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Physical Convictions, Metaphysical Principles and Keplerian Inspiration

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Volume 52

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ISSN 1421-6329 ISSN 2296-6080 (electronic)
Science Networks. Historical Studies
ISBN 978-3-319-21235-7 ISBN 978-3-319-21236-4 (eBook)
DOI 10.1007/978-3-319-21236-4

Library of Congress Control Number: 2015951719

Springer Cham Heidelberg New York Dordrecht London

Cover illustration: From Waller Ms de-00215, August Beer: Über die Correction des Cosinusgesetzes bei der Anwendung des Nicol'schen Prismas in der Photometrie, after 1850. With friendly permission by The Waller Manuscript Collection (part of the Uppsala University Library Collections).

Printed on acid-free paper

Springer International Publishing AG Switzerland is part of Springer Science+Business Media (www.birkhauser-science.com)

Foreword

Authors like the late Eric Aiton, Domenico Bertoloni Meli, François Duchesneau, Alexandre Koyré and many others have diligently studied, explained or criticized Leibniz's planetary theory. Leibniz, it is true, changed his relative opinions in many respects in the course of time. But he always adhered to some fundamental convictions, among them being the strong assertion that all hypotheses must be based on mechanical models. This is especially true of his different explanations of gravity that are closely connected with his cosmological considerations. He thus inevitably refused Newton's celestical mechanics because it was based on the unexplained notion of gravity.

Paolo Bussotti makes a new, comprehensive effort to interpret Leibniz's different trials to develop a consistent planetary theory well knowing that "it is difficult to offer a coherent picture of Leibniz's theory of motion". Yet, he rightly emphasizes that Leibniz aimed at a physical-structural theory, not only at a kinematical or dynamical theory in order to understand the world system.

Bussotti presents a subtle analysis of Leibniz's thinking and argumentation. Leibniz's natural inertia is not Newton's inertia. Leibniz had no inertia concept that was comparable to that of Newton. He tried to replace it by means of his forces. Leibniz's main physical quantity was speed, not acceleration. When he elaborated his theory of a harmonic circulation and a paracentric motion as basic ingredients of his planetary theory, he did it with regard to Newton's *Principia mathematica*. He wanted to offer a physical alternative to Newton's physics.

What is more, Bussotti's aim is to explain the internal change of Leibniz's concept of gravity. Leibniz finally came to the conclusion that gravity originates from the circulation of the ether. Yet, the origin of gravity was not certain for him. He continued to write on it up to the end of his life. He attributed to Kepler the idea that gravity is due to the centrifugal force of the fluid. It is worth mentioning that such a fluid is a reminiscence of Ptolemy's cosmology.

Therefore Bussotti justly concludes that a full understanding of Leibniz's planetary theory is not possible without an understanding of its connection with Leibniz's general, physical, and metaphysical principles.

In my eyes Bussotti's last chapter is especially important and original. It analyses Kepler's influence on Leibniz's scientific thinking and planetary theory. Influence does not necessarily mean agreement, though Leibniz himself considered himself as somebody who continued Kepler's work. For example Leibniz did not accept Kepler's planetary souls or magnetic influences. For him even the orbit of the planets might be not an ellipse.

Bussotti demonstrates that Leibniz falsely ascribed the insight to Kepler that in a curvilinear motion a body tends to escape along the tangent. But Leibniz obviously took the idea of the paracentric motion, as well as that of a decomposition of planetary motions, into two components from Kepler. On the other hand, he was not influenced by his countryman when he conceived of the *circulatio harmonica*. Both scientists shared the conviction that harmony determines the structure of the universe.

In spite of many differences between the two thinkers, Bussotti emphasizes the similarity between their ways of thinking, of approaching the problems, and of conceiving of the universe and of its relation with God. Bussotti teaches the reader to see Leibniz's metaphysics under a new perspective, to see Leibniz as a modern Keplerian. Kepler and Leibniz shared indeed a common vision of the universe that was based on harmony, final causes, and on a conception of the world as a true *kosmos*.

