Introduction

One cannot deny the significance of the contributions that Gottfried Wilhelm Leibniz (1646–1716) made to science in his day. Nor can one deny their impact on posterity. Even in an era dominated by Newtonianism, the discovery of infinitesimal calculus and the invention of dynamics, to give two examples, certainly could not have been overlooked. The influence of Leibnizian science was profoundly felt throughout the 18th and 19th centuries, even when Newton's model reigned supreme. Following a complete overhaul of physics in the beginning of the 20th century and the gradual displacement of the Newtonian model, Leibniz appeared more and more as someone offering an original and, in many ways, relevant conception of the scientific method, as someone whose scientific theories had played a major role in the history of science.

Contemporary scholars have indeed worked on reconciling certain, more recent theses with earlier formulations that can be traced back to Leibniz, a precursor of the Enlightenment. As such, they have drawn diachronic comparisons on themes like relativist analyses of motion, the rational ideality found within the foundations of the cosmological categories of time and space, the need for a concept of force for theorizing energy and field effects, and the role of principles of conservation in deciding upon explanatory models. All of these themes might serve as subjects of analysis and comparison, so long as we avoid the risks of altering their contents or introducing anachronisms. All of these also possess references and convergent meanings that today's science shares with Leibniz's, which clearly distinguished itself in its time from the argumentative style and the theses developed by Newton and the Newtonians. Herbert Breger rightly points out that the reasons why scientific Leibnizianism ceded its place to Newtonian physics are the very same ones that have, in our time, renewed interest in Leibniz's approach to science.[1] The theoretical Newtonian model would present itself as a strictly mathematical system, "deduced from phenomena" and designed to account for a vast host of empirical problems. By contrast, Leibniz endeavoured to study the "metaphysical" foundations of physics, and thereby the development of principles of explanation and analysis that would allow for approaching empirical problems in

1 "Symmetry in Leibnizian Physics," in Breger (2016), 13–27.

a way consistent with the demands of theoretical sufficient reasons. This explanatory approach relies on architectonic principles and hypothetical-deductive inferences for analyzing phenomena. Such is the specific content of the Leibnizian style, which not only demonstrates its relationship with contemporary methodology, but also underscores the historical uniqueness of its concepts, theories and models for representing phenomena.

Ultimately, the recent interest of scientists and philosophers in Leibniz's work seems to be epistemological in nature more than anything else. The way in which Leibnizian theories are modeled is intriguing and can offer insight into fundamentals of the philosophy of science such as the formulation of models for analyzing phenomena, the demands of causal explanation, the relativity of concepts of sufficient reason that represent the empirical world, and the invention and justification of theories in conformity with architectonic principles.

We have elected to focus here on the origins and structure of the most elaborate theoretical body in Leibniz's science, the dynamics. Leibniz himself planed for the dynamics to become the heart of his physics. The dynamics unfolds against a historical backdrop. Its starting point is a particular theory of the combination of motions placed within the framework of a mechanistically conceived natural philosophy. Even before his stay in Paris (1672–1676), Leibniz had elaborated an abstract mechanics in the *Theoria motus abstracti* (1671), whose counterpart in the *Hypothesis physica nova* (1671) consisted of a hypothetical physical theory involving material structures, which were themselves the products of combinations of motions. Faced with the inconsistency of this first synthesis, Leibniz must then take into account the empirical laws of impact as established, from 1668 on, by Huygens, Wallis, Wren and Mariotte. At the end of his stay in Paris, he sets out to reconcile these laws as well as the theorems concerning percussive forces with the help of the principle of conservation of quantity of motion for which Descartes had provided the formula in 1644. Following a remarkable demonstration of combinatorial analysis and with the help of *sui generis* methodological rules, Leibniz thus succeeds in formulating a new principle of conservation. As the work of Michel Fichant has taught us,[2] this systematic reform occurs at the beginning of 1678. But public announcements of the discovery do not emerge until 1686 with the publication of the *Brevis demonstratio erroris memorabilis Cartesii*. A host of arguments and texts, some published and others not, will provide the foundations of a complicated theoretical structure for this new science that will soon blossom. The *Dynamica de potentia* (1689–1690), the *Specimen dynamicum* (1695), and the later *Essay de dynamique* (c. 1700) represent significant steps of this process. Some famous controversies and correspondences on the demonstrative arguments of the theory, particularly on the so-called *a priori* approach, yield a complex and disparate body of work, across which

2 Fichant (1990); Fichant, Introduction, in Leibniz (1994), 9–65.

one of the major discoveries of modern science takes shape. Focusing on these significant texts, and with a view to the series of arguments that they contain, our objective will be to analyze the methodological procedures and methods of theorization at work in what constitutes Leibniz's dynamics.

Certain difficulties beset this type of research. As a whole, the scientific work of Leibniz has suffered from several partial interpretations or distortions. The works that the librarian of Hanover published during his lifetime only represented a small part of his corpus; these often included allusive texts that only indirectly reflected the magnitude of fully completed analyses. The publication of manuscripts has been spaced out up until our own time and still continues; hence, all accounts, including those of the recent past, were doomed to produce some necessarily truncated picture of a multifaceted subject. Responding to this problem, Michel Fichant worked for several years to reconstruct the text of the *De corporum concursu* (1678) and provide us with an edition (Leibniz 1994). This very important draft contains the birth of the reformed mechanics; it reveals how Leibniz perceived the necessity of reforming Cartesian mechanics and substituting the principle of conservation of quantity of motion (measured by the product mv) with a new principle of conservation that would account for living force (measured by the product mv^2). Leibniz implements this reform with the help of methodological and epistemological tools that none of the great interpreters of his work before Fichant had identified as reaching this stage of development. Such a lacuna proves significant. However, in the majority of cases, the difficulty of constructing a representation of Leibniz's science reveals itself in a more subtle way. The texts are numerous, often fragmented, and sometimes divergent, addressing diverse questions. The *sui generis* coherence of the whole tends to escape us. It is easy, if not inevitable, to stray from a sufficiently faithful analysis for an arbitrary reconstruction of a larger than life Leibnizian model.

