***Gottfried Wilhelm Leibniz. La réforme de la dynamique: De corporum concursu (1678) et autres textes inédits*. Edition, présentation, traductions et commentaires par Michel Fichant. Paris: Librairie philosophique J. Vrin, 1994, 444 pp.**

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This is a truly outstanding contribution to contemporary scholarship on Leibniz's methodology and natural philosophy. By providing the original edition of Leibnizian manuscripts dating back to the period 1676-1680, in particular the *De corporum concursu*, Michel Fichant has confirmed what some previous scholars had surmised—that Leibniz had substituted his new principle of conservation of *vis viva* (measured by mv^2) for the Cartesian principle of conservation of quantity of motion measured by mv shortly after his return from France, and quite a few years before the publication of the *Brevis demonstratio erroris memorabilis Cartesii* in the *Acta Eruditorum* (1686). Fichant has conclusively shown that the turning point rightly occurs in the midst of Leibniz's writing the *De corporum concursu* in January-February 1678. At the time, Leibniz was groping for a coherent system of physical and mathematical reasons to ground the mechanical laws of motion beyond the relativistic formulas which Huygens, Wallis, and Wren had provided in response to the enquiry launched by the Royal Society in 1668.

In the Introduction to this edition, Fichant justifies his use of the term "dynamics" to describe the theoretical shift that affected Leibniz's views on mechanics at the very beginning of 1678. Strictly speaking, Leibniz invented the term and the concept only in 1689-1690 while working on the *Dynamica de potentia*. At that later time, a more abstract principle of conservation—that of quantity of formal or essential action, which can be elicited both *a priori* and *a posteriori*—will ground the architectonic system of laws unfolding from Leibniz's theory of force; this more general system will comprise the *vis viva* theorem (made public in 1686) which related to the building-up and exhaustion of moving forces in such experimental settings as would involve Galileo's law of free fall. Fichant argues (p. 9) for a broader use of the term "dynamics" in view of the fact that some twelve years before the *Dynamica de potentia*, in the *De corporum concursu*, Leibniz had already developed his concept of force measured by mv^2, formulated and justified a new principle of conservation (later to be called principle of conservation of *vis viva*), and had foreseen several of the scientific and metaphysical consequences of his parting with a Cartesian mechanics. The larger part of Fichant's Introduction is devoted to a systematic account of the situation of mechanics when Leibniz undertook drastically to revise his original theories of *Hypothesis physica nova* and

Theoria motus abstracti (1671). Indeed, specially from 1676 on, the mechanical works of Wallis, Huygens, and Mariotte exerted a direct and profound influence on Leibniz as he attempted strenuously to set the ground for a synthesis that would justify the empirical laws of motion by demonstrating their consistency with more rational principles. This progressive work on the core problem of mechanics may be followed through various incidental remarks to correspondents and several sketchy drafts: these lead to the 1678 reformation of mechanics and testify to the intensity of Leibniz's effort at providing a relevant theory for the "system" which experience reveals. Instead of an abstract system conceived in purely geometrical fashion which needed contingent bridging with a physical hypothesis to account for phenomenal interactions, the objective is now that of framing up a theoretical system based on such mechanical laws as may be shown to underlie the various sequences of motions among colliding bodies.

