CHAPTER 1

INTRODUCTION

The Age of Reason is left the Dark Ages of the history of mechanics.
Clifford A. Truesdell[1]

1.1 THE INVISIBLE TRUTH OF CLASSICAL PHYSICS

There are some questions that physics since the days of Newton simply cannot answer. Perhaps the most important of these can be categorized as 'questions of ethics', and 'questions of ultimate meaning'. The question of humanity's place in the cosmos and in nature is pre-eminently a philosophical and religious one, and physics seems to have little to contribute to answering it. Although physics claims to have made very fundamental discoveries about the cosmos and nature, its concern is with the coherence and order of material phenomena rather than with questions of meaning. Now and then thinkers such as Stephen Hawking or Fritjof Capra emerge, who appear to claim that a total world-view can be derived from physics. Generally, however, such authors do not actually make any great effort to make good on their claim to completeness: their answers to questions of meaning often pale in comparison with their answers to conventional questions in physics.[2] Moreover, to the extent that they do attempt to answer questions of meaning, it is easy to show that they draw on assumptions from outside physics.[3] However, it seems that the fact that physics, ethics and religion are sometimes mixed, should not be attributed to anything inherent in these fields, but to incorrect *understandings* of these fields and their interrelationships. Goethe said that Newtonian science puts "nature on the

[1] Truesdell, "A Program toward Rediscovering the Rational Mechanics of the Age of Reason" (1960), 87.

[2] For Hawking, see: Hakfoort, "Fysica en wereldbeeld van Descartes tot Hawking" (1992); for Capra and other New Age representatives, see: Vanheste, *Copernicus is ziek* (1996).

[3] Hösle, "Über die Unmöglichkeit einer naturalistischen Begründung der Ethik" (1989). The energeticism of Wilhelm Ostwald also provides excellent material for study. See, for example, Hakfoort, "Science Deified: Wilhelm Ostwald's Energeticist World-View and the History of Scientism" (1992).

rack," using a metaphor that he borrowed from Bacon.[4] We can give it a new twist and say that physics only makes ethical and religious statements under the compulsion of an inquisitor. Physics, ethics and religion appear to be separated from each other by 'natural' limits.

There are some questions of other types that physics since the days of Newton has not *tried* to answer, not the least of which is the search for the ontology, or essence, of things. At first glance this search might seem closely related to the aim of physics, if we formulate that as achieving a complete mathematical description, in a single system, of all material processes. After all, does not such a description also imply that we know the ontological basis of all that can be experienced? And is this not the answer to the old question into the essence of things? Nevertheless, questions such as: "what is time?"; "what is force?"; "what is a photon?"; "what is the basis of the laws of nature?" can only be answered in physics by showing how these basic concepts function in the entirety of the mathematical-physical system. Time, mass and distance are defined by using a measure that is nothing other than a reproducible unit of the same quantities: time, mass and distance. As a result, the relevant basic concept can be assigned a value, but the concept itself remains elusive. Force, seen until far into the eighteenth century as the *cause* of an effect, is now *defined* by this effect, which is acceleration: $\underline{F} = m \times \underline{a}$. It is natural, therefore, that mathematical relationships are considered as the most important result of physics. In the eyes of the modern physicist, the fact that mass can be transformed into energy and *vice versa*, according to the formula $E = mc^2$, and that experimental measurements of time and energy are fundamentally limited in their precision by Heisenberg's uncertainty principle, means more, for example, than Kant's opinion that time is the *a priori* form of sensibility or the relationship of physical to psychological and biological time. The physicist does not in fact feel any need to speak about fundamental concepts as such, and therefore rejects questions about the essence of nature.

When it comes to questions about the essential nature of phenomena, as distinct from questions of meaning, it is much less clear whether the boundaries defining what physics may deal with are natural or artificial. The Enlightenment and nineteenth century positivism, in particular, have advocated the need to free natural science from metaphysics and theology, the traditional disciplines to which questions of meaning and essence belong. Although this opinion may no longer be maintained in such an extreme form, its general implication—that the creation of modern natural sciences has entailed the gradual elimination of metaphysics and theology from physics—continues to be widely held even among historians who consider the intellectual context of the history of science.[5] For example, in Eduard Dijksterhuis's

---

[4] Goethe, *Zur Farbenlehre* (1810), 69.

