PAPER • **OPEN ACCESS**

Émilie du Châtelet's Institutions de Physique: a Leibnizian-Newtonian Synthesis? A methodological approach

To cite this article: Anne-Lise Rey 2024 *J. Phys.: Conf. Ser.* **2877** 012014

Journal of Physics: Conference Series **2877** (2024) 012014 doi:10.1088/1742-6596/2877/1/012014

Émilie du Châtelet's Institutions de Physique: a Leibnizian-Newtonian Synthesis? A methodological approach

Anne-Lise Rey

Institut de recherches philosophiques, Université Paris Nanterre, 200 avenue de la République, 92001 Nanterre Cedex, France

Abstract. This paper seeks to show how historiographical categories that place philosophies within schools of thought entail accepting a high theoretical cost: the category circumscribes a general framework for interpretation, but at the same time conceals what makes a particular thought unique and sometimes original. If they are only Leibnizian or Newtonian, why give them a place in the corpus? In order to establish the limits and challenges of this categorisation, this paper coins the category of 'Leibnizo-Newtonianism', not in order to identify a paradoxical school of thought, but rather to question this reading of the history of philosophy. On the other hand, it proposes to use the analysis of epistemological practices (the relationship between hypothesis and experience, the status of principle etc.) to identify the problem Émilie du Châtelet set out to answer: how can one establish the certainty of our knowledge of nature?

1. Introduction

Voltaire in his *Lettres philosophiques* of 1734 and Jean le Rond d'Alembert in his *Discours préliminaire* were agreed in acknowledging that the French "conversion to Newtonianism" coincided with the advent of the Enlightenment [1]. However, for us, this conversion has to contend with another: the conversion of Émilie du Châtelet - today well known as the translator of Isaac Newton's *Principia* - to the Leibnizian principle of conservation of vital forces. It is also to another interpretation of the Enlightenment that this paper wishes to contribute: the interpretation which sees a specific articulation between some aspects of Leibniz and others of Newton as part of a widespread attitude in the century of Enlightenment.

The idea that the priority dispute over the infinitesimal calculus as well as the debate about the nature of space and time in the correspondence between Gottfried Leibniz and Samuel Clarke [2] (1715-1716) quickly established the conviction that there is a deep contradiction between Leibniz's natural philosophy, whose physics is supposed to be based on metaphysics, and modern science, as embodied by Newton who "does not imagine hypotheses," so profound that this antinomy between conjectural and experimental approaches has even been seen as two incommensurable scientific methods.

The understanding of the different natural philosophy options of this period that this paper proposes to construct here, using the category of "Leibnizo-Newtonianism", seems to be a fruitful way of offering from a new perspective a different interpretative hypothesis regarding the epistemologies of the 18th century. This paper aims to show that many scientists in the 18th century articulated some aspects of the Leibnizian and the Newtonian natural philosophies, but this articulation was sometimes hidden or became invisible because of the historiographical opposition of paradigms.

Several commentators have pointed out the existence of certain elements of Newton's thoughts and some elements of the natural philosophy of Leibniz in the natural philosophy of many scientists in the 18th century, and Émilie du Châtelet is a very good candidate for that. The first of these was Carolyn

Merchant in her paper *The Leibnizian-Newtonian Debates: Natural Philosophy and Social Psychology* [3].

But what this paper aims to highlight is quite different. It would like to show not only, or rather not mainly, that there were some additions of Leibnizian elements and Newtonian elements in some texts of natural philosophy in the eighteenth century, but mostly that there was an elaboration of a new philosophical territory which allowed the creation of new epistemological conceptions and not simply additions. It shows that reading in terms of schools of thought is not enough to account for the major texts of this period. To better describe this complex historical reality, one must therefore resort to the transversal category of Leibnizo-Newtonianism, not as if it were an additional school, but to use it as an indicator to emphasise that certain individual positions composed, in a singular way each time, features derived from one or other doctrine. This composition is not a simple juxtaposition: each time it is the individual's own scientific and philosophical itinerary that determined its content. This category therefore has a heuristic function first and foremost: to show that alongside an interpretation in terms of historical filiation it is possible to identify epistemological practices, regimes of certainty and reconfigurations of the field of knowledge that are often constituted in this distance from schools of thought.

In this way this paper will re-evaluate the relationship between these two schools of thought by showing how they were continually linked in the work of a large number of 18th century scholars.