Berlin, Germany
June 2015

Eberhard Knobloch

Preface

The genesis of this book begins with an Alexander von Humboldt fellowship that I had achieved in the period 2003–2005 at Ludwig Maximilians University, Munich though in those years I did not focus on Leibniz. Some years later I extended the privilege of this Fellowship during a three month period from December 2013 to February 2014 at the Berlin-Brandenburg Academy of Science, Berlin. The host of my fellowship was Professor Dr. Eberhard Knobloch. In the previous six months, I had frequent e-mail contacts with Professor Knobloch and we shared the idea that, during this time period in Berlin, I would focus my studies on the influence exerted by Kepler on Leibniz's planetary theory. Therefore, I began my research with this clear intention. However, my reading of Leibniz's works and the existing literature on the subject, as well as discussions with Professor Knobloch, convinced me to extend my research beyond this narrow intention. Thus, my aim was widened to frame Leibniz's planetary theory inside his physics and metaphysics. In particular, I wondered if planetary theory was, for Leibniz, something like an academic exercise or, in any case, a secondary part of his general order of ideas, scarcely connected with the whole of his production or if, in contrast, it played an important role in the development of his entire way of thinking. My attempts to answer such questions are the core of this book, inside which, without entering into details, which the reader will control in the running text, it is possible to recognize three main conceptual centres:

1) Description and specification of the details (in particular mathematical and physical details) of Leibniz's planetary theory, also considering its historical evolution. The Chaps. 2 and 4 are dedicated to this problem;
2) Connection between Leibniz's gravity theory—perhaps better to speak of Leibniz's ideas on gravity rather than a theory in a proper sense—and planetary theory. This is the subject of Chap. 5;
3) Kepler's influence on Leibniz. This was my original project. It is developed in Chap. 6, where I show the influence exerted by Kepler on Leibniz's planetary theory, but where I try to extend the argumentation, as I attempt to prove that

> Kepler was also influential on Leibniz's metaphysics, in particular as far as the concept of pre-established harmony is concerned.

Chapter 1 is a historical and conceptual introduction to the scenario described in the book, while Chap. 3 has to be interpreted as a brief parenthesis concerning the concept of inertia in Leibniz, especially focusing on the aspects connected to planetary theory. To be clear, my intention has not been to deal with the complex general problems of Leibniz's physics, on which a huge and profound literature exists.

As to the quotations, in the running text I have always offered the English translation from original works or letters, which are almost exclusively written in two languages: Latin (in most cases) and French (in several cases). If not explicitly specified otherwise, the translation is mine.

I wish to express my particular gratitude to Professor Dr. Eberhard Knobloch. He followed my research in Germany and he read the whole of my work, giving me precious advice. Finally, he contacted the publishing house Birkhäuser to propose the publication of this book. Without his collaboration and precious help, this research would have been neither written nor published.

I am also grateful to Professor Danilo Capecchi for his qualified, numerous and profound tips, as to the content and form of my work.

I am indebted with Dr. Raffaele Pisano, with whom I have published several works and who also gave me valuable help.

I wish to thank Professor Niccolò Guicciardini for an important observation concerning Chap. 4 and Dr. Stefano Gattei for some advice regarding Chap. 2.

It is obvious that possible mistakes or imperfections rest entirely upon the author.

I wish to express my gratitude to the Alexander von Humboldt Foundation for having financed my research-period in Berlin.

I am grateful to the Birkhäuser Publishing House for having accepted my book for publication.

Udine, Italy Paolo Bussotti

Contents

Chapter 1
An Introduction: The Historical-Conceptual Reference Frame

Leibniz dealt with planetary theory in three papers written between 1689 and 1706.[1] The first paper, titled *Tentamen de Motuum Coelestium Causis*, is the only one which was published—in the *Acta Eruditorum Lipsiensium*, 1689—during Leibniz's lifetime. In the *Tentamen* Leibniz tried to construct a planetary theory based on a refinement and specification of the vortex theory. In particular, he attempted to supply a series of mathematical considerations, which allowed him to obtain (1) Kepler's area law; (2) the inverse square law; (3) ellipticity of the planetary orbits, without resorting to the Newtonian concept of force. Leibniz developed a second version (*zweite Bearbeitung*) of the *Tentamen* (see note 1), which was not published at that time, but which presents important specifications, in particular as to: (a) the structure and history of vortex theory; (b) the nature of gravity; (c) the completion of mathematical proofs which were only outlined in the published version.