[5] One problem in evaluating the relationship that metaphysics had, and still has, with modern physics is undoubtedly the fact that this relationship is emotionally charged for some people with the memory of the hostile, or at least dogmatic, position of the Church with regard to science. This association is not accidental, as can be seen from the polemic that E.W. Beth directed at the neothomist Hoenen in Holland just after the Second World War. The issue in this polemic was the

continued on next page

famous history *The Mechanization of the World Picture* (Dutch original 1950), mechanics is primarily a special form of the mathematical description of material reality.[6] In his 1976 essay on the development of early modern physics, Thomas Kuhn distinguished only the mathematical and experimental traditions, and not the traditions of natural philosophy or of metaphysics.[7] However, this approach is scarcely satisfying as an understanding of the past, at least for anyone with a broad vision of metaphysics and theology.

This book will question the low opinion of metaphysics in physics by showing that the metaphysical dimension played a significant, indeed a guiding role in the development of eighteenth century mechanics. Although metaphysics was all too often openly scorned, from the Enlightenment onward, this does not imply that it was absent. Metaphysical arguments continued to play an important role, sometimes not recognized as such, sometimes implicitly assumed. This almost always related to questions of essence; my argument will leave theology, and with it, most questions of ultimate meaning, almost untouched, except where metaphysical themes are involved.

As previously stated, I will focus here on mechanics in the eighteenth century, and specifically on the period between Leibniz and Newton on the one hand and Lagrange on the other. Controversies provide a good starting point for understanding the relationship between metaphysics and mechanics, especially where the metaphysical aspect is concealed. During the relevant period, there were several important controversies concerning the concept of force in mechanics, in which metaphysics and mechanics were closely interrelated. Three of these will be dealt with here:

1. The controversy about the true measure and the conservation of living force (1686–1743)
2. The controversy about the principle of least action (1734–1781)
3. The Berlin Academy's competition question about the foundation of force (1779)

---

continuation of former page
significance of neothomism for understanding modern physics (Hoenen, *Philosophie der anorganische natuur* (1938); Beth, *Natuurphilosophie* (1948)). Metaphysics was easily portrayed as a veiled form of Church dogmatism. Just as the Church wants to found the moral order of the world on Revelation, metaphysics would seek to found the ontological order on dogmatic and unverifiable concepts.

Although this sketch is a caricature, it is important to take account of this emotional charge when conducting historical research. After all, many scientists from the eighteenth century were explicitly anti-Church, although they were still religious. In deism and eighteenth-century freethinking we can observe an ambivalent attitude to belief that is somewhat difficult for our modern secularized society to understand. Their rejection of metaphysical considerations must therefore be taken with a grain of salt.

[6] E.J. Dijksterhuis, *The Mechanization of the World Picture* (1961, translated from the Dutch *De mechanisering van het wereldbeeld* (1950)).

[7] Kuhn, "Mathematical versus Experimental Traditions in the Development of Physical Science" (1976).

There are a number of reasons for limiting the present study to questions surrounding the concept of mechanical force. In the first place, mechanics was the first natural science to be mathematicized and was also the most extensively mathematicized. The essence of Dijksterhuis's thesis about the mechanization of the world picture is that, in the course of the seventeenth century, mechanics became the single most important model for the mathematization of other natural sciences such as optics and electricity.[8] Thus the relationship between metaphysics and mechanics would be expected to provide at least a partial analogy to the relationships between metaphysics and other mathematical natural sciences, although the historical developments were not simultaneous.

Secondly, the concept of force is particularly suited for the articulation of metaphysical suppositions. Until well into the eighteenth century, the concept of force was applied to many different phenomena which would later be differentiated as energy, weight, momentum, etc. As I will show in Chapters 2 and 3, this was not the result of confused thinking, but was due to the fact that the similarities were much clearer than the differences. *There was a unity underlying the various meanings, and this unity was inherited from the substantial concept of force in scholasticism.*

Chapters 4 to 7 show how the concept of mechanical force changed in several ways during the eighteenth century. First of all, the experiential basis shifted from an *internal-bodily* experience of strength, power or force to an *external-sensory* experience of resistance, which meant that 'force' became a qualitative rather than quantitative concept. Secondly, the concept changed in an ontological sense from a substantial to a structural one. These two shifts and their interaction over time are the common thread that runs through this book.