Let us mention Sarah Hutton's paper *Between Newton and Leibniz: Émilie du Châtelet and Samuel Clarke*:

"*Nevertheless, her subscription to both Newton and Leibniz remains problematic from a modern perspective, especially in view of the way Newton and Leibniz are nowadays treated as leading representatives of the empiricist-rationalist schools, and therefore of rival British and German philosophical traditions. […] Since Émilie du Châtelet's Institutions de Physique, assumes compatibility between Newtonian theories and Leibnizian metaphysics, it is reasonable to expect that her view of this controversy [the Leibniz-Clarke dispute] should hold clues about her understanding of the relationship of Leibniz's philosophy to Newton's.*"

This approach will allow a new perspective on how modern science was constituted, based on two major re-assessments: 1) replacing the empiricist credo means incarnating modernity in science by taking into consideration the importance of the forms of articulation of conjecture and experience in sketching out a new epistemology; and 2) conceiving the reflection concerning the degrees of certainty that one could obtain in our knowledge of nature and their relationships with probability without the idea that they should be considered in terms of their subordination to mathematical evidence or of the application of mathematical evidence to them, but for themselves.

To do that, this paper identifies a kind of "epistemological inventivity", which is built explicitly against an explanation of thoughts in terms of "filiations".

Particularly, its conviction is that a thought is rarely well interpreted, or at least, not completely interpreted, if one decides to identify the main influence of one author to determine in which historiographical category it is more appropriate to rank it. If the identification of a thought, in terms of belonging to a historiographical class, is quite interesting, this paper then analyses the interpretation of epistemological practices.

That is why it prefers to propose the category of "epistemological inventivity": it is not a negation of the historical influences, it is rather another interpretation of them. Beside the orthodoxy of a doctrine which interprets the other interpretative ways as ignorance or a misunderstanding, or worst: a "woman philosophy", "une philosophie pour les dames", it is also possible to interpret these other ways, distinct from the orthodoxical ones, as a positive discrepancy. By epistemological inventivity is meant the idea of the construction of a specific epistemological field and questioning. And the conviction is that inventivity is easier to emphasise if it is understood as a consequence of a Leibnizo-Newtonianism.

This attitude satisfies an identifiable epistemic need: to provide theoretical consistency to certainty in physics.

Émilie du Châtelet's personal and intellectual journey is well known, so let this simply be summed

up in brief: her time in Paris covered the literary circle begun by her father in their 'hôtel particulier', where she spoke science with Bernard Le Bovier de Fontenelle and Voltaire, it also includes her first "lessons" in Newtonianism, delivered by Pierre Louis Maupertuis and then Alexis Claude Clairaut. From 1735 on, settled in Cirey with Voltaire, who had already published his *Lettres philosophiques*, she wrote her first scientific works and did experiments with Voltaire on the propagation of fire, which would lead to the clandestine composition of her *Dissertation on the nature and propagation of fire* in response to the competition launched by the Académie Royale des Sciences in 1737.Leonhard Euler may have won the prize, but both Voltaire's (who had also submitted) and Émilie du Châtelet's papers were published by the Académie. It was the first time for this sign of recognition and distinction to be bestowed upon a woman. Émilie du Châtelet had now, thanks to this distinction, won herself a place in the community of savants. It was in this context that Émilie du Châtelet wrote and then anonymously published the *Institutions de Physique* and then set about translating Newton's *Principia*.

Du Châtelet's initial hostility towards Leibniz's principle of conservation, before the composition of the *Institutions de Physique*, is widely known. The steps of her "conversion," often recounted [4], nevertheless merit a mention here: an initial phase of learning during which, following the example of Maupertuis and Voltaire, she declared herself hostile to the principle, then remorse over a passage of "*slight insipidness*" in her *Dissertation sur la nature et la propagation du feu* [5] (in which she mentioned her disagreement with said principle) and the vigour with which she put herself to having Maupertuis remove the offending passage from her text [6]. This remorse more or less coincided with Voltaire's return from Holland in 1737. During his exile, he had first-hand experience of the experiments conducted by the Dutch savants of Leiden. So Du Châtelet seems to have been "converted" by the Newtonians themselves (Voltaire the first amongst them, primarily through 's Gravesande and the Musschenbroek brothers [7], but also through Maupertuis, whose close ties with the Bernouilli encouraged him towards greater sympathy for the Leibnizian principle of conservation, as attested by the letters he exchanged with Du Châtelet from 1738 onwards [8]). From this moment on, the conversion to Leibniz's principle of conservation was in effect, something that is confirmed by her correspondence with Maupertuis during the year 1738. The final step was her public defence of the principle contained in the last chapter of the *Institutions de physique*. However, Du Châtelet most likely wrote this chapter after Samuel König's arrival at Cirey; he testified to a level of adhesion to Leibnizianism which is revealed in the fields of both metaphysical principles and dynamics.