Unfortunately split between two sections of *Leibniz-Handschriften* (in Bodemann's Catalogue: LH XXXV, 9, No. 23, f. 1-22 and LH XXXVII, 5, f. 86-91), the *De corporum concursu* consists of ten plus two additional folio sheets of paper, folded so as to afford four writing pages each. We thus get *Scheda prima* to *Scheda decima*, plus the later inserted *Scheda secundo-secunda* and *Scheda secundo-sexta* which served to prepare the decisive shift occurring in *Scheda octava*. In the first seven *Schedae*, Leibniz attempts to provide a systematic treatment of the rules governing the modes of collision for two bodies of equal or unequal dimensions, in various states of rest and motion, with and without percussion (understood as resulting from elasticity). Thus he endeavors to account for the various possible combinations of mass (= volumic density), speed, and direction, following the Cartesian principle that the quantity of effect is directly proportional to the quantity of body times the quantity of speed (considered not in vectorial, but in scalar fashion). All these attempts involve Leibniz in protracted calculations of various sorts, at times beset with notable shortcomings or failures—for instance in his parametric assessment of *vis percussionis* wherein he strays from the more adequate formulas to be found in Huygens and Mariotte. Then, in *Scheda* 8, Leibniz abandons the Cartesian postulate and declares contrariwise that the quantity of effect should be assessed by considering the height above starting point to which a body can lift itself in virtue of its speed. Hence moving force would stay the same not when quantities of motion, that is $\sum mv$, stay the same, but when $\sum mv^2$ do. Both *Schedae* 8 and 9 then proceed to demonstrate that this new formula for quantity of effect affords the correct solution for the various states of motion among colliding bodies and that, as a consequence, from now on all those epistemic difficulties can be discarded which the previous concepts and models entailed. Henceforth, all sequences of motions in cases of impact will be considered as falling under the jurisdiction of a threefold system of principles: (1) a principle of conservation of forces (between such antecedent and consequent states as involve a full expression of motive power); (2) a principle of conservation of direction (ruling over the translation of the common center of gravity of any system of colliding bodies and justifying the conservation of a vectorial quantity of motion according to Huygens's boat model); (3) a principle of conservation of appearances (as these are expressed in the equation of relative velocities before and after impact). In *Scheda* 8, a note summarizes the case: "*Calculus ex his tribus principiis: virium servatarum, servatae directionis in summa, et servatarum apparentiarum*" (p. 152). As Fichant points out, these are precisely the three principles which the later *Essay de dynamique* (c. 1700), following the *Dynamica de potentia*, will try and combine axiomatically. *Scheda* 10 is a kind of addendum to the demonstrations provided by the two preceding *Schedae*: its purpose is to sketch a possible extension of the Leibnizian research program to oblique collisions and those involving more than two bodies.

After reaching a revised principle to ground his systematic analysis of states of motion in impact, Leibniz identifies certain corrections to be brought to the concepts and mathematical arguments originally phrased out in the first seven *Schedae*. In such instances, he introduces revision notes that mention such phrases as *post reformationem.* This suggests that Leibniz believed he was initiating a major theoretical shift in mechanics and natural philosophy. Another very important feature of the text is Leibniz's appeal to architectonic principles for heuristical purposes. As Leibniz scholars are aware, these architectonic principles—specially the principle of equivalence between full cause and entire effect and the variants of the principle of continuity which underpin the 1678 demonstrations—manifestly will play a major role not only in subsequent development of the dynamics, but more broadly in significant transformations of the metaphysics as these unfold following the reformation of mechanics.

However, in order to explain the special methodological significance of these principles in 1678, I shall take advantage of an opportunity afforded by Fichant's edition and add some comments on the manner in which for instance Leibniz put the principle of equivalence between full cause and entire effect to use at this initial stage. This principle is presented as the chief means of organizing the analysis of the various phenomenal cases. For instance, in *Scheda* 7, just before the *reformatio* takes place, it is called upon to integrate all (tentative) analyses analogous to those already presented. Indeed, as Leibniz underlines in a *post reformationem* note, the continuous progression in laws which the new architectonic principle suggests will need to involve a revision of the graphic curves representing the various cases. In particular, non-rectilinear progressions shall obtain in a certain number of cases; and such progressions may comprise hyperbolic inflections as a result of substituting mv^2 for mv in measuring the conserved force. Indeed, the presentation of the principle reminds one of the *De arcanis motus* (1676), edited by Heinz-Jürgen Hess [in *Leibniz à Paris (1671- 1676), Studia Leibnitiana, Supplementa* 17, Wiesbaden: F. Steiner, 1978, p. 202-205], but it is analytically more sophisticated now because of the formal assimilation of cause and effect as successive steps in a continuous series. The principle of causality thus described is subsumed under the principle of continuity: the identity of a serial law underlies the mechanical changes and renders them intelligible as if issuing from some hypothetical necessity. This means that the formal structure of a cause should be determined to the least assignable difference in order to account for the formal structure of the effect. Leibniz draws an example from the present state of the world which differs as little as possible from its preceding state. Another example is that of the isosceles triangle ABC transforming into the square BDCE which differs from the initial figure by the least possible quantity (by maintaining equal surfaces). Also, the preceding state of a machine will produce the next state by a mere change of *situs* of the forces defining the power it is endowed with: from one state to the next, the progression consists in the unfolding of structures that may prove equivalent through the changes of *situs*. As formulated, the principle stresses the assimilation of formal structures between causes and effects through a transition to the limit:

