ISSN 2186-4284

# Recueil d'études sur l'*Encyclopédie* et les Lumières

# 『百科全書』・啓蒙研究論集

N° 2

mars 2013

Société d'études sur l'*Encyclopédie*

『百科全書』研究会

# The emergence of the *dynamique* in the Paris academy of sciences: From a science of force to a science of motion

Nobumichi ARIGA

## Introduction

"Dynamics" is a modern invention. *The Oxford English Dictionary* suggests that the English word "dynamics" first appeared in 1780s.[1)] As for French language, the dictionary of Académie Française adopted "dynamique" in its fourth edition (1762).[2)] It seems that, therefore, the science of dynamics became popular only in the Age of Enlightenment. We have many studies on the history of dynamics in the modern sense, but very little has been written about the word "dynamics" itself.[3)] The present study attempts to give an overview of its diffusing process, mainly in France.

It is not a simple diffusion, however. In the dictionary of Académie Française,

---

1) *The Oxford English Dictionary*, second ed. (Oxford: Clarendon Press, 1989), vol. 5, p. 7, "dynamics." It refers to "1788-89 HOWARD, *Royal Encycl.*" which probably means Howard, George Selby, *The new royal cyclopaedia and encyclopaedia [...]* (London: Printed for A. Hogg, [1788]).

2) *Les dictionnaires de l'Académie Française : 1687-1798* [CD-ROM] (Paris: Champion Electronique, 2000), "dynamique." This term is not found in the first (1694), second (1718) and third (1740) editions.

3) For example, see Richard S. Westfall, *Force in Newton's physics: The science of dynamics in the seventeenth-century* (London: Macdonald; New York: American Elsevier, 1971) and Cannon, John T. and Sigalia Dostrovsky, *The evolution of dynamics: Vibration theory from 1687 to 1742* (New York: Springer Verlag, 1981). These works discuss the history of dynamics understood in the modern sense. On eighteenth-century mechanics in general, see, for example, Dugas, René, *A history of mechanics*, tr. J. R. Maddox (New York: Dover Publications, 1988), part 3; Truesdell, Clifford, "A program toward rediscovering the Rational Mechanics of the Age of Reason," in idem, *Essays in the history of mechanics* (Berlin: Springer-Verlag, 1968), pp. 85-137; Yamamoto, Yoshitaka, *Koten rikigaku no keisei: Newton kara Lagrange e* [*The formation of classical mechanics: From Newton to Lagrange*, written in Japanese] (Tokyo: Nippon Hyoron Sha, 1997).

one finds a sort of double definition:

> DYNAMICS. s.f. Means properly the science of forces or powers which move the bodies. It is said more particularly of the science of motion of bodies which act on one another, by pushing or pulling mutually in any way.[4)]

Apparently it gives two meanings: science of force and science of motion of bodies in mutual action. Where was this double explanation from? How are these two meanings related to each other? I shall discuss these questions in what follows.

At this point, some people may think about d'Alembert's *Traité de dynamique*, the famous treatise published in 1743. It is plausible that d'Alembert played a great role in popularizing that new word and the new science of dynamics itself. But it should be noted that it was not d'Alembert himself who invented the *dynamique*. In the article "Dynamique" in *Encyclopédie* he explains that "Leibniz is the first who employed this term"[5)] and, in the preface of *Traité*, that he chose "dynamics" for its title "since the word of *Dynamics* is well used today among Scholars."[6)] Thus, that term had been originally introduced by Leibniz and was in current use "among Scholars" when d'Alembert prepared his treatise.

After discussing the original Leibnizian meaning and its diffusion (section one), I proceed to examine how "dynamics" established itself in the Paris academy of sciences around 1740 (section two) and by which route this new science entered the academy (section three). In total, we will see that in this process "dynamics" was transformed from a science of force into a science of motion. In order to emphasize this second meaning which emerged in France, I call it *dynamique* throughout this article.

---

4) Citation from the fourth edition (see n. 2): "DYNAMIQUE. s.f. Signifie proprement la science des forces ou puissances qui meuvent les corps. Il se dit plus particulièrement de la science du mouvement des corps qui agissent les uns sur les autres, soit en se poussant, soit en se tirant d'une manière quelconque."

5) Alembert, Jean le Rond de, "DYNAMIQUE," *Enc*., V, pp. 174-176, on p. 174b: "M. Leibnitz est le premier qui se soit servi de ce terme [...]."

6) Alembert, Jean le Rond de, *Traité de dynamique* (Paris: David, 1743; rep., Bruxelles: Culture et civilisation, 1967), p. xxiii: "comme le mot de *Dynamique* est fort usité aujourd'hui parmi les Savans [...]."