So the question that arises is whether the Marquise, in her *Institutions*, restricted herself to defending a principle of conservation, or whether by marrying that defence to a presentation of an "abbreviated Leibnizian metaphysics" she wasn't also led, more or less implicitly, to taking on the consequences of that adhesion in Leibnizian terms, that is to say, both the metaphysical implications *and* a new idea of science. The answer to this question is complicated by the fact that this abbreviated Leibnizian metaphysics is actually in many respects a presentation of Christian Wolff's philosophy, [9] which differed in more than a few and most importantly in *decisive* respects from Leibniz's thought. The importance accorded to Newtonian physics, borne out in the very structure of the *Institutions*, only deepened the complexity of the response. This is where König's role must be made clear: if, thanks to the comparison undertaken by Linda Gardiner Janik between published and handwritten text, it is possible to distinguish the pre-König stratus of the text from the input resulting from his presence at Cirey, then it is also possible to distinguish two levels of Leibnizianism in Du Châtelet's text. One of these issues from the natural evolution of her intellectual maturation, the other, the result of König's "lessons"[1], reinforces the first, informing it.

Bringing the Marquise's Leibnizianism to light, that is, the interpretation of Leibniz's thought that she proposed, correlatively supposed placing this theoretical position within the context of the debate

[1]Linda Gardiner Janik, in [9], clearly shows how a reading of the manuscripts reveals the presence of the following formulas in the margins of certain passages: “à expliquer”, “fiat lux”, “cela est-il bien?”, “ceci n’est pas le mot”, “un autre mot” etc.

over *vis viva*.

Indeed, along with other studies, what the now classic work *La signification d'un débat sur trente ans: la question des forces vives* [10] by Pierre Costabel reveals is the different levels the debate was engaged upon, depending on the thinkers who were treating it. The interpretative prism Père Costabel adopts in accounting for these divergences can be summed up in two points. Firstly, in the debate which opposes the two principles of conservation (conservation of quantity of motion and conservation of quantity of force), the division relates to the meaning given to the term "force."[2] Secondly, within that partition itself, he sees two attitudes: one which ratifies the philosophical significance of choosing between the two principles, the other which claims to deny it but which, in doing so, overlooks the underlying philosophical position implicitly adopted in the choice of one or the other principles of conservation. In other words, what Costabel highlights is the illusion (to which, for example, Jean Bernouilli as well as J.J. Dortous de Mairan yielded) of being able to undertake a strictly mathematical approach to the question of *vis viva*. In this way, Costabel is able to underline the nascent (and expanding) desire, specific to certain early 18th century savants, to dissociate science and philosophy or better yet to practice a science freed from philosophy, while at the same time underlining the impossibility of that dissociation.[3]

2. Hypotheses and experiments

One of the Du Châtelet's slogans gives an indication of the status she accorded to metaphysics: there is no physics, not even experimental, without a metaphysics to ground it. Thus, she did make a reinforcement of it but, at the same time, she indicated in this famous sentence from §183[4] [that]

"*even though it is very important in metaphysics to know that there cannot be physical atoms and that every extension is ultimately composed of simple things, yet these questions have only the most distant influence within experimental Physics, so that the Physicist can ignore the various sentiments of Philosophers on the elements of matter, without it resulting in the slightest error in his experiments and in his explanations, and this because we will never reach the simple things, nor the atoms*."

How should this passage be interpreted: does it advocate an independence or an interdependence? All the while affirming the importance to be granted to a modern, if not to say Newtonian, physics, stripped of its metaphysical raiments, the Marquise held onto the Cartesian schema of a metaphysical foundation to physics. However, she was sometimes hesitant to radically dissociate the two fields (physics and metaphysics), considering them in a sense as operating in heterogeneous domains. This attests to a swinging between two attitudes: the attempt at emancipating science with regard to metaphysics, fed by Voltaire's remarks on the impossibility of arriving at the ultimate elements of matter, and on the other side, the urge to propose a coherent apparatus in which the order of the physical world is guaranteed by the principle of sufficient reason. Nevertheless, carefully reading chapter XXI, which at first glance appears to be dedicated to proving by experiment the principle of conservation of vital forces, it seems that it is in fact the second attitude which wins out.