> L'effet entier est seulement un certain changement de la cause pleine, et en fait le moindre qui puisse se produire. [...] Du moins l'effet et la cause ne diffèrent que sous une particularité de forme, mais conviennent dans l'ensemble. [...] L'effet entier procède de la cause pleine, et le concept de l'effet procède du concept de la cause, en tant qu'elle enveloppe aussi la nécessité d'un changement. Or le changement s'entend toujours comme le moindre possible. (*Scheda* 7: Fichant's translation, p. 292-293)

The latter part of the statement is presented as a corollary of the former. One needs to conceive of a sufficient reason for modifying the power or force behind mechanical processes. But clearly this is the formal element *par excellence* which cannot be assimilated to a change of *situs*, and hence of motion. Instead, this element must stay constant beyond those mutations affecting the *situs* of bodies. Once more, the generative law of a series may provide a model: according to this pattern, each causal element would show up as an adequate expression of the law and in addition announce the next state by infinitely progressive variation. Indeed, the full cause which the law expresses must be ultimately refered to an entity distinct from phenomenal bodies. But, in 1678, this reference is still conceived according to a form of "occasionalism" that makes divine will the one true cause. Evidently, the prevalent representation concerning secondary causes is that of parameters in serial equations signifying systems of bodies, that is "machines"; and, by extension, the entire physical world must be applied this type of model. So Leibniz confirms:

> D'où: l'*effet entier est équipollent à la cause pleine* ou a même puissance. C'est un corollaire de la proposition précédente, parce qu'il ne peut y avoir nulle nécessité de changer la puissance, même s'il y a nécessité de changer sa situation. Remarque: en toute rigueur métaphysique l'état précédent du Monde ou d'une autre Machine n'est pas la cause du suivant, mais Dieu est cette cause, quoique l'état précédent soit un indice certain de ce que l'état suivant va suivre. Mais nous parlons ici de physique, et aucune erreur n'en peut résulter, du fait même que l'indice est certain. La quantité des forces demeure toujours la même dans une même Machine ou dans l'agrégat d'un nombre quelconque de corps disposés en action ou passion réciproques. Car tout corps externe est exclu ou du moins n'est pas pris en considération. Il y a toujours la même quantité de forces dans le Monde, parce que le Monde tout entier est une unique Machine. Donc la quantité de mouvement est toujours la même dans le Monde. [*After reformation comment*:] Doute s'il s'agit de la quantité de mouvement, vrai s'il s'agit de la quantité de forces. (p. 293)

