Studies in History and Philosophy of Science 42 (2011) 525–543

Contents lists available at SciVerse ScienceDirect

Studies in History and Philosophy of Science

journal homepage: www.elsevier.com/locate/shpsa

Kant's dynamical theory of matter in 1755, and its debt to speculative Newtonian experimentalism

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ARTICLE INFO

Article history:
Received 4 September 2009
Received in revised form 6 March 2011
Available online 6 October 2011

Keywords:
Kant
Repulsive force
Air
Ether
Newton
Hales
Boerhaave

ABSTRACT

This paper explores the scientific sources behind Kant's early dynamical theory of matter in 1755, with a focus on two main Kant's writings: *Universal Natural History and Theory of the Heavens* and *On Fire.* The year 1755 has often been portrayed by Kantian scholars as a turning point in the intellectual career of the young Kant, with his much debated conversion to Newton. Via a careful analysis of some salient themes in the two aforementioned works, and a reconstruction of the scientific sources behind them, this paper shows Kant's debt to an often overlooked scientific tradition, i.e. speculative Newtonian experimentalism. The paper argues that more than the *Principia,* it was the speculative experimentalism that goes from Newton's *Opticks* to Herman Boerhaave's *Elementa chemiae* via Stephen Hales' *Vegetable Staticks* that played a central role in the elaboration of Kant's early dynamical theory of matter in 1755.

1. Introduction

In 1786, in *Metaphysical Foundations of Natural Science*, Kant famously introduced attraction and repulsion as two fundamental forces in nature, within the context of his defence of a "dynamical natural philosophy". The purpose of a "dynamical natural philosophy" was to explain natural phenomena in terms of "moving forces of attraction and repulsion originally inherent in them",[1] by contrast with the "mechanical natural philosophy" which "under the name of *atomism* or the *corpuscular philosophy*" retained its authority and influence from Democritus to Descartes. Repulsive force was introduced to explain how matter can fill a determinate region of space: it was regarded as an expansive force "also called elasticity" and "all matter is therefore originally elastic".[2] To illustrate repulsive

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[1] AK 4: 532.38–533.1. Kant (1786); English translation (2004), p. 72. In this context, Kant uses the terms Anziehung und Zurückstoßung to indicate, respectively, attractive and repulsive force as forces inherent in matter, and responsible for matter's different specific densities. Both forces act among parts of matter. Indeed, at the outset of the chapter on Dynamics (Explication 2), Kant says that there are only these two forces (Anziehung und Zurückstoßung) with which one point of matter can impress motion on another (AK 4: 498.17–33). A few lines down, in Proposition 2 [AK 4: 499.6–18, 500.2] and throughout the chapter, Kant uses Zurückstoßungskraft interchangeably with repulsive Kraft, and he explicitly identifies it with an expansive force (Ausdehnungskraft or expansive Kraft), which is nothing but the elasticity of matter (Elasticität). Apropos of attraction, Edwards (2000), p. 142, identifies in the chapter on Dynamics (but also in *Universal Natural History*) two possible views of it, which he calls a "collective view", identifiable with Newtonian gravitation (Gravitation) as a long-range force acting at a distance on planetary bodies, and a "distributive view", identifiable with the cohesion of solid bodies as a short-range force (Anziehung) acting by contact between juxtaposed parts of matter. One may wonder whether a similar distinction can be found in the same period as far as repulsive force is concerned (for example, the repulsive force at work between the north and south poles of two magnets when brought together seems to defy the characterization of Zurückstoßungskraft as a short-range contact force—I thank an anonymous referee for pointing this out). It suffices here to note that—as we will see below—the terminology Anziehung und Zurückstoßung as used in the aforementioned passage from the 1786 chapter on Dynamics is exactly the same terminology Kant used thirty years earlier in the 1755 *Universal Natural History*, where he first presented his dynamical theory of matter.

[2] AK 4: 500.2–6.