In[5] chapter IV of the *Institutions de physique*, Émilie du Châtelet proposed defining 'hypothesis', understood as "*a supposition which accounts for a phenomenon*" (§69), by relating her conception of

---

[2] Costabel has developed this point by clarifying what is at stake in the meaning of force in [11].

[3] For example, regarding Jean Bernoulli's "illusory attempt" to deal with the question of living forces as a mathematician and not as a philosopher, Costabel writes: "*this mathematician thought it possible to work out a measure of force stripped of all discussion of language and philosophical reflection by introducing a standard, the closing of a given standard spring. This seemed to him to be concrete, experimental, 'direct', whereas on the one hand it's just a thought experiment, and on the other hand the basic axiom remains incomplete if we don't specify [what] we call force...*".

[4] See also [12].

[5] cf. [13].

hypothesis to the determination of certainty that it entails:

"*Hypotheses are thus but probable propositions which have a greater or lesser degree of certainty, according to whether they satisfy a greater or lesser number of circumstances accompanying the phenomenon we wish them to explain, and since a very great degree of probability has led to our assent, and produced in us almost the same effect as certainty, hypotheses in the end become truths when their probability increases to such a point that we can morally present it as a certainty, and this is what happened with Copernicus' system of the world and with M. Huygens' system concerning Saturn's ring*."[6]

The importance of this extract is that it enables the path which carries hypothesis from supposition to truth to be determined. And, definitively speaking, the whole task Du Châtelet undertook in this chapter is both to point out unwarranted inductions made from hypothesis to truth and correlatively, to show the correct path they should follow in order for them to be legitimate. Thus, as the preface indicated, it would be absurd to ban hypotheses from physics, since one cannot know with certainty what the causes of motion in nature are.[7]

"*However, only one capable of assigning and demonstrating the causes of everything that can be seen would be allowed to entirely banish hypotheses from physics, but for the rest of us, who do not seem constituted for such knowledge, and who often can arrive at truth only by crawling from plausibility to plausibility, it is not for us to so boldly declare ourselves against hypotheses*."

On the other hand, one has to be sure *not* to understand them as truths: they are the "scaffolding" of a house under construction: physical science. Use of hypothesis is thus considered legitimate when it permits the explanation of phenomena whose cause reveals itself to be inaccessible to either experiment or demonstration. So hypothesis is considered as the starting point, sometimes risky, but always necessary, of important discoveries. These hypotheses give rise to experiments which can confirm the hypothesis provided that it enables an explanation of the phenomenon in question. In the remainder of the chapter, Du Châtelet detailed the rules to follow in order to avoid poor usage of hypotheses: the first among these being, of course, the fact that it not be in contradiction with the principle of sufficient reason[8] (§61). Consequently, Émilie du Châtelet set herself to reflecting on the relationship between the correct use of hypotheses and recourse to experiments, indicating alternately that

"*a single experiment is not sufficient for the admission of a hypothesis, yet just one is enough for its rejection, should it contradict it.*"[9]

and again:

"*a hypothesis may be true in one of its parts and false in another: in such a case, the part which is found to be in contradiction with the experiment must be corrected*."[10]

What is found, then, is a veritable guide to the proper use of hypotheses, one that could bring to mind certain contemporary epistemological considerations on critical experiment.

---

[6] cf. Ch. IV, §67, p 91. One will simply be note here the theme of irresistible assent leading to certainty, which cleverly combines Cartesian criteria of certainty with the Marquise's conception of hypothesis.
[7] cf. Ch. IV §55.
[8] As F. Duchesneau shows in [14]: "*On the one hand, hypotheses are anticipations of sufficient reasons that escape any attempt at direct analytical deployment. On the other hand, by establishing an analytical explicitation of hypotheses under cover of admissible presuppositions, such as the principle of continuity, we can show that a given hypothesis has the power to express and systematize the variety of empirical relations. This "geometrization of empirical knowledge confers their rational status on hypothetical truths*."
[9] cf. §64.
[10] cf. §65.

And one may arrive at a better understanding of the status attributed to hypotheses by mentioning a personal note to be found in Cahier 36, entitled *Brouillons et commentaires avec du papier pour en faciliter l'intelligence* ("*Rough notes and comments on paper, to facilitate understanding"):*

"*no perceptible resistance evidenced by the phenomena, a priori no void in evidence, by remaining reason there must then be a way of using matter that we do not know of and which removes its perceptible resistance, or else there may be matter without perceptible resistance, personal reflection, because a well observed experiment and a priori reasoning cannot contradict each other*."