**Leibnizian dynamics and its diffusion**

"Dynamics" was proposed by Leibniz in an effort to establish his new philosophy. While Descartes identified the essence of body as extension, Leibniz found it insufficient, thus gave an essential role to "force." Although he mentioned to his program in a few publications from 1690, it was in the *Specimen dynamicum* (1695) that he gave a detailed account of the new science of "force".[7)]

*Specimen dynamicum* classifies "force" in two ways. One classification is based on the distinction between "primitive" force, which is in the domain of metaphysics, and "derivative" one, which is related to physics. The other is about the opposition of "active" and "passive" force, or, "virtue" and "resistance." Thus one has four kinds of "force" in total.[8)]

Leibnizian dynamics is mainly about the "derivative" and "active" force. Leibniz classifies this kind of force further into two species: *vis viva* (living force) and *vis mortua* (dead force). According to him, *vis viva* was connected to bodies in actual motion, while *vis mortua* was related to the situation that motion did not exist yet, but did only "solicitation" for motion. Thus bodies in motion have some "force" (*vis viva*), which becomes manifest in the case of impact (i.e. force of percussion), and, even in the situation of apparent rest, bodies have a tendency to motion which is conceptualized as a kind of "force" (*vis mortua*). And it was the new science of *vis viva* that Leibniz named "dynamics."[9)]

It is well known that Leibnizian concept of "force" caused a great debate called *vis viva* controversy. The central question of this dispute was how to measure the "force of bodies in motion," although many other factors (both intellectual and social) were in operation.[10)] Leibniz maintained that "force" was proportional to

---

[7)] Leibniz, Gottfried Wilhelm, "Specimen Dynamicum [...]," in *Mathematische Schriften*, hg. C. I. Gerhardt, Bd. VI (Halle: H.W. Schmidt, 1860; rep., Hildesheim: Georg Olms, 1971), S. 234-246. On Leibniz's dynamics, Daniel Garber provides a nice summary. See his "Leibniz: Physics and philosophy" in *The Cambridge companion to Leibniz*, ed. N. Jolley (Cambridge: Cambridge University Press, 1995), pp. 270-352 and *Leibniz: Body, substance, monad* (Oxford: Oxford University Press, 2009), chap. 4.

[8)] Leibniz, "Specimen Dynamicum," S. 236-237.

[9)] Leibniz, "Specimen Dynamicum," S. 238.

[10)] Japanese readers may find a survey in Ariga, Nobumichi, "What was the *vis viva*

mass and squared velocity ($mv^2$), opposing to the Cartesian view that it was proportional to mass and velocity ($mv$) or quantity of motion. (Leibniz already made this point in his article of 1686, before inventing the name *vis viva*.) Since Leibniz believed that the total amount of "force," or more precisely *vis viva*, was conserved in physical processes, Leibnizian science of dynamics included the conservation of *vis viva* as a basic component.[11)]

At the beginning of eighteenth century, some mathematicians and philosophers were in support of Leibniz. It was these followers, rather than Leibniz himself, who maintained Leibnizian measure of "force" in the *vis viva* controversy. Especially notable among them were Christian Wolff and Johann Bernoulli.

Wolff was the most influential philosopher in the German speaking world after Leibniz, not only in metaphysics but also in mathematical sciences. (Kant's understanding of mechanics was mainly due to him, for example.)[12)] With regard to

---

controversy?" [written in Japanese], *PHS Studies* (Department of Philosophy and History of Science, Kyoto University), no. 3 (2009), pp. 39-57. Among many historical studies on this subject, following articles are of particular importance: Hankins, Thomas L., "Eighteenth-century attempts to resolve the *vis viva* controversy," *Isis*, vol. 56 (1965), pp. 281-297; Laudan, L. L., "The *vis viva* controversy, a post-mortem," *Isis*, vol. 59 (1968), pp. 131-143; Iltis, Carolyn, "The decline of Cartesianism in mechanics: The Leibnizian-Cartesian Debates," *Isis*, vol. 64 (1973), pp. 356-373; idem, "The Leibnizian-Newtonian debates: Natural philosophy and social psychology," *British Journal for the History of Science*, vol. 6 (1973), pp. 343-377; Scott, Wilson L., *The conflict between atomism and conservation theory, 1644-1860* (London: Macdonald & Co.; New York: Elsevier, 1970), book 1; Papineau, David, "The *vis viva* controversy: Do meanings matter?," *Studies in History and Philosophy of Science*, vol. 8 (1977), pp. 111-142; and Terrall, Mary, "*Vis viva* revisited," *History of Science*, vol. 42 (2004), pp. 189-209.

11) Leibniz, Gottfried Wilhelm, "Brevis Demonstratio Erroris memorabilis Cartesii et aliorum [...]," in *Mathematische Schriften*, hg. C. I. Gerhardt, Bd. VI (Halle: H. W. Schmidt, 1860; rep., Hildesheim: Georg Olms, 1971), S. 117-123. See also, Iltis, Carolyn, "Leibniz and the *vis viva* controversy," *Isis*, vol. 62 (1971), pp. 21-35.