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doi:10.1016/j.shpsa.2011.09.008

force as an original elastic force that comes in degrees in different matters, Kant repeatedly resorted to the example of air, or "air matters",[3] sometimes associated with heat[4] intended either as "oscillation of elastic matter"[5] or (in the General Remark to Dynamics) as the "matter of heat...whose own elasticity is perhaps original".[6] A few lines below in the same passage, Kant called the matter of heat "caloric"[7] [*Wärmestoff*] and presented it as an example of chemical penetration, insofar as it penetrates the empty interstices of bodies. Kant gave also other examples of chemical penetration, namely the dissolution of matter as when acids dissolve metallic bodies or the "dissolving forces" at work in "vegetable or animal operations".[8] There follows Kant's defence of the ether as a matter filling all space, but very subtle compared to the matter of ordinary bodies: "In the aether, the repulsive force must be thought as incomparably larger in proportion to its inherent attractive force than in any other matters known to us".[9]

Why does Kant say that repulsive force, as an expansive elastic force, comes in different degrees in different matters, among which nonetheless the same attractive force operates?[10] Why does he refer to the expansive force of air, heat, and ether to illustrate the different degrees of repulsive force at work in nature? What do air, heat, and ether have in common that justifies their association with repulsive force? In this paper, I take a first step towards answering these open questions.

Thirty years earlier, in the 1756 *Physical Monadology*, Kant had already introduced some seminal ideas for his dynamical theory of matter. Not only did he introduce the two fundamental forces of attraction and repulsion; but he also expressly made repulsive force the cause of the impenetrability of bodies, and identified it with an elastic force acting by direct contact, and coming in different degrees in different things (hence the different elasticities of bodies).[11] And among elastic bodies, Kant included the "aether, that is to say, the matter of fire".[12]

I believe that some pre-Critical aspects of Kant's dynamical theory of matter were taken up in more complex ways in the Critical period, so I do not want to make any swift claim suggesting that we should read the *Metaphysical Foundations* through the lenses of the pre-Critical writings of 1755–6. However, I do think that some baffling aspects of Kant's Critical treatment of repulsive force have their seeds in the pre-Critical theory of matter of 1755. It is the aim of this paper to shed light on them by reconstructing some of the scientific sources behind Kant's identification of repulsive force with an expansive, elastic force acting by contact.

I am going to concentrate on the very origins of Kant's dynamical theory of matter in *Universal Natural History and Theory of the Heavens* (1755a), and *De igne* (1755b—henceforth referred to as *On Fire*). I identify an important, and so far overlooked, scientific tradition behind it, namely British and Dutch natural philosophy of the eighteenth century, which—with a firm footing in the Queries of Newton's *Opticks* (first Latin edition 1706; second English edition 1717)—flourished in England with Stephen Hales' *Vegetable Staticks* (1727) and in Leiden with Herman Boerhaave's *Elementa chemiae* (1732). The relevance of this alternative experimental tradition can be found not only in Kant's analysis of repulsive force in the explanation of a variety of chemical and thermal phenomena in *On Fire,* but also in some key aspects of his cosmogony (1755a) as well as in his early elaboration of causality in *New Elucidation* (1755c), as I shall mention in Section 3.2.

While most of the secondary literature on this topic has in recent times concentrated on Kant's conversion and debt to Newton's *Principia*, especially as far as his 1786 defence of Newton's universal gravitation is concerned,[13] some scholars have drawn attention to the relevance of corpuscular and chemical theories of matter in the seventeenth and eighteenth century natural philosophy for Kant's dynamical theory of matter.[14] The aim of this paper is to contribute to the existing literature by both (i) complementing the received view of Kant's debt to the *Principia*, and (ii) by further exploring the legacy of both dynamical corpuscularism and materialism of the seventeenth century for Kant's early theory of matter.