It is noted that this is a comment on a book by François Jacquier. There should not be any contradiction between experiment and a priori reasoning.

This altogether classic presentation of how to use hypotheses has the principal twofold particularity of reminding us that Newton is less hostile to hypotheses than his disciples, and that a well-reasoned use of hypotheses (one that does not see natural philosophies which take that path as running the (tragic) risk of fiction)[11] supposes the application of non-contradiction towards the principle of sufficient reason as a safeguard. But looking at it more closely, it seems that the Marquise made room for the question of visibility as an instrument for articulating the proper use of hypotheses with recourse to experiments, and this is undoubtedly another distinctive point of her thought.

Although the metaphor of blindness and clairvoyance may be a well-worn approach in accounting for our necessarily partial knowledge of nature, this paper suggests that the Marquise brought new life to it by proposing an interesting variant which mobilised both the optical instrument, the microscope ("*these new eyes that human industriousness has been able to grant us*"[12]), as well as the Leibnizian thematic of a limited perceptive acuity being necessary to guarantee correct assimilation of the harmony of the world.[13] So beginning with the idea that "*Experimentation is the staff that nature has given us, the blind, to advance us in our research*,"[14] the Marquise turns this into an instrument for confirming the principle of indiscernibles: the microscope reveals the differences in what the naked eye sees as alike.[15] But at the same time, Émilie relied on this perceptive limitation, both to justify the progress of

---

[11] cf. ch. IV §55, p 79.

[12] cf. ch.10, §186 p 209.

[13] Thus, to explain the presence of evil in the best of all possible worlds, she resorted to an illuminating analogy (if one may say so), ch.II, §27 p.53: "*The human eye, for example, could not see the smallest parts of an object without losing sight of the whole; we would see a few points, very distinctly, if our eyes were Microscopes, but we would lose sight of the whole. It is therefore necessary for our sight to be less distinct in order to be proportioned to our needs, since the distinction of the smallest parts and the total view of the whole cannot be combined, since it is more useful to us to see the whole object than to distinguish all its points one after the other; thus, it is a chimera to believe that man's eye would have been more perfect, if it had distinguished the smallest parts of things, since on the contrary such a view would have been almost useless to us*."

[14] cf. Foreword p 10. This recognition of our limitations was itself supported by the preceding lines (pp.8-9): "*In physics, we are still like the blind man to whom Cheselden restored sight: it was only by trial and error, and after a considerable time, that he began to see clearly; this time has not yet fully come for us, and perhaps never will; There are probably truths which are not meant to be seen by the eyes of our mind, just as there are objects which the eyes of our body will never perceive, but he who refuses to learn by this consideration would be like a lame man who, having a fever, would not take the remedies which could cure him of it, because these remedies could not prevent him from limping*".

[15] *Institutions de physique*, chapitre I, §12, p.31. "*This infinite diversity that reigns in nature is felt by us as far as the range of our organs can extend. [...] There are other objects which their smallness makes us see as similar, because we see them confusedly, but microscopes discover their differences to us: thus Experiments which even are not necessary to the truth of this principle still confirm it.*" (emphasis added), cf. also §173 and 177.

our understanding ("*as the World ages, so do men push their discoveries ever further, and ever clearer do we find that the fabric of the World and the least of its parts is marked with a design*"[16]) and also to explain that the confusion into which one falls by taking phenomena for reality is not so much based on this perceptive drawback as it is on the difficulty in distinguishing the image born in us from the actual reality of things. This distinction is thus characterised as the condition for "*penetrating down to the origin of Phenomena.*"[17] By proceeding in this way, Du Châtelet turned our limited perception into an instrument at the service of our capacity to discern, precisely because of this very limitation, phenomenal confusion from reality. This limitation is simultaneously understood as a perceptive drawback and also as a condition of or even an access path *to* a discriminated grasp of what is real.[18] Hence, she renewed the Leibnizian lesson of the theory of perception and in doing so, she turned our visual experience into not so much a validating element of a hypothesis as rather a means of installing a mistrust of what is immediately perceived in favour of emphasising a capacity for judgment manifest at the very heart of the experience, something which allows it to be understood for what it is: a simple image of the world which must be read as a mode of access to something *other* than what it is. By understanding through visual experience that phenomena are the expression of the principle active in simple substances, one can access the "*Elements [which] must contain the origin of everything found in the bodies that are composed of them*."[19]

At first glance, this upgrading of hypothesis to necessary starting point in discovery entails all the criteria which enable an option that would be acceptable to Newton (rather than to Newtonians) to be made of it, but it is its regulation under the principle of sufficient reason which constructs a veritable epistemological diversity between Leibniz and Newton.