12) On Wolff's thought about mechanics and his influence in German-speaking world, see Watkins, Eric, "The laws of motion from Newton to Kant," *Perspectives on Science*, vol. 5 (1997), pp. 311-348; Clark,William, "The death of metaphysics in enlightened Prussia," in *The sciences in enlightened Europe*, ed. W. Clark, J. Golinski, and S. Schaffer (Chicago: The University of Chicago Press, 1999), pp. 423-473; Boudri, J. Christiaan, *What was mechanical about mechanics: The concept of force between metaphysics and mechanics from Newton to Lagrange*, tr. Sen McGlinn (Dordrecht: Kluwer Academic Publishers, 2002), chap. 6; Matsuyama, Juichi, *Wakaki Kant no rikigaku-kan* [*Young Kant's view on mechanics*, written in

the dynamics, he was the author of a highly abstract article *Principia dynamica*, published in the first volume of *Comentarii* of the Petersburg academy of sciences.[13] Apparently more important was that he explained concepts of *vis viva* and *vis mortua* in his encyclopedic Latin textbook *Elements of universal mathematics* (*Elementa matheseos universae*) and his German *Mathematical lexicon* (*Mathematisches Lexicon*). Published in as early as 1710s, these works contained the earliest descriptions about Leibnizian concepts of force.[14]

By early 1720s, Wolff's textbook arrived at the Paris academy of sciences. Its *Histoire* (bulletin of the academy) for the year 1721 reports an attempt to refute Leibnizian measure of force by Louville, a member of the academy, introducing the matter as follows:

> From the year of 1686 Mr. Leibniz had advanced his paradoxical proposition in the Journal of Leipzig [i.e. *Acta Eruditorum*]. Since it had not been received by any Mathematician, and that everybody had continued, without taking account of it, to go on his ordinary way, one made little mention to it, perhaps out of respect for a man as great as its Author; but Mr. Wolff, despite his brilliance being apparently attracted by a great authority, has adopted for a short time that principle in his Course of Mathematics [i.e. *Elementa matheseos universae*]; Sir Louville, then, was convinced to fight against an evil which began to win and could gain strength by a new and considerable authority.[15]

---

Japanese] (Tokyo: Hokuju Shuppan, 2004).

13) Wolff, Christian, "Principia dynamica," *Commentarii Academiae Scientiarum Imperialis Petropolitanae*, t. 1: ad annum 1726 (pub. 1728), pp. 217-238.

14) Wolff, Christian, *Elementa matheseos universae*, *t. I. Qui [...] staticam et mechanicam [...] complectitur* (Halae Magdeburgicae: Prostat in officina libraria Rengeriana, 1717), p. 541b; idem, *Mathematisches Lexicon* [...] (Leipzig, Bey Joh. Friedrich Gleditschens seel. Sohn, 1716; rep., Hildesheim: Olms, 1965), col. 1461. The 1717 edition of *Elementa* appears to be identical to the first edition (1713), which I have not seen. See also its revised edition, t. 2 (1733), reprinted in Wolff's *Gesammelte Werke*, II-30 (Hildesheim: Georg Olms, 2003), p. 5b.

15) "Sur la force des corps en mouvement," *Histoire de l'Academie Royale des Sciences* [hereafter indicated as *HARS*]. Anné 1721 (pub. 1723), *Histoire*, pp. 81-85, citation from p. 81: "Dès l'an 1686 M. Leibnitz avoit avancé sa proposition paradoxe dans les Journaux de Leibsick. Comme elle n'avoit été reçûë d'aucun

Leibnizian ideas were totally unpopular. Who in the world adopted his dynamics?

However, the situation had changed when the 1728 volume of *Histoire* was composed. In the popular article "On the force of bodies in motion" (the same title as that of 1721 article), one finds detailed account of recent discussion about the measure of force.[16] Now some academicians were in support of Leibniz, and a controversy was going on within the academy (1728-1729). According to Terrall's archival study, of many papers only three were published in the bulletin in order to conceal the great division. Now *vis viva* was under serious consideration.[17]

What brought this change was a treatise by Johann Bernoulli, the prominent mathematician in Basel. Originally submitted to the prize competitions of the Paris academy (for the years of 1724 and 1726), his *Discourse on the laws of the communication of motion* provided a full account of *vis viva* and *vis mortua* (perhaps for the first time in French).[18] Although Bernoulli had been interested in Leibnizian dynamics since 1690s, immediately after the publication of *Specimen dynamicum*, it was with this French dissertation that he emerged as one of the greatest supporters of

---

Mathematicien, & que tous, sans y avoir égard, avoient continué d'aller leur chemin ordinaire, on n'en faisoit guere de mention, peut-être par respect pour un aussi grand homme que son Auteur, mais M. Volfius[sic], séduit apparement malgré ses lumieres par une grande autorité, ayant adopté depuis quelque temps ce principe dans son Cours de Mathematique, M. le chevalier de Louville a cru devoir s'opposer à un mal qui commençoit à gagner, & qui pouvoit acquerir des forces par une nouvelle autorité considerable."