Several important works have directly contributed to establishing a more adequate vision of Leibniz's science and the philosophy of science that accompanies and underpins it. But this is above all true for studies focusing on the contributions of Leibniz to the formal sciences, such as the analyses of Couturat, Kauppi, Ishiguro, Burkhardt, several others on the logic, and the analyses of Hofmann, Belaval, Knobloch, Serfati, and their present successors on Leibniz's mathematics.[3]

Leibniz's epistemology of the natural sciences is a different story, notably with regard to the mechanics. Indeed, numerous commentators have taken an interest in this sort of research on Leibniz, but in our view, only one remarkable work on the dynamics proper had been published, Martial Gueroult's *Leibniz. Dynamique et métaphysique* (Gueroult 1967; first edition: 1934). Gueroult placed the neo-Kantian and positivist interpreters of Leibniz's science back to back. He established the particular coherence

3 All these works are cited in the bibliography.

of a scientific approach that aimed to construct a sufficient and autonomous representation of the phenomenal order by combining inductive and deductive methods; he showed at the same time how this explanatory construction justified itself within the metaphysical context that defines the monadological system, and how it required theoretical foundations more profound than the laws governing the interaction of phenomena. The picture that Gueroult paints is remarkable for a host of reasons, and far surpasses in depth and scope all of the partial reconstructions of the dynamics with which interpreters had busied themselves.

We must however push back against the master on certain points. Gueroult approaches all of the Leibnizian texts known to him as if they ought to form so to speak a coherent, atemporal whole. But the changes that Leibniz's work underwent are significant and must necessarily be taken into account. The lack of appreciation for the evolutive character of Leibniz's scientific thinking is apparent, first, in the absence of any reference to the methodological styles that were successively developed in the texts that prepared the way for, and then dedicated themselves to the dynamics. Indeed, Gueroult never identified the seminal text of the reform, *De corporum concursu*; but more generally, all of the Leibnizian methodology lay hidden in the shadow of this brilliant analysis of the normative structure of the dynamics. From this approach there followed a categorial denunciation of the so-called *a priori* method for demonstrating the principles of conservation of living force and formal action, and by contrast, an equally categorical prioritization of the so-called *a posteriori* method. In this regard, it seemed that Gueroult understated the complexity of the theoretical constructions and relied on the surreptitious resurgence of a model dominated by the Newtonian paradigm. Comprising knowledge procedures capable of founding and justifying dynamics as a science, it was still a Kantian epistemological model that served as a point of reference and allowed the originality of the Leibnizian position to be inferred. Finally, it was difficult to imagine, beyond the limits of the dynamics, how Leibniz could have conceived of the structure of a science of complex phenomena. The reconstituted coherence of Leibniz's mechanical system obscured in a sense the broad spectrum of possible theoretical models, which owed to the degree of complexity of the phenomena being considered. If Gueroult gave expression to the "metaphysical form" of the dynamics, he sidestepped every analysis of the methodological profile of Leibniz's science. In conformity with a post-Kantian tendency, the conception of the system took precedence over the conception of the method when it came to framing the argumentative structure of Leibniz's physics.

By contrast, a number of more recent studies on Leibniz's science outline the first steps of an approach similar to the one that we intend to adopt.[4] These studies will

4 Cf. Bouquiaux (1994); Fichant (1998); Garber (2009); Tho (2017); Arthur (2018); Garber and Tho (2018).

buttress the establishment of a framework of analysis that we regard as more suitable for representing the epistemological interpretation of Leibniz's science. We shall therefore not inscribe *Prolem sine matre creatam* upon the frontispiece of this work, as Montesquieu did for his *L'Esprit des Lois*. In the contemporary context of the history and philosophy of science, we may content ourselves with being well-informed, critical successors, apt to explore some new avenue of research that might prove original and promising. Our means are no doubt furnished by the riches accumulated by our predecessors, distant and close. Such a debt merits recognition.

In another work on *Leibniz et la méthode de la science*,[5] I drew from the analysis of the dynamics to bring to light some more general perspectives relating to Leibnizian science as a whole. I focused on the programmatic aspects of Leibniz's conception of science, and examined the methodological considerations that it furnished philosophical analysis. I therefore addressed epistemological topics such as the creation of an innovative methodology that proves to be not only combinatorial and analytic in nature but also rational and empirical, the relationship between the various categories of truth, the fundamental and complex role of conditionally necessary truths, the structure and function of scientific hypotheses the model for which is both analytic and heuristic, and finally, the specific role assigned to architectonic principles, namely finality, the identity of indiscernibles, and continuity.

One cannot however deny that the invention of the dynamics dictates all reflection on the scientific methodology of Leibniz. The true method develops over the course of his scientific labors, and reveals itself through the demands of the science's development. This is true of the Leibnizian method both in terms of its evolution and its content. Our plan here is therefore to locate the genesis of the dynamics as science, and to retrace the main steps of the argumentative structure that emerges and unfolds across Leibniz's works. The chapters that we shall devote to this scientific project include the genesis of the reformed mechanics, the structure of the theoretical corpus of the dynamics, and the meaning that we must attribute to one of the most problematic methodological aspects of such a construction, the *a priori* analytic model.

5 Duchesneau (1993); Duchesneau (2022).