Introduction

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The essays gathered in this issue of the journal *Noctua* focus on the various relationships that were established between philosophy and mathematics from Galileo and Descartes to Kant, passing by Newton.[1] According to a grand narrative that never completely stopped to be told, Galileo and Descartes initiated a process of mathematization of physics that changed the course of the sciences.[2] Émile Meyerson, Edmund Husserl and Alexandre Koyré made this grand narrative emerge. Meyerson described Descartes, who identified matter and extension, as the «true legislator of the modern science».[3] Husserl claimed that Galileo was the first to substitute mathematical idealities for concrete things that were intuitively given and thus to open the path to an objective knowledge of the things of the world, while Descartes gave a metaphysical ground to this objectivity when he distinguished *res cogitans* from *res extensa*.[4] Introducing Husserlian themes in the history of science, Koyré argued that the mathematization of nature and of the natural sciences was central to the Scientific Revolution. According to Koyré, the two main heroes in this Revolution were Galileo, who introduced a first math-

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2 In what follows, I take over some ideas already developed in Roux 2010(1), 319-337.

3 Meyerson 1995, 229. On Meyerson's conception of modern science, see Roux 2010(2), 91-114.

4 Husserl 1970, § 9, 23-59.

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ematization of motion, and Descartes, who made explicit the metaphysical premises of this first mathematization.[5] With Galileo and especially Descartes, mathematics begun to constitute a standard of certitude by which other disciplines had to be assessed and to which they had to conform themselves as far as possible. Consequently, there were attempts to mathematize other disciplines than natural philosophy. In France, the eighteenth century witnessed the first attempts to mathematize the human and social sciences.[6] In Germany, it witnessed an enduring and memorable controversy on the question of whether philosophy could proceed *more geometrico*, as Christian Wolff pretended, or not, as Pierre-Louis Moreau de Maupertuis, Leonhard Euler and other Newtonians claimed.[7] Kant finally put an end to the dream of developing a philosophy *more geometrico* by stressing that definitions have neither the same place nor the same function in mathematics and in philosophy. It should be noted that Kant's works can also be read as an effort to give a metaphysical foundation to Newtonian physics.[8] And indeed, if we consider the history of physics in the eighteenth century, the unavoidable natural philosopher was Newton.

Grand narratives such as this one are never completely false, but they obviously need some qualifications. First, the mathematization of natural philosophy took more diverse forms than it is usually said and these different forms need to be explored more carefully than they have been until now. In 1667, exactly ten years before Spinoza's *Ethica ordine geometrico demonstrata*, Nicolas Steno published his *Elementorum myologiae specimen, seu, musculi*

5 For a presentation of Koyré's theses, see JORLAND 1981; on the influence that § 9 of the *Crisis* had on Koyré, see DE GANDT 2005, 97-103.
6 GRANGER 1989; RASHED 1956; FRÄNGSMYR, HEILBRON, RIDER 1990.
7 TONELLI 1959, 37-66.
8 FRIEDMAN 1992.

descriptio geometrica, in which he claimed to introduce in anatomy the mathematical way of proceeding that was successfully used in astronomy and optics. For Steno like for Spinoza, proceeding in a mathematical way meant in the first place following a synthetic order similar to the geometrical order, that is to begin with definitions, hypotheses and axioms and to deduce from them subsequent theorems. But, for Steno, proceeding in a mathematical way had another meaning still, that had no equivalent in Spinoza; it also meant giving a geometrical description of the muscles, especially representing the muscular fibers of muscles as parallelepipeds.[9] This second meaning involves geometrical figures like parallelepipeds, triangles and circles, even when they do not intervene as supports of mathematical demonstrations. Such a 'spatialization' appears in treatises exposing procedures of surveying, the art of cartography, the linear perspective in painting, etc. As Ange Pottin shows in his essay, *Mathématisme et tourbillons dans les* Principes de la philosophie *de Descartes*, Descartes was primarily concerned with that kind of mathematization. What Pottin calls 'mathematism' is Descartes's intention to proceed in physics thanks to principles that are also received in geometry, that is to explain all physical properties through spatial properties alone. Such an intention holds in particular for the notoriously false explanation of the motion of the planets through vortices.

That is not all though. There were obviously two other characteristics of geometry – which at the time was a synecdoche for mathematics in general – that were important if one wanted to extend its unrivalled certitude to physics. First, there was what we could call 'quantification', that is the opera-

9 ANDRAULT 2010, 505-536.

tion of capturing certain aspects of material things through numbers. Such a capture requires measurements, concrete apparatus and a growing concern for precise and standardized data, but also graphical techniques to present numerical results and intellectual techniques of approximation and averaging. Already in the early seventeenth century, there were attempts of quantification in domains that until then had been considered as the domain of humors and qualities. Sanctorius published in 1614 his *De Statica medicina*, in which he explained how he had built a special chair thanks to which, for more than thirty years, he weighted not only himself, but also everything he ingested and everything he excreted, in order to test Galen's assertion that respiration also occurs through the skin as 'insensible perspiration'. One century later, in the wake of Newton's *Principia mathematica philosophiae naturalis* (1687), quantification had significantly developed at the crossroads between experiments and mathematics. In his detailed paper, *'s Gravesande on the Application of Mathematics in Physics and Philosophy*, Jip van Besouw establishes among several other things that 's Gravesande's *Elementa physica*, which is usually considered as a popularization of Newtonian physics thanks to experiments, contains in fact more and more mathematics from one edition to another. Interestingly enough, 's Gravesande gave a reason for the privilege of mathematics: they deal with ideas of quantities that do not refer to anything real outside the mind (contrary to the ideas of physics) and that are the simplest among ideas (contrary to the ideas of metaphysics and theology).