16) "Sur la force des corps en mouvement," *HARS*. Anné 1728 (pub. 1753), *Histoire*, pp. 73-97.

17) Terrall, "*Vis viva* revisited" (n. 10). Technical details of the published articles are discussed in Iltis, "The decline of Cartesianism in mechanics" (n. 10).

18) Bernoulli, Johann, *Discours sur les loix de la communication du mouvement [...]* (Paris: Claude Jombert, 1727); rep. in *Recueil des pieces qui ont remporté les prix de l'Academie royale des sciences [...]* (Paris: Gabriel Martin [et al.], 1752); also in idem, *Opera omnia [...]* (Lausannae et Genevae: Sumptibus Marci-Michaelis Bousquet et Sociorum, 1742; rep., Hildesheim: Georg Olms, 1968), t. 3, pp. 1-107. On this work and the competitions to which it was submitted, along with the articles by Iltis and Terrall mentioned above (n. 17), see especially Scott, *The conflict between atomism and conservation theory* (n. 10), chap. 2. I also have analyzed Bernoulli's and others' treatises in Ariga, Nobumichi, "Theory of collision as an example of Rational Mechanics, from 1720 to 1730" [written in Japanese], *PHS Studies*, no. 6 (2012), pp. 17-37.

Leibniz.[19] As d'Alembert would describe later, "[t]his work was the epoch of a kind of schism in the scholars over the measure of *forces*."[20]

It should be noted, however, that neither in Bernoulli's *Discours* nor in the popular articles from *Histoire* one can find the very term "dynamics." Although the Eloge of Leibniz (1716), delivered at the Paris academy, mentioned his attempts "to establish a new *Dynamics*, or Science of forces," apparently that word was not in circulation through 1720s.[21]

**Establishment of a new science**

As far as the Paris academy of sciences is concerned, the first treatise with "dynamics" in its title was published in its 1736 bulletin. That was "Solution of some Problems of Dynamics" by Clairaut, the young mathematician with talent. According to the introduction provided by the secretary of academy, this study developed from a controversy between Clairaut and Fontaine, another member of the academy, on a mathematical curve called *Tractrice* or *Tractoire*. The problem was to determine the curve described by one body when another body drew it by a thread (inflexible one). In fact, Clairaut greatly expanded this original problem, discussing seven problems related to the motion of two bodies which were connected to each other. Thus these "problems of dynamics" were not so much about force itself as motion of bodies in mutual action (constrained motion, in modern physical terminology).[22]

Curiously enough, that article does not explain why it has "dynamics" in its title. In fact, in his text Clairaut does not employ that term at all. The introduction to

---

[19] See Heimann [later Harman], P. M., " 'Geometry and nature': Leibniz and Johann Bernoulli's theory of motion," *Centaurus*, vol. 21 (1977), pp. 1-26.

[20] Alembert, Jean le Rond de, "FORCE VIVE, OU FORCE DES CORPS EN MOUVEMENT," in *Enc*., VII, pp. 112-114, on p. 113a: "Cet ouvrage a été l'époque d'une espece de schisme entre les savans sur la mesure des *forces*."

[21] "Eloge de M. Leibniz," *HARS*. Anné 1716 (pub. 1718), *Histoire*, pp. 94-128, citation from p. 108: "établir une nouvelle *Dynamique*, ou Science des forces [...]."

[22] Clairaut, Alexis-Claude, "Solution de quelques Problemes de Dynamique," *HARS*. Anné 1736 (pub. 1739), *Mémoires*, pp. 1-22; "Sur quelques Problemes de Dynamique par rapport aux Tractions," *HARS*. Anné 1736 (pub. 1739), *Histoire*, pp. 105-110.

this article is not so kind, either; it only says that "[m]otions of one or more bodies drawn by threads are one of the principal objects of the *Dynamics* or Science of Forces."[23] With the publication of the second article on "dynamics," which appeared in the *Histoire* volume for 1741, readers may have gained somewhat better understanding. According to its introduction, "[t]he name of *Dynamics*, which is only recently in use among French Mathematicians and which Mr. Leibniz employed first, means the speculative and sublime mechanics which treats motive and active forces of Bodies." Also it says that "[...] the true object of the Dynamics is, [...] the theory of Forces actually in action." These introductions explain "dynamics" rather faithfully to its original Leibnizian meaning.[24]

The introduced 1741 article was entitled "Problem of Dynamics." The author was Montigni (or Montigny), totally unknown person in history of mechanics. The present work appears to have been his only contribution to this field.[25] The problem he challenged is the following one: on a horizontal surface stands a ring available to rotate on a fixed point, through which a bar can move smoothly; to this bar are attached two or more bodies, and one gives some motion to the bar; then it is required to determine how these bodies will behave. Montigni treated the two-body case in his first problem and then generalized it in the second one, supposing an infinite number of bodies. His solution is apparently incorrect, in fact, but the point is that he discusses, as was the case with Clairaut, constrained motion of bodies. While "dynamics" was formally defined as a science of force, its actual matter was rather different.[26]

---

[23] "Sur quelques Problemes de Dynamique par rapport aux Tractions" (n. 22), p. 105: "Les mouvements d'un ou de plusieurs Corps tirés par des Cordes, sont un des principaux Objets de la *Dynamique* ou Science des Forces [...]."

