Variations which for him had metaphysical overtones, and even theological implications. He believed, indeed, to be able to prove the existence of God by his mathematics. He became the object of Voltaire's satire because of such assertions. Maupertuis's image greatly suffered from the defamation campaign launched against him by the philosopher.

Maupertuis and Voltaire were first friends as both championed for the Newtonian theory of gravity. Their relationship soured in Berlin where they became rivals for the favors of Frederick. Voltaire made fun of Maupertuis in a satirical poem and in his science fiction novel *Micromégas* (1752) where Maupertuis is being observed by two extraterrestrials from Saturn and Sirius who surprise him making love with the Lappish girls. Voltaire parodied Maupertuis as a greedy mad scientist named "Dr. Akakia". Even the figure of Pangloss in his novel *Candide* may have been inspired by Maupertuis rather than by Leibniz.

AS: *How is he considered today?*

OP: Foreign scientists have recently contributed to improve Maupertuis's tarnished image in his home country. The comprehensive biography [3] by Mary Terrall, professor of history of science at UCLA, rehabilitated Maupertuis's fame as a versatile major scientist of the Enlightenment. By the way, Terrall was the president of the jury when I defended a doctoral thesis [1] at the University of Lapland on abbé Réginald Outhier, a somewhat forgotten priestly co-traveler of Maupertuis. The thesis, written in French, earned me the Chaix d'Est Ange prize of the Institut de France. More recently, Anouchka Vasak and I have published a commented critical edition of Maupertuis's writings from Lapland [2]. These writings have not been available for French readers since the 18th century. And then, of course, your movie also participates in Maupertuis's comeback. But there would be even more to say on Maupertuis. He is sometimes regarded also as Darwin's forerunner as he formulated something like a principle of evolution and survival of the fittest in a biological treatise named *Vénus physique*.

AS: *How did you become interested in Maupertuis's expedition in the first place?*

Well, my first doctoral thesis, back in 1988, was in Differential Geometry where I came across the names of Maupertuis and Clairaut and realized that, centuries ago, these guys had visited my country… In 1998, I organized an international conference in Tornio on the occasion of the 300th anniversary of Maupertuis.

AS: *And that was the first time you played the role of Maupertuis?*

OP: Yes, a French documentarist, Yves de Peretti, began shooting a movie on Maupertuis in the summer of 1998. Already on that occasion, I played the role of Maupertuis, shooting rapids in the Tornio river, among other things. De Peretti with his team was supposed to return for winter scenes as well, but may have lost heart because the winter of 1998–1999 was extremely cold in Lapland, with temperatures falling below -50 Centigrade…

AS: *How do you see your relationship with Maupertuis? It is clear that he is your subject of study, and you are both mathematicians, but is there something in particular that drew you to him?*

OP: Differential Geometry which I studied in Paris has many applications in physics: in some sense, Differential Geometry is the study of the "shape of the Universe". The *Principle of Least Action*, due to

Maupertuis, is still relevant in today's mathematical physics. However, nobody has been able to formulate the right kind of Action Principle for a *Grand Unified Theory* (sometimes called M-theory) of fundamental physics to explain the workings of the Universe. The problem set by Maupertuis in his metaphysical writings is still open. Finding such an Action Principle would be tantamount to discovering the "Holy Grail" of fundamental science. Intriguingly, Maupertuis claims to have seen the ultimate knowledge about our Universe in a faint writing appearing in the mysterious stone of Käymäjärvi in Lapland! His visit to that stone, together with Celsius who was known as an expert of runic writing, could make the topic of another movie (part II of the present one…?). The Käymäjärvi stone was reputed to be sacred for the Lapps. We visited the stone back in 2003 with the professor of History of Religion Juha Pentikäinen, a renowned expert of Lappish lore, but saw no writing at all appearing on the stone.

AS: *I have also seen you on stage in the role of Maupertuis. You seem to be passionate about the role.*

OP: A long time ago, I did part of my military service as an artillery measurement officer of the Finnish armed forces in Lapland. In those days, we used very traditional methods of measurement, actually determining our position from the stars and using triangulation – just like Maupertuis! So I have concretely done essentially the same thing that he did in Lapland. Moreover, when I studied in France, I was a guest scholar in mathematics at the École Polytechnique which is a military academy, so I feel a little bit like a French musketeer, just like Maupertuis. My 18th century costume also comes from France; it is a costume tailored for me. Putting it on is a part of the "willing suspension of disbelief" so necessary both for the spectators and myself to achieve the metamorphosis of a mathematician into an actor.

The two authors share a passion in Science and Art

Axel Straschnoy (born 1978) is a visual artist from Buenos Aires based in Helsinki. His long-term and research-focused projects include *Kilpisjärvellä* (2011–12) a planetarium film on exploration in Finnish Lapland under the Northern Lights (Museo de Arte Moderno, Buenos Aires; Mirta Demare Gallery, Rotterdam), *La Figure de la Terre* (2014) a short film on the trip to Lapland of Pierre Louis Moreau de Maupertuis (Galería del Infinito & Museo del Cine, Buenos Aires; Institut finlandais, Paris) and the on-going project *Notes on the Double Agent* (2013–). Straschnoy has studied art history at the University of Buenos Aires and participated in Le Pavillon residency at Palais de Tokyo (2008–09) in Paris.

Osmo Pekonen (born 1960), PhD, D.Soc.Sci., is a Finnish mathematician, historian and author. As a mathematician, he has published in mathematical physics, string theory, Teichmüller spaces, and K-theory. He is also known as the Book Reviews section editor of *The Mathematical Intelligencer*. As a historian, he has published several papers and monographs on 18th century scientists, among them Pierre Louis Moreau de Maupertuis. His work as an author includes, for instance, the first-ever verse translation into Finnish of the *Beowulf* (written together with the Old English scholar Phil. D. Clive Tolley).

References

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