Last, but not least, the new symbolic algebra raised a distinct hope with respect to mathematization. Insofar as algebra is a blind manipulation of signs, it was seen as eventually leading to a universal science that would be applicable to anything without taking into consideration the content of the matter at hand. In his essay, *Comment sortir du labyrinthe. Condillac critique de Spinoza, entre* mos geometricus *et langue des calculs*, Diego Donna shows that, despite Condillac's opposition to Spinoza's system, the presuppositions of his 'language of calculations' were not as different from Spinoza's presuppositions as he claimed them to be.

To sum up, the first qualification with respect to the grand narrative that I recalled to begin with is that, even if it is granted that mathematization was at the heart of seventeenth century natural philosophy, it remains to make explicit what is meant and implied by mathematization. I argued that the extension of mathematics to natural philosophy took different forms according to the characteristic of mathematics that was privileged. The famous *mos geometricus* did not only refer to the adoption of a deductive order, but also to three other ways of using mathematics, that I respectively dubbed spatialization, quantification and symbolization. Now, the second qualification that should be added to the narrative of the mathematization of the world picture concerns the relations that were established between mathematics and philosophy, or perhaps, as we will explain, metaphysics. According to this narrative, the dream to reach in philosophy a certitude similar to the certitude which is common in mathematics was never dismissed before Kant. But a closer inspection reveals that philosophers hold nuanced positions in that respect, whether philosophy and metaphysics are understood as theology, as moral philosophy, or as reasoning on essences.

Yannick Van den Abbeel and Marco Storni devote their essays to Maupertuis, who may appear as a go-between who first purveyed French people with Newtonian science and then purveyed German people with French philosophy. Both their essays are devoted to the publications Maupertuis made when, as a president of the Berlin's Academy, he turned from mathematics to more speculative matters. After studying the emergence of Maupertuis's Principle of Least Action from the beginning of the 1740s on, Van den Abbeel shows that the metaphysical and the mathematical aspects of this principle as exposed in *Les lois du mouvement et du repos, déduites d'un principe de métaphysique* (1746), far from overlapping, are in tension one with the other. Here philosophy refers to metaphysics and metaphysics in turn refers to theology, since the Principle of Least Action was supposed to be deduced from the attributes of God and to lead to the derivation of the main laws of nature. Thus, in his Berliner days, Maupertuis was not so much opposed to metaphysics in general than opposed to a metaphysics like the one of Newton, which pretended to infer the existence of God from the complexity of particular phenomena, whether the formation of animals or the paths of comets. Rather, for Maupertuis as for Malebranche, it was the simplicity and the generality of the laws of nature that were to be positively associated, as it were, to the existence of a wise and powerful Creator. In a similar way, Storni shows that, if Maupertuis condemned Wolff and more generally those who contented themselves with a superficial imitation of mathematical procedures, he nevertheless exposed in his *Essai de philosophie morale* (1749) an ethics founded on a calculation of quantitative goods and evils. In these circumstances, the question is to determine what Maupertuis could expect from this mathematization of ethics and why he distinguished it from those that he disdained. The difference is not so much metaphysical here – and, by 'metaphysics,' Storni refers to the ontology of mathematical objects – than epistemological.

Last, but not least, Elise Frketich tackles in an original way the famous opposition that Kant made between the mathematical and the philosophical methods. In *Wolff and Kant on Reasoning from Essences*, she argues that, while Wolff and Kant both thought that a particular geometrical figure can be used to prove a theorem concerning all the figures of the same species, Wolff's theory of essences led him to claim that the property of geometrical figures to represent universals holds for things in nature, which is precisely what Kant denied. Here, we are confronted to another meaning of 'metaphysics' still, according to which this word refers neither to claims concerning God nor to mathematical ontology, but rather to a modal doctrine of essences. Hence, the second qualification of the grand narrative I began with will be that our understanding of 'metaphysics' has to be diversified as well. For those who were called scholastics in the eighteenth century, general metaphysics was still the science of being as being, special metaphysics having for objects God and the souls of human beings.[10] But, at the end of an evolution in which Descartes and Malebranche had a decisive role, metaphysics was also characterized in the eighteenth century as a theory of knowledge, comprising both an examination of the ontological principles of knowledge and an inquiry about mind and language.[11] Between those two meanings, as we just saw, there was plenty of room for other meanings which make the interplay between philosophy and mathematics at the turn of the eighteenth century challenging to explore. This is what is done is the present issue.

SOPHIE ROUX

MATHESIS, RÉPUBLIQUE DES SAVOIRS

ÉCOLE NORMALE SUPÉRIEURE, PARIS

10 LOHR 1988, 537-638.

11 BARDOUT 1999, chap. I and II, and BARDOUT 2000, 139-164.

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