[24] "Sur un Problème de Dynamique," *HARS*. Anné 1741 (pub. 1744), *Histoire*, pp. 143-145, citations from p. 143: "Le nom de *Dynamique* qui est depuis peu en usage parmi les Géomètres François, & dont M. Leibnitz s'est servi le premier, signifie cette méchanique spéculative & sublime qui traite des forces motrices & actives des Corps [...]"; "[...] le véritable objet de la Dynamique est, [...] la théorie des Forces actuellement agissantes."

[25] On Montigni, see "Eloge de M. de Montigni," *HARS*. Anné 1782 (pub. 1785), *Histoire*, pp. 108-121. On p. 101 it touches on the article in question, "the only Memoire of Mathematics he published" (le seul Mémoire de Mathématiques qu'il ait imprimé).

[26] Montigni [or Montiny, on the published article], Etienne Mignot de. "Problèmes

The meaning of "dynamics" was changing. In the following year, when Clairaut composed another paper on this theme, its introductory article described "dynamics" as a branch of the science of motion:

> The questions of Dynamics have usually for their object a system of bodies, to one or more of which one imagine that any motion be given and that it be communicated to all others; after that it is required to determine the velocities, positions, and oscillations of each of these bodies, and the various curves they describe on one or more fixed planes either in motion or in the absolute and immobile space.[27)]

Here "system" refers to an assemblage of two or more bodies connected by inflexible rods, chains, flexible threads or, in general, any mutual actions whatever. Also the solar "system" or a "system" of planet and satellite are objects of "dynamics," so that, according to this introduction, "one can say that Mr. Newton solved many Problems of Dynamics in his Book of Principles [i.e. *Principia*]." Apparently Leibnizian connotations had been erased.[28)]

It was in this context that d'Alembert named his treatise *Traité de dynamique*. By that time, there had emerged a new kind of problems called by the generic term "dynamics." The *Histoire* volume for 1743, the year when *Traité* was published, included not only a short review of that treatise but also a brief account of the "Problem of Dynamics." This time, the challenger was d'Arcy, yet another member of the academy. The problem was, when one body descents along a curve set on

---

de Dynamique, où l'on détermine les Trajectoires & les vîtesses d'une infinité de Corps mis en mouvement autour d'un centre immobile," *HARS*, Anné 1741 (pub. 1744), *Mémoires*, pp. 280-291. Montigni supposes that the centrifugal forces of bodies produce motion of bar, which is impossible.

27) "Divers Problèmes de Dynamique," *HARS*. Anné 1742 (pub. 1745), *Histoire*, pp. 125-131, citation from p. 125: "Les questions de Dynamique ont ordinairement pour objet un systême de corps, à l'un ou à plusieurs desquels on imagine qu'il soit donné un mouvement quelconque qui se communique à tous les autres ; après quoi il faut déterminer les vîtesse, les positions, les oscillations de chacun de ces corps, & les différentes courbes qu'ils décrivent sur un ou plusieurs plans fixes ou en mouvement, & dans l'espace absolu & immobile."

28) Citation from p. 126: "[...] l'on peut dire que M. Newton a résolu plusieurs Problèmes de Dynamique dans son Livre des Principes [...]."

another body which can smoothly slide on a horizontal surface, to determine their motions due to their mutual action. The new science of *dynamique* had been firmly established within the academy.[29)]

But there remain some questions: how did the term "dynamics" come to be in use, especially for Clairaut's first treatise? By which route did the new science of *dynamique* entered the Paris academy?

**Bernoullian connection and the conservation of *vis viva***

Clairaut in his article (1736) employed several methods to solve his problems, one of which was based on the principle of "Conservation of Living forces" (Conservation des Forces vives). This principle, "which has been treated with much elegance by the celebrated Messrs. Bernoulli Father and Son [supposedly Johann and Daniel Bernoulli]," was that the sum of the mass of bodies multiplied by their squared velocity ($\Sigma mv^2$, in modern notation) was always constant, or, what modern readers may call the conservation of kinetic energy (under no external force). Clairaut introduced this proposition in his third solution for the second problem and also explicitly referred to it in the third, sixth, and seventh problems.[30)] In a similar manner, Montigni discussed his two problems by this principle.[31)] Problems of dynamics were often connected to the conservation of *vis viva*, proposition derived from Leibniz.