3. A diverse epistemology: taking up Leibniz's critique of Newtonian attraction

In the Preface, Émilie wrote:

"*It seems to me, moreover, that refusing to admit attraction as a hypothesis would be just as unfair on the part of Cartesians as it is unreasonable for Newtonians to make of it a primitive property of matter*."[20]

Émilie du Châtelet restored Newton's original thought by meticulously distinguishing it from the excesses of the Newtonians. In other words, she articulated the voice of a Newton who was not hostile to hypotheses, just so long as their field of application was contained, and a Newton who did not conceive attraction as a real property of matter. It is within this astute re-utilisation of Newton's thought that it is then possible to construct a common territory between both Leibniz's and Newton's conceptions. In particular, this principle serves to determine the relevance of the Newtonian theses in terms of demonstrative rigor: it is a genuine critical instrument working on Newtonian thought and doing its utmost to distinguish Newton's thought from the excesses of the Newtonians. And this is precisely how the Marquise constructed this common territory.[21]

The presentation of Newtonian attraction Émilie du Châtelet delivered in chapter XVI of the *Institutions* was built around three steps of argument which each have in common the fact of acknowledging the necessity of attraction on the condition that it be conceived of as a phenomenon and not as a cause: "my goal was only to make you see, in general, how the Newtonians claim to explain these phenomena through attraction and what the reasons are that oblige the rejection of this attraction

[16] *Institutions de physique*, chapitre I, §26, p.51.
[17] cf. ch.8, §154 et 155 (pp 179–80).
[18] cf. ch.8 §153, p 178.
[19] cf. ch.8, §156, p 181.
[20] cf. Foreword, p 8.
[21] In a sense, one is close to what S. Hutton proposes [15, pp 77–95].

when it is presented as cause."[22] She began by singling out the contradiction between a conception of attraction as *property of matter*, thus enabling in principle the explanation of all phenomena involving matter (astronomical phenomena, cohesion of bodies, falling bodies, chemical effects, phenomena of light etc.), as well as pointing out how the Newtonians who chose to grant this status to attraction were obliged "*to suppose other laws of attraction".* She then explained this extension of the hypothesis of attraction not only to all astronomical phenomena, but also to the totality of all other phenomena, as a rash interpretation of the questions found at the end of Newton's *Optics*: an interpretation which transformed what it labelled as Newton's doubts into a foundation of hypotheses.[23] Subsequently, as was her wont, she used the principle of sufficient reason to evaluate the status that the hypothesis of attraction must have ("*this principle of sufficient reason, which the first chapter has shown you is impossible to abandon, destroys this enchanted palace built upon attraction*."[24]). She took the example of a body A attracted by a body B, in a vacuum and asked how the reason for the change in A could be explained and above all, where it should be situated, as she found it neither in the body nor outside it. Her conclusion was the impossibility of finding the sufficient reason of this motion.[25] "*It follows from all the foregoing remarks that, since the direction and speed which result from attraction are variables, attraction is not at all a property of matter, because the properties grounded in the essence are, like the latter, necessary, but what is necessary can be possible in one manner only*."[26] Here she was playing on the apparent contradiction between univocity of properties and variability in the direction and speed of bodies in motion. It is thus what is judged to be the unconvincing nature of identifying the hypothesis of attraction as the cause of phenomena (the Marquise would go so far as to say that it is not "*at all an admissible cause*") which led her to reject it as cause.

A final epistemological consideration: the illustration of the argumentative approach used by the Newtonians who employed objections to the hypothesis of vortices as arguments in favour of validating the hypothesis of attraction. By pointing out the logical fault (in §399) it contained the Marquise patiently deconstructed the possibility of limiting conceptions of the explanation of motion at work in nature to the form of mere alternative.

The Marquise used the principle of sufficient reason as a logical Occam's razor by taking Wolff's injunction on board: "*understand the how of what is*." Hence, the principle of sufficient reason, in its Wolffian sense, enabled her to define a new reflexive territory: the logical evaluation of Newtonian arguments.

What consequence can be drawn from this epistemological framework for the conception of certainty of physics?