The *first aim* of this book is to defend the general proposition that the historiography of science should take account of metaphysical suppositions. I will show that the *historical comprehensibility* of the developments in eighteenth century mechanics mentioned above is increased if metaphysical suppositions are included in the account, and that such metaphysical suppositions played not only a negative, but also a positive role in the development of mechanics. Note that the terms 'positive' and 'negative' in this context refer not to a norm that is raised above actual history (for example, one might take contemporary mechanics as a norm), but rather to the importance of the suppositions for the further expansion and development of the science of mechanics *of that time.* I do not wish in any way to assign a normative significance to metaphysics, as if explicit metaphysical considerations were a precondition for the successful development of mechanics. But I do want to defend the proposition that metaphysics, during the historical process of discovering the 'secrets of nature', actually functioned as the soil in which the tree of science took root.

The *second aim* is to unravel the broad lines of development in metaphysics itself and in its relationship to mechanics. To return to the metaphor of the tree and the soil, we will deal with changes in the properties and composition of the soil itself

[8] Dijksterhuis, *Mechanization*, 500-501 (section V.9).

and how the tree is rooted in the soil, whether with visible, aerial roots or those hidden in the soil. With regard to the *content* of metaphysics, I will emphasize the *transition from substance to structure*, and with regard to its relationship to mechanics, I will emphasize the *transition from an explicit to an implicit form*.[9]

1.2 HISTORIOGRAPHIC ORIENTATION

1.2.1 The Horizon of the Scientific Revolution

In the historiographic tradition of the Scientific Revolution, it has come to be generally accepted that the rise of modern physics was accompanied by the rejection of the Aristotelian-scholastic metaphysics of substance and quality, form and matter, potential and act. There is, by contrast, deep disagreement about whether a different metaphysics has taken its place—and if so, what it is.

The historians Burtt and Koyré have answered this question affirmatively. In 1924 Edwin Arthur Burtt concluded that the metaphysics of modern natural science consisted essentially of ascribing "ultimate reality and causal efficacy to the world of mathematics, which world is identified with the realm of material bodies moving in space and time."[10] For him, mathematics was the language of the reality underlying the phenomena.[11] Alexandre Koyré also saw the historical significance of the language of mathematics, not only as a *description* of reality, but also as an expression of its *essence*.[12] However, Koyré and Burtt's theme was the transformation of Aristotelian-scholastic natural science into Newtonian science, so their statements about post-Newtonian physics should be treated as a 'working hypothesis' at best.

The most radical refutation can be found in the positivism of Auguste Comte, previously mentioned. According to Comte, the father of positivism, physics rose above the levels of theology and metaphysics at the beginning of the seventeenth century, and since then has deserved the title "positive science."[13] The irrepressible ascent of the star of positive philosophy from that time was to be attributed to Bacon, Descartes, and Galileo.[14] During the following centuries, there was nothing left for physicists to do but to scrape away the last remains of metaphysical (and *a forti-*

---

[9] I will return to the key concepts used here in sections 1.3.3 and 1.3.4.

[10] E.A. Burtt, *The Metaphysical Foundations of Modern Physical Science* (1924), 300.

[11] H.F. Cohen, *The Scientific Revolution. A Historiographical Inquiry* (1994), 94.

[12] *Ibidem*, 79.

[13] Comte describes the positive phase of science as follows: "(...) in the positive phase, the human mind (...) [applies itself] solely to discovering, by the well-integrated use of reasoning and observation, the actual laws [of phenomena, JCB], i.e. the invariable relations of succession and correspondence" ("(...) dans l'état positif, l'esprit humain (...) [s'attache] uniquement à decouvrir, par l'usage bien combiné du raisonnement et de l'observation, leurs lois effectives, c'est-à-dire leurs relations invariables de succession et de similitude") (Comte, *Cours de philosophie positive. Vol. I. Philosophie première*, 21-22).

[14] *Ibidem*, 27.

http://www.springer.com/978-1-4020-0233-5

What was Mechanical about Mechanics
The Concept of Force between Metaphysics and Mechanics from Newton to Lagrange
Boudri, J.C.
2002, XVI, 280 p., Hardcover
ISBN: 978-1-4020-0233-5