This was also the case for another material of significance registered in *Procès-Verbaux* (the minutes) of the academy. Clairaut's first paper was, as indicated in the published bulletin, begun to read at the meeting of April 30 in 1735. But in the minutes it reads that "Mr. Clairaut began to read a piece of Writing on the Motion of Bodies together[sic]," thus lacking the word "dynamics."[32)] The crucial description

---

29) "Problème de Dynamique," *HARS*. Anné 1743 (pub. 1746), pp. 165-167 [on d'Arcy's challenge]. One finds the description of d'Alembert's book on pp. 164-165 in the same volume. D'Arcy's article itself was not published.

30) Clairaut, "Solution de quelques Problemes de Dynamique" (n. 22), pp. 9, 13, 20, 21, citation from p. 9: "qui a été traité avec tant d'élégance par les célébres M$^{rs}$ Bernoulli Pere & Fils [...]."

31) Montigni, "Problèmes de Dynamique" (n. 26), pp. 281, 286.

32) Académie royale des sciences, *Procès-verbaux*, 1735, fol. 106v: "M$^{r}$ Clairaut a

comes, then, at the next meeting of May 4. There one finds a description that "Mr. Clairaut continued his Lecture" and, to continue, "Mr. de Maupertuis read The following Problem related to the same subject."[33] This problem, accompanied with its solution, is transcribed in *Procès-Verbaux* under the title: "Dynamical Problem proposed by Mr. Koenig."[34]

The "Dynamical Problem," recorded in *Procès-Verbaux*, is the following one: when two bodies are connected to the ends of a thread on a horizontal plane, given any velocity to one body, what sort of curve will another body describe? This is, indeed, "related to the same subject" as that challenged by Clairaut. Moreover, Maupertuis solved his problem first by deducing the equation for the conservation of *vis viva*, and by using this relationship. Apart from Clairaut's article, whose original title is not clear, Maupertuis's short paper appears to have been the earliest case where the new connotation of "dynamics" appeared in the Paris academy of sciences.

Maupertuis was the central figure who revived interest in mathematical sciences within the Paris academy in 1730s. As a representative "Newtonian" in France, he is famous for his Lapland expedition (1736-1737), which allegedly determined the figure of earth and showed the validity of Newtonian universal attraction. But Maupertuis was also a modest member in the Leibnizian camp. When the *vis viva* controversy broke out within the academy in 1728, he was present there as one of its ordinary members. Moreover, between 1729 and 1730 he visited Johann Bernoulli in Basel to study differential and integral calculus at length. According to his modern biographer Terrall, at that time Maupertuis was an acknowledged supporter of *vis viva* and, after returning to Paris, composed a treatise to back up his master by the latter's request. This treatise was, however, only circulated among

---

commencé à lire un Ecrit sur les Mouvements des Corps // ensemble[sic]." I used a digitalized image available on Gallica website (Bibliothèque nationale de France). There might be some words after "Corps" before starting the new line (denoted by "//") because this image is difficult to read near to the right edge.

33) Ibid., fol. 107r: "M$^{r}$ Clairaut a continué sa Lecture"; "Et M$^{r}$ de Maupertuis a lû Le Problème suivant par rapport au même sujet."

34) Ibid., fols. 107v-108v: "Problème Dynamique // proposé par M$^{r}$ Koënig." It is also documented that Maupertuis read the sequels of this paper on May 11, 14 and 21, but without their details. See fols. 111r, 114r and 116r.

close friends, being not published, nor read at the academy.[35)]

We have indirect evidence that Maupertuis had been in support of *vis viva* at least by the end of 1730s. It is a letter sent to him from Koenig, whose name was associated with the "dynamical problem" mentioned above, and this letter was enclosed with "a small piece on the measure of living force."[36)] Koenig's "small piece" and Maupertuis's response do not survive, but in his letter Koenig briefly explained his idea for demonstrating Leibnizian measure, writing that:

> Since the demonstration appears simple and exposed to no objection, even easy to verify by the experiment, I have thought, Sir, that you would not be unpleased to have it, [and] perhaps you will be able to make use of it against some of those Gentlemen still prejudiced for the ancient hypothesis.[37)]

Clearly Koenig was convinced that he and Maupertuis were in the same camp.

As Maupertuis, Koenig had studied under Johann Bernoulli. He stayed in Basel from 1730 to 1735 and during this period he got acquainted with Maupertuis. From then on, these two men were on good terms through 1740s (Maupertuis introduced Koenig to Châtelet as her private tutor, for example).[38)] Moreover, when Maupertuis visited Basel again in the fall of 1734, he was accompanied with Clairaut. Also was there Johann's son Daniel, who came back from Petersburg in the

---

[35)] Terrall, Mary, *The man who flattened the Earth: Maupertuis and the sciences in the Enlightenment* (Chicago: University of Chicago Press, 2002), pp. 51-53, 61-64 [on his support of *vis viva*]. On Maupertuis's role in the revival of mathematical sciences, see also Greenberg, John L., "Mathematical physics in eighteenth-century France," *Isis*, vol. 77 (1986), pp. 59-78.