The paper is divided in five sections. In Section 2, I focus on some salient aspects of Kant's *Universal Natural History* that in my view betray his allegiance to the more speculative Newton of the *Opticks.* To substantiate these claims, in Section 3, I give a rather detailed survey of some aspects of speculative Newtonianism (§ 3.1), as these aspects were further developed by Stephen Hales (to whom § 3.2 is dedicated) and by Herman Boerhaave (§ 3.3). My interpretive line is that Newton's ambiguity about the ether engendered two traditions, a mechanical one and a materialistic one—to borrow Schofield's (1970) terminology—which can be

[3] AK 4: 500.20–26. English translation, p. 37: "When, in the barrel of an air pump filled with air, the piston is driven closer and closer to the bottom, the air-matter [Luftmaterie] is compressed. If this compression could now be driven so far that the piston completely touched the bottom...then the air-matter would be penetrated". And again, AK 4: 505.10–19, English translation p. 42: "the smallest parts of the air repel one another in inverse ratio to their distances from one another, because the elasticity of these parts stands in inverse ratio to the spaces in which they are compressed...a greater or smaller space is to be represented as completely filled by one and the same quantity of matter, that is, one and the same quantum of repulsive force".

[4] AK: 4: 522.30–38, English translation p. 61: "But we may also view the expansive force of air not as the action of originally repelling forces, but as resting rather on heat, which compels the proper parts of air...to flee one another, not merely as a matter penetrating it, but rather, to all appearances, through its vibrations". And again AK 4:524.02–06, English translation p. 62: "attraction rests on the aggregate of matter in a given space, whereas its expansive force, by contrast, rests on the degree of filling of this space, which can be very different specifically (as the same quantity of air, say, in the same volume, manifests more or less elasticity in accordance with its greater or lesser heating)".

[5] AK 4:522.37. Eng. trans. p. 61.

[6] AK 4:530.2–3. Eng. trans. p. 69.

[7] AK 4:532.4.

[8] AK 4:531.39. Eng. trans. p. 71.

[9] AK 4: 534.9–11. English translation, p. 73.

[10] AK 4:533.38–40, 534.1–2. English translation, p. 73: "repulsive force, which has a degree that can be different in different matters; and, since in itself it has nothing in common with the attractive force, which depends on the quantity of matter, it may be originally different in degree in different matters whose attractive force is the same".

[11] AK 1: 483.11, 486.36–38. Kant explained in Proposition XII how the different densities of bodies in the nature ("for example, aether, air, water, and gold") should be explained by assuming "a specific difference between the simplest elements" that compose bodies (AK 1: 486.11–13). In the following Proposition XIII he then ascribed to individual simple elements an innate, perfectly elastic force "which is different in different things" and through which the elements would occupy the space of their presence (AK 1: 486.36–38, 487.1–2).

[12] AK 1: 487.18. Kant (1756), English translation (1992), p. 66. As we shall see below, the introduction of attraction and repulsion, and the identification of the ether as the repository of repulsive force and as the matter of fire pre-dates Physical Monadology, appearing for the first time in 1755 in *De igne*.

[13] See especially Friedman (1992a), (1992b), (2004) translation of Kant (1786), and Friedman (2006). For a detailed reconstruction of Kant's conversion to Newton in the pre-Critical writings after 1747, see Schönfeld (2000). For Kant's early dynamics (with a particular focus on Kant's first 1747 work *True estimation of living forces* and on Kant's 1755 cosmogony), see also Schönfeld (2006a, 2006b), respectively.

[14] See Adickes (1924), Carrier (1990, 2001); Edwards (2000), chapter 6. Edwards, in particular, has argued that the assumption of physical ether, as an imponderable elastic matter, is pivotal to Kant's dynamical theory of matter, and more in general to the evolution of Kant's thought from the pre-Critical writings of 1755 through the Critical period, up to the *Opus postumum*. It is not the aim of this paper to draw any overarching conclusion about the role of Kant's dynamical theory of matter for his overall philosophical project. My more modest aim is to clarify what I take to be some relevant scientific sources for understanding better Kant's treatment of repulsive force.