In general, Leibniz's ideas on astronomy were not welcome: Huygens developed a series of criticisms, which were not based on the mathematical treatment, but on some physical concepts introduced by Leibniz, in particular that of *circulatio harmonica*. The correspondence between Huygens and Leibniz is important to understand the nature of Huygens' critics and of Leibniz's point of view.[2] Varignon discovered a mathematical mistake, which could be corrected without compromising the general structure of the theory.[3] However, the campaign against Leibniz

[1] All the mentioned contributions have been published by Gerhardt in Leibniz (1860, 1962), VI. The first one is the *Tentamen*, pp. 144–161; the second one is the *Tentamen (Zweite Bearbeitung)*, pp. 161–187; the third one is *Illustratio Tentaminis de Motuum Coelestium Causis*, parts 1 and 2 plus *Beilage*, pp. 254–280.

[2] For the critics addressed by Huygens to several concepts Leibniz used in his planetary theory, in particular the concept of *circulatio harmonica*, see Chap. 2, where I will deal with this question in detail.

[3] See the letter Varignon sent to Leibniz on the 6th December 1704, in Leibniz ([1849–1863], 1962, IV, pp. 113–127).

P. Bussotti, *The Complex Itinerary of Leibniz's Planetary Theory*,
Science Networks. Historical Studies 52, DOI 10.1007/978-3-319-21236-4_1

came, basically, from Newton and the Newtonians: Newton himself, Gregory and Keill were the protagonists.[4] Their criticisms were of various kinds:

1. some supposed mathematical mistakes were pointed out;
2. from a physical point of view, the charge was that Leibniz had not taken into account vortices-instability proved by Newton. In particular the movements of the comets would have been inexplicable inside Leibniz's theory;
3. the third Kepler law was not coherent with some of Leibniz's assumptions.

Leibniz wrote one paper titled *Illustratio Tentaminis de Motuum Coelestium Causis* (see note 1) divided into two parts. This contribution, written probably around 1706, was not published in Leibniz's lifetime. In the *Illustratio* Leibniz tried to answer the critics and to better clarify the physical bases of his theory. Other works by Leibniz, written at the end of the seventeenth century do not deal directly with astronomy, but, since they concern—in part or *in toto*—gravity, they get a relevant importance in our context. These works are *De Causa gravitatis, et defensio sententiae Autoris de veris Naturae Legibus contra Cartesianos*, published in the *Acta Eruditorum Lipsiensium*, 1690 and the two parts of the *Specimen Dynamicum*, the former published in *Acta Eruditorum Lipsiensium*, 1695, the latter unpublished in Leibniz's lifetime.[5] Significant references are also present in Leibniz's correspondence and in other published or unpublished works, but the mentioned ones are the most important.

The reasons of interest behind Leibniz's celestial mechanics are numerous:

1. From a historical point of view: why did Leibniz publish a contribution on planetary theory two years after the publication of Newton's *Principia*, in which, for the first time, a complete physical theory of planetary motions was expounded?
2. From a mathematical standpoint: are the mathematical argumentations used by Leibniz correct?
3. In a physical perspective:
   (a) is the physical structure of the world proposed by Leibniz, inside which he tried to explain the movements of the planets, stable?
   (b) Is the use of the physical quantities utilized by Leibniz suitable for an inquiry on the planetary motions? These questions imply that the term *physical* has three meanings:
      (b-i) referred to the supposed *real physical structure of the world* (for example: according to Leibniz the vortices are physically existing entities). I call a theory dealing with this level of reality a *physical-structural theory*.

[4] See D. Gregory (1702, pp. 99–104), Newton (1712?, 1850), Keill (1714).

[5] For the *De causa gravitatis*, see Leibniz (1690, 1860, 1962, VI, pp. 193–203); for the *Specimen Dynamicum* parts 1 and 2, see Leibniz (1695, 1860, 1962, VI, pp. 234–254).

(b-ii) referred to *dynamics* (let us remember that Leibniz was the inventor of this term), that is to explanations of the movements by means of *forces* (whatever the meaning of this word is). This implies not only a kinematical description of the movements, but also the research of the cause/s of the movement or of the change of movement (this last one is Newton's perspective).

(b-iii) referred to *kinematics*: namely a theory can provide a description of certain movements and can be able to foresee the positions of certain bodies without dealing either with the physical reality of the world or with the actions which determine the movements or the change of movement. Only to give an example: Ptolemaic planetary theory expounded in the *Almagest* is merely kinematic.