[36)] Koenig's letter to Maupertuis, dated Jan. 27, 1739, in Le Sueur, Achille, *Maupertuis et ses correspondants : Lettres inédites [...]* (Montreuil-sur-Mer: Notre-Dame des Prés, 1896; rep., Genève: Slatkine, 1971), pp. 109-111, citation from p. 109: "une petite pièce sur la mesure des forces vives [...]."

[37)] Ibid., p. 110: "Comme la démonstration paroit simple et point exposée aux objections, même facilement à vérifier par l'expérience, j'ai cru, Monsieur, que vous ne seriez pas faché de l'avoir, peut-être en pourrez-vous faire quelque usage auprès de quelqu'un de ces Messieurs prévenus encore pour l'ancienne hypothèse."

[38)] Terrall, *The man who flattened the earth* (n. 35), pp. 294-295; Fellmann, E. A., "Koenig (König), Johann Samuel," in *Dictionary of Scientific Biography*, ed. Charles Coulston Gillispie in chief (New York: Charls Scribner's sons, 1981), vol. 7, pp. 442-444.

preceding year.[39] Thus Johann and Daniel Bernoulli, Koenig, Maupertuis and Clairaut were all in Basel for a while.

It is highly plausible that the science of *dynamique,* with the solution by the conservation of *vis viva*, was first brought into the Paris academy through this Bernoullian connection. Maupertuis's "Dynamical Problem" presented in the academy, which we discussed above, may have been one directly proposed by Koenig in Basel or communicated in his letter. At one occasion, for example, Koenig sent to Maupertuis "a half dozen" (une demi-douzaine) of problems, requesting "to recommend these problems to young mathematicians of your acquaintance."[40] Although these problems seem to have been different from one found in *Procès-Verbaux*, it is possible that Maupertuis took up one of the problems sent by Koenig, for this latter appears to have written to the former "very often" (bien souvent).[41]

Maupertuis's unpublished article, as well as Clairaut's published one, effectively defined the *dynamique* in the Paris academy of sciences. It was a science of motion of bodies in mutual action, characterized by the Leibnizian-Bernoullian principle of the conservation of *vis viva.* It is certain that Maupertuis was familiar with this new science. In his another article presented in 1740, when the term "dynamics" was not so popular yet, he employs this word without explanation and refers to the conservation of *vis viva*.[42]

---

[39] Itard, Jean, "Clairaut, Alexis-Claude," in *Dictionary of Scientific Biography*, (n. 38), vol. 3, pp. 281-286, on p. 281; Straub, Hans, "Bernoulli, Daniel," ibid, vol. 2, pp. 36-46, on p. 36.

[40] Koenig's letter to Maupertuis, dated May 1, 1735, in Le Sueur, *Maupertuis et ses correspondants* (n. 36), pp. 106-107, citation from p. 106: "Faite-moi la grâce, Monsieur, de recommender ces problèmes aux jeunes géomètres de votre connoissance."

[41] Ibid. In this letter Koenig suggests that he "publicly proposed" (proposées publiquement) these problems, and one can find actually his letter published in a journal. See S[amuel] K[oenig], "Epistla ad geometras," *Nova Acta Eruditorum*, Aug. 1735, pp. 369-373. This "Epistla" contains seven problems but does not include one corresponding to Maupertuis's "Dynamical Problem."

[42] Maupertuis, Pierre-Louis Moreau de, "Loi du repos des corps," *HARS*. Anné 1740 (pub. 1742), pp. 170-176, on p. 171; slightly modified version in *Œuvres de Maupertuis*, nouv. éd (Lyon: Jean-Marie Bruyset, 1768; rep., Hildesheim: Olms, 1965-1974), t. 4, pp. 43-64, on p. 47.

**Conclusion**

Dynamics, in its original Leibnizian sense, referred to a science of "force" as something essential to bodies. Leibniz maintained that "active" and "derivative" force, or *vis viva*, was proportional to mass and squared velocity and conserved in the universe. Although Leibnizian concepts of *vis viva* and *vis mortua* became well-known in Paris mainly thanks to Johann Bernoulli, the term "dynamics" itself was not popular through 1720s. And when this word came to be in use around 1740, it had acquired a new meaning: science of motion of bodies in mutual action. Characterized by the employment of the conservation of *vis viva*, this new connotation was brought into the Paris academy by Maupertuis and Clairaut, who had connections with the Bernoullis and Koenig.