In §57 of the *Institutions*, Émilie du Châtelet developed a reflexion on certainty, on probability and on their distance from truth. A hypothesis which matches all phenomena possesses a certainty which is "*not far from demonstration*." In §58, she continued to reunite the conditions which make one consider a hypothesis to be "*nearly equivalent to a demonstration*,"[27] the predictive capacity of the hypothesis increases the probability "*to such a point that we cannot refuse it our assent*". Or again, Christiaan Huygens' discovery of Saturn's ring resulted from "*the agreement between the hypothesis and the*

[22] cf. Ch.XVI, §389, 1st edition.
[23] cf. §391, 1st edition: "*it must be admitted that some of these hypotheses are a little forced, and that there is quite a difference in accuracy and precision between the applications of attraction to celestial phenomena and its use in the other effects I have just mentioned; also, this use of attraction is not as universally accepted by the Newtonians themselves as that used to explain astronomical phenomena*."
[24] cf. §395, 1st edition.
[25] Here she takes up the argument of the Reply to Clarke's 4th Ecrit, when Leibniz wrote: "*It is necessary that what is mobile can change its situation in relation to something else, and that a new state discernible from the first can arrive, otherwise the change is a fiction.*" (*GP* VII, 396).
[26] cf. §396, 1st edition.
[27] When she wrote that "*all the consequences we draw from this are consistent with the observations*."

observations" which "*finally turned that supposition into a certainty*." She incited (in §62) the estimation of the degrees of probability in order to avoid confusing the uncertain and the certain, while at the same time seeing what a hypothesis was in need of for it to become a certainty. One would be forgiven for thinking this was paragraph 125 of the *Discursus praeliminaris*! The more a hypothesis explains a large number of phenomena and a large number of details within a phenomenon ("*the circumstances which accompany the phenomenon we seek to explain through them*"), the more the "*degree of probability leads to our assent*" such that hypotheses become truths (§67) and one can "*morally pass them off as a certainty*."
Both quantitatively and qualitatively speaking, the predictive and explicative capacity of a hypothesis provide it with such a high probability that it becomes certain, even true!

4. A certain agreement

The Marquise's *Institutions* inventively proposed a mode of articulation between the conceptions of Leibniz and Newton by constructing a common territory which put aside oppositions of principle, disputes in effect, and especially historiographic constructions of irreducibly opposed schools of thought. *By contrast*, as an attentive reader of Newton (against the Newtonians) and connoisseur of a Leibnizian thought, often reformulated in the terms of a Wolffian philosophy, she elaborated a common space of interrogation on the intelligibility of nature: what functions were to be attributed to experiment and to hypotheses in the defence of a metaphysical hypothesis? And, correlatively, how were these functions to be evaluated through the principle of sufficient reason? It is a Wolffian conception of certainty that she drew out.

Émilie du Châtelet justified the Leibnizian principle of conservation on several levels: first of all, by restoring the experiments usually extracted from the texts of Leibniz's disciples - notably, the invaluable contribution of the *Mémoires de l'Académie de Saint-Pétersbourg*, whether it be Jacob Hermann's, nominally cited, or Johann Bernouilli's, more clearly used, as attested by his correspondence, or still other experiments borrowed from Willelm 's Gravesande in chapter XXI. Through this restoration, she implicitly proposed the establishment of the criteria for conclusive experimentation. She also proposed a varied methodology to serve the demonstration of Leibniz's principle of conservation, a methodology which articulated a twofold demonstrative regime: through experiment *and* through reason. This regime has the particularity of differentiating, in the text of the *Institutions*, a pedagogical logic and a more "savant" logic, borrowing its standards from demonstrative logic. In the end, the inventive synthesis Du Châtelet introduced in the guise of natural philosophy led her to forge a curious compromise between the Leibnizian and Wolffian apprehensions concerning substance. This last point shows that Du Châtelet's natural philosophy can be understood as a defence via Wolffian apparatus of Leibnizian dynamics. There still remains the observation that the Leibnizian idea of science conveyed by dynamics, more so than the dynamics itself, was validated by Du Châtelet.

This paper wished to dissociate Leibniz's thought from Wolff's in order to contest the relevance of there existing a Leibnizo-Wolffian thought, understood as a convergent thought bringing together the common points of the two thinkers' philosophies, an idea which König would have communicated to Émilie du Châtelet during his stay at Cirey. In lieu of a paradox, at the end of this development one could sketch out the idea that what Du Châtelet constructed in the *Institutions de physique*, under the guise of an introduction of Leibnizian thought into France, is in fact a "Leibnizo-Wolffian" thought. On condition of understanding, not just like William Barber imagined it - as an exposition of Wolff's theses presented as Leibniz's thought and using the latter's vocabulary - but rather as a thought, informed by the modern Newtonian science, which finds, within Wolff's philosophy, an urge to articulate Leibnizian theses with a Newtonian methodology. In a word, the Wolffian part of Émilie du Châtelet's thought bears witness, among others, to these attempts at connecting Leibniz's and Newton's ideas[28] which were present during the first half of the 18th century. Through this, the precautions she took to elaborate a use of these hypotheses which Newton could have legitimated, as well as the importance she conferred to experiments for the validation of the Leibnizian principle of conservation, all indicate the outlines of her epistemological practice: to take the agreement between experiment and hypothesis and make of it

the guarantee of the certainty of our knowledge.