An explanation can be dynamical, but not physical-structural. For example, gravity theory explained by Newton in the *Principia* is dynamical, but not physical-structural, because Newton deals with gravity as a given force and does not look for its origin in some features of the real physical world. This is the meaning of the famous "Hypotheses non fingo". For, a physical explanation has to provide the structure of the world and the origin of the acting forces in this structure. In the case of Leibniz, the vortices are real entities and gravity action has to be explained in terms of plausible mechanism of the real physical world. Instead, a dynamical explanation can take for granted the origin of a certain force and only propose a model, which is coherent with the phenomena and with the supposed features of the considered actions. This is an explicative level different from a merely kinematical approach—where forces play no role—but which is less demanding than the physical-structural explicative level. The difference between the three meanings of the words *physics*/*physical* is an important topic in history of physics and astronomy. This distinction has not always been given sufficient consideration in the literature, while the difference dynamics/kinematics is well known and explored.

4. As to the relations among the different aspects of Leibniz's thought: which are the connections between Leibniz's physics (at least the physics he developed after the publication of Newton's *Principia*) and his planetary theory? In a more general perspective: how did Leibniz's metaphysical and ontological convictions influence his planetary theory?
5. With regard to Leibniz's sources, one author seems to be particularly significant: Kepler: (i) what are the real connections between Kepler's physical astronomy and Leibniz's physical astronomy? (ii) What did Leibniz think about the relations between his own and Kepler's points of view, that is how did Leibniz interpret the physical parts of Kepler's astronomy? Many other authors influenced Leibniz's celestial mechanics, in particular Descartes, Borelli and

Huygens. However, their influence on Leibniz is clear enough, while this is not always the case with Kepler.

In the literature, there are several contributions on Leibniz's planetary theory, although they are far less numerous than those dedicated to his physics or mathematics or philosophy. Probably the most significant researches are due to three authors: Alexandre Koyré, Eric J. Aiton and Domenico Bertoloni Meli.[6] In the appendix A of his *Newtonian Studies*, Koyré deals with Leibniz's celestial mechanics. Without entering into the general structure of Koyré's reasoning, his judgement on Leibniz's celestial mechanics is extremely negative, basically because of a supposed physical-mathematical mistake: Koyré interprets the locution *velocitas circulandi* used by Leibniz as referring to the module of velocity. If this were the case, the whole theory expounded by Leibniz would have been affected by a mistake, which would have completely compromised it. In a series of four fundamental papers written in the period 1960–1965 and published in *Annals of Science*, Aiton carries out a robust campaign in defence of Leibniz. He begins by interpreting *velocitas circulandi* as *transverse velocity*. If this is true, the critics of Koyré would derive from a serious misunderstanding of Leibniz's concepts. In the first paper, Aiton describes the bases of Leibniz's theory and, despite a general positive judgement, he adheres to some critics by Newton and the Newtonians. However, in the following contributions he changes his mind: these criticisms are due to an incorrect understanding of Leibniz's thought, which—in spite of numerous obscurities in the language—is basically correct. In his paper written in 1965, Aiton explicitly critisizes Koyré's interpretation. Aiton proposes the same picture in his book *The vortex theory of planetary motion*, 1972.

A fundamental contribution is Bertoloni Meli's *Equivalence and Priority: Newton versus Leibniz*, 1993, because Bertoloni Meli: (1) looks for Leibniz's sources; (2) tries to understand the relations between Leibniz's planetary theory and Newton's *Principia*, in particular if the intention to propose a theory alternative to Newton's played a role in the development of Leibniz's concepts; (3) expounds and translates into English the *Tentamen* and a series of Leibniz's unknown manuscripts on celestial mechanics, which were written in the years immediately preceding the publication of the *Tentamen*. In this way the development of Leibniz's thought can be convincingly traced.

Given this picture, many aspects of Leibniz's planetary theory have been clarified. Nevertheless, some of them still remain rather obscure or, at least, not completely clear. In particular:

(A) As to Leibniz's sources, the relations between Kepler's and Leibniz's theories and the interpretation Leibniz gave of Kepler's astronomy and Kepler's concept of inertia;

[6] The fundamental works on Leibniz's planetary theory are: Aiton (1960, 1962, 1964, 1965, 1972), Bertoloni Meli (1993), Koyré (1965), Appendix A. Important studies are also: Aiton (1984, 1995), Bertoloni Meli (1988a, b, 1990, 2006), Cohen (1962), Hoyer (1979a).