The use of the conservation of *vis viva* did not mean "Leibnizian," however. As Clairaut noted, that principle was "recognized true by all Scholars, in spite of the disputes which had been caused by the theory of Living forces."[43] Or, as explained in an article from *Histoire*, it was "often employed by other renowned Mathematicians who firmly rejected the Living forces, or who did not want to enter the discussion of that famous dispute, from which it can be easily separated."[44] The principle of the conservation of *vis viva* had lost its cosmological importance and was employed just for solving mathematical problems of motion.

D'Alembert's *Traité de dynamique* was, in one significant sense, nothing about "dynamics." Pursuing the clear, distinct and certain knowledge of mechanics, he entirely banished the force of moving bodies itself, calling it "obscure and Metaphysical being, which is only capable to spread the darkness on a Science which is clear by itself."[45] This was extreme, indeed, but d'Alembert's thought was

---

43) Clairaut, "Solution de quelques Problemes de Dynamique" (n. 22), p. 13: "[...] reconnu vrai de tous les Sçavants, malgré les disputes qu'ont[sic] causées la théorie des Forces vives."

44) "Sur un Problème de Dynamique" (n. 24), on p. 145 : "[...] souvent employé par d'autres Géomètres fameux qui rejetent formellement les Forces vives, ou qui n'ont point voulu entrer dans la discussion de cette célèble dispute, dont il peut être aisément séparé."

45) D'Alembert, *Traité de dynamique* (n. 5), p. xvi: "êtres obscurs & Métaphysiques, qui ne sont capables que de répandre les ténèbres sur une Science claire par elle-même." On D'Alembert's thought on mechanics, see especially Hankins,

not so peculiar if contextualized in the emergence of the *dynamique* in the Paris academy.[46] Moreover, this change seems to have been a part of the general trend of eighteenth-century mechanics: transition from a metaphysical to a mathematical science or, from one branch of natural philosophy to an autonomous science of mechanics.[47]

(Rikkyo University)

Thomas L., *Jean d'Alembert: Science and the Enlightenment* (Oxford: Clarendon Press, 1970) and Firode, Alain, *La dynamique de d'Alembert* (Paris: Vrin; Montréal: Bellarmin, 2001).

46) In his recent article, Schmit attributes d'Alembert's conception of dynamics to Pierre Varignon. For my part, I suppose that Varignon's influence was indirect, although I was convinced of the latter's importance. See Schmit, Christophe, "Les articles de mécanique de l'*Encyclopédie*, ou D'Alembert lecteur de Varignon," *RDE*, vol. 46 (2011), pp. 169-199, on p. 170. I thank Irène Passeron for informing me of this important study.

47) See especially, Terrall, Mary, "Metaphysics, mathematics, and the gendering of science in eighteenth-century France," in *The sciences in enlightened Europe* (n. 12), pp. 246-271; Boudri, *What was mechanical about mechanics* (n. 12); and Pulte, Helmut, "Order of nature and orders of science: On the mathematical philosophy of nature and its changing concepts of science from Newton and Euler to Lagrange and Kant," in *Between Leibniz, Newton, and Kant: Philosophy and science in the eighteenth century*, ed. Wolfgang Lefèvre (Dordrecht: Kluwer Academic Publishers, 2001), pp. 61-92.

# 略　号

# SIGLES ET ABRÉVIATIONS

DPV　Diderot, Denis, *Œuvres complètes*, éditées par Herbert Diekmann, Jacques Proust, Jean Varloot & al., Hermann, 1975 et suiv. 34 vol. prévus.

*Enc*.　*Encyclopédie, ou Dictionnaire raisonné des sciences, des arts et des métiers, par une société de gens de lettres*, Paris, Briasson, David, Le Breton, Durand, 1751-1765, 17 vol. in-fol.

RDE　*Recherches sur Diderot et sur l'*Encyclopédie, Paris, Société Diderot.

REEL　*Recueil d'études sur l'*Encyclopédie *et les Lumières*, Tokyo, Société d'études sur l'*Encyclopédie*.

SVEC　*Studies on Voltaire and the Eighteenth Century*, Oxford, The Voltaire Foundation.

Le numéro des tomes est indiqué en chiffres romains, la ou les pages en chiffres arabes

本誌に掲載された論文は、査読委員会による査読を経たものです。

本誌は日本学術振興会による科学研究費補助金を受けて出版するものです。
ここに厚く御礼申し上げます。

Tous les textes de ces Actes ont été soumis à l'examen de notre comité de lecture.

Notre groupe bénéficie d'une subvention du gouvernement japonais (Grant-in-Aid for Scientific Research (B))

『百科全書』・啓蒙研究論集　第 2 号

発　行　日　2013 年 3 月 7 日
編集・発行　『百科全書』研究会
連　絡　先　180-0003　東京都武蔵野市吉祥寺南町 4-24-24
　　鷲見　洋一
印　　刷　株式会社　インフォテック
　　206-0033　東京都多摩市落合 2-6-1
　　電話 042-311-3355

Recueil d'études sur l'Encyclopédie et les Lumières : Numéro 2

Date de parution : le 7 mars 2013