References

[1] Shank J B 1931 Pierre Brunet *L'introduction des théories de Newton en France au XVIIIe siècle* (Paris: Blanchard) p 17
[2] Meli D B 1993 *Equivalence and Priority: Newton versus Leibniz* (Oxford: Oxford Science Publications)
[3] Carolyn [Merchant] Iltis 1973 The Leibnizian-Newtonian Debates: Natural Philosophy and Social Psychology *The British Journal for the History of Science* **6** 343–77
[4] Walters R L 2001 La querelle des forces vives et le rôle de Mme du Châtelet *Studies on Voltaire and the Eighteenth Century* no. 11 pp 198–211
[5] Du Châtelet É 1739 *Dissertation sur la nature et la propagation du feu dans Pièces qui ont remporté le prix de l'Académie royale des sciences, en MDCCXXXVIII*. (Paris: Imprimerie royale) p 85–168
[6] Lettre 151 to Maupertuis in 1738 November, in 1958 *Les Lettres de la Marquise du Châtelet, publiées par Theodore Besterman* (Genève, Institut et Musée Voltaire) pp 270–1
[7] Gauvin J F 2006 le cabinet de physique du chateau de Cirey et la philosophie naturelle de Madame du Châtelet et de Voltaire, in 2006 Emilie du Châtelet: rewriting Enlightenment philosophy and science, ed. Zinsser J P and Hayes J C 01 pp 165–202
[8] Letter 120 to Maupertuis in 1738 February, in 1958 *Les Lettres de la Marquise du Châtelet, publiées par Theodore Besterman* (Genève, Institut et Musée Voltaire) pp 215–8
Letter 124 to Maupertuis in 1738 May 9, in 1958 *Les Lettres de la Marquise du Châtelet, publiées par Theodore Besterman* (Genève, Institut et Musée Voltaire) pp 224–8
[9] Janik L G 1982 Searching for the metaphysics of science: the structure and composition of Mme du Châtelet's Institutions de physique (1737-1740) *Studies on Voltaire and the Eighteenth Century*, no. 201 pp 85–113
[10] Costabel P 1984 *La Signification d'un débat sur trente ans (1728-1758) : la question des forces vives*, Cahiers d'histoire et de philosophie des sciences, Nouvelle série, no. 8 (Paris)
[11] Costabel P 1971 Newton's and Leibniz' Dynamics, in *The Annus Mirabilis of Sir Isaac Newton 1666-1966* ed. Palter R (Cambridge, Mass.: M.I.T. Press) pp 109–16
[12] Rey A-L 2017 La Minerve vient de faire sa physique *Philosophiques* **44** 233–53
[13] "Le leibnizo-newtonianisme : la construction d'une philosophie naturelle complexe dans la première moitié du XVIIIe siècle. La méthode d'Émilie du Châtelet: entre hypothèses et expériences" *revue Dix-huitième siècle*, dossier "La Nature" juin 2013, pp 115–29
[14] Duchesneau F 1982 *Philosophiques* **9** 231
[15] Hutton S 2012 "Between Newton and Leibniz: Émilie du Châtelet and Samuel Clarke" lorsqu'elle écrit: "reading Newton through Leibnizian spectacles" in *Émilie du Châtelet between Leibniz and Newton* ed. Hagengruber R (Springer)

[28] S. Hutton also noted in [15, p 78]: "Nevertheless, her subscription to *both* Newton and Leibniz remains problematic from a modern perspective, especially in view of the way Newton and Leibniz are nowadays treated as leading representatives of the empiricist-rationalist schools, and therefore of rival British and German philosophical traditions. […] Since Émilie Du Châtelet's *Institutions de Physique* assumed compatibility between Newtonian theories and Leibnizian metaphysics, it is reasonable to expect that her view of this controversy [the Leibniz dispute] should hold clues about her understanding of the relationship of Leibniz's philosophy to Newton-Clarke's."