This notion of a closed order expressing itself in causal sequences patterned along a serial generation of states is what the concept of *natura irresistibilis* corresponds to after reformation. By this, Leibniz means the correspondence between the laws of directive translation of the common center of gravity and of conservation of relative speeds on the one hand, and the principle of conservation of force as measured by the quantity of effect on the other. The necessity of a formal correspondence lies at the background of causal analysis as it shapes up according to algebraic intelligibility, that is by combination of equations. In the same fashion, in *Scheda* 9, Leibniz will reinterpret Huygens's boat model as comprising a combinatorial nexus of equations about relative motions before and after impact: in a way, this reflects the rule of serial connexion and equipotency between integral causes and effects from the standpoint of the change of *situs* involved (expressed for instance in the theorem of conservation of relative speeds). Similarly, what will become the principle of conservation of quantity of progress, should be interpreted as the symbolic expression of a combinative order entailing constant directive translation for the system's common center of gravity, insofar as the system obeys the principle of causal equivalence. Thus an architectonic link is called upon to rule over the framing of models to represent the order of phenomena. This shows up for instance in *Scheda* 10 when Leibniz asserts:

> L'axiome "la nature tout entière est irrésistible" (*Naturam totam esse irresistibilem*) fait à la fois que les forces restent les mêmes, et que la direction du centre de gravité reste la même. En posant seuls en effet deux ou plusieurs des corps dont il s'agit, et en faisant abstraction de l'action des autres sur eux, ils constituent une nature entière ou comme un Monde séparé. Or cette machine totale retient toutes ses forces, parce que rien ne les diminue, et retient aussi sa direction totale, dans la mesure où toutes choses ont la même direction en tout. (p. 333)

This technique of combinative expression makes it possible to distinguish between *vis ascendendi*, which means such power as consumes itself in the effect, and *vis agendi in se invicem, seu sese propellendi*, that is a force of impulse proper which forms the residue of *vis ascendendi* when the increase in speed is reabsorbed in the initial instantaneous effect. In reverse order, this prefigures the doctrine according to which elementary *conatus* are integrated in an *impetus* that builds up progressively and generates such effects as may serve to express the subjacent *vis viva*. But the 1678 analysis merely touches upon this generative process. Leibniz is content with postulating a formal conciliation between the various conservation principles so that the equations they translate into may be taken to accord with each other. To a certain extent, this entices us into considering whether the *De corporum concursu* reveals the formal skeleton of the future dynamics. However, the exact theoretical significance of the *potentia* or *vis* that gets thus measured by mv^2 is yet to be unveiled. Also, in the process launched by this revised computation, a metaphysical "reformation" will take place—one which shall deal with the nature of substances and the order of nature. From this perspective, the *De corporum corporum* and associated manuscripts tell a new story of origins for a major part of Leibnizian science and philosophy. The rediscovery of these pieces will probably remain as one of the landmark events in contemporary studies.

It is worth stressing in conclusion that Fichant has achieved an editorial feat in transcribing the complex Latin original and symbolic apparatus of the *De corporum concursu* and in providing an elegant French translation of large portions of the text as well as detailed analyses of the various *Schedae*. These pieces of analysis provide an indispensable Ariadnean thread for understanding and interpreting the epistemological complexities of one of the most difficult Leibnizian texts. In the same vein, two Appendices comprise further manuscript pieces from the *Leibniz Archiv* and analytical commentaries concerning the preparation of *De corporum concursu* as well as Leibniz's immediate attempts at exploiting the elements of his reformed mechanics. In any event, there is not much room for criticism of Michel Fichant's remarkably accurate work on the principal missing link in the history of Leibnizian dynamics. Personally, I acknowledge that his reconstitution of the *De corporum concursu* was a necessary condition for my own endeavor at reinterpreting the structure and evolution of Leibniz's theories about force (cf. F. Duchesneau, *La dynamique de Leibniz*, Paris: Librairie philosophique J.Vrin, 1994). At the time I was working on that subject, he provided me with a preliminary version of the text he had so carefully transcribed. Since then, I have found out with pleasure that there is considerable agreement—some kind of harmony—between our respective accounts (his more topical and detailed, mine more general and analytic) of Leibniz's *De corporum concursu*—this tentative masterpiece in which contemporary eyes may witness a "logic of error" yield to a "logic of truth".

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