



Epistemology of a believing historian: Making sense of Duhem's anti-atomism



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ABSTRACT

Pierre Duhem's (1861–1916) lifelong opposition to 19th century atomic theories of matter has been traditionally attributed to his conventionalist and/or positivist philosophy of science. Relatively recently, this traditional view position has been challenged by the claim that Duhem's opposition to atomism was due to the precarious state of atomic theories during the beginning of the 20th century. In this paper I present some of the difficulties with both the traditional and the new interpretation of Duhem's opposition to atomism and provide a new framework in which to understand his rejection of atomic hypotheses. I argue that although not positivist, instrumentalist, or conventionalist, Duhem's philosophy of physics was not compatible with belief in unobservable atoms and molecules. The key for understanding Duhem's resistance to atomism during the final phase of his career is the historicist arguments he presented in support of his ideal of physics.

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Everything is the way it is because it got that way
Sir D'Arcy Wentworth Thompson

1. Historiographical introduction

Pierre Duhem (1861–1916) was a French scholar with important contributions in physics, philosophy of physics and history of science. In physics, Duhem supported Energetics or Generalized Thermodynamics, a scientific program that aimed at a generalized application of thermodynamics to include mechanical, chemical, electric and magnetic phenomena, without making any reference to unobservable atoms and molecules or any other hypotheses regarding the constitution of matter. In history of science he is mostly known for his work in the history of medieval science. The main historiographical theses he formulated supported the continuity between late medieval and early modern mechanics and astronomy and emphasized the positive role that Christianity (especially French Catholicism) played in the emergence of modern science.

Duhem's general philosophical outlook has been traditionally portrayed as being one of conventionalism, positivism or instrumentalism. Duhem himself is partly responsible for this. In his most important philosophical work *La théorie physique: son objet et sa*

structure (1906) he declares right at the beginning that “a physical theory...is an abstract system whose aim is to *summarize* and *classify logically*, a group of experimental laws without claiming to explain these laws.”¹ Duhem's perceived positivism or conventionalism pretty much explained his aversion to atomic theories of matter as well as his rejection of major developments in the physics of the time.² According to this view, Duhem's resistance to atomism, like that of Ernst Mach (1838–1916), was philosophically motivated and, therefore, it is not surprising that they were the only two major figures who never accepted the atomic hypothesis (they both died in 1916).³ This interpretation resonated well with traditional historiographical views that saw the history of 19th century atomism (chemical and physical) as a continuous march towards experimental verification, accumulation of predictive and explanatory power, and wider acceptance.⁴

¹ Duhem (1954), p.7.

² Brush (1968) has distinguished at least nine different varieties of atomic theories during the course of the 19th century. In this paper, 19th century atomism will stand mainly for the claims of chemical atomic theory and those of the kinetic theory of gases. Among the other scientific developments rejected by Duhem were Maxwell's electromagnetic theory and Einstein's theory of relativity.

³ Nyhof (1988).

⁴ Gardner (1979), Nyhof (1988), and Chalmers (2009) (see especially chap.10, for a summary of the 'old story' regarding chemical atomism).

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For historians who support this historiographical view regarding the development of 19th century atomism, any opposition to the particulate structure of matter at the end of the century was due to purely philosophical reasons:

In retrospect it seems clear that the criticisms of the kinetic theory in this period were motivated not primarily by technical problems, ... but, rather by a general philosophical reaction against mechanistic or 'materialistic' science and a preference for empirical or phenomenological theories, as opposed to atomic models.⁵

This conclusion, however, is not shared by all historians. Opponents of this historiographical view refer to the fact that, despite its early successes in explaining known experimental laws and predicting novel phenomena, the kinetic theory, from 1880 to 1895, was perceived to be in decline by its critics. It could not generate any new predictions and some of its fundamental assumptions were undermined by experiment.⁶ Two were the major problems confronting the kinetic theory at the time: the experimental refutation of its predictions about the ratio of the specific heat of a gas under constant pressure to its specific heat under constant volume and the apparent incompatibility between the reversibility of the microscopic behavior of colliding particles and the irreversibility of macroscopic phenomena as implied by the Second Law of Thermodynamics. Furthermore, the statistical explanation of the Second Law of Thermodynamics, used by proponents of the kinetic theory in order to explain the reversibility problem, clashed with the program of phenomenological thermodynamics, which, at the same time, was developing as a successful alternative to the atomic–kinetic program.⁷ The perceived decline of the kinetic program and the rise of phenomenological thermodynamics has been used by some historians in order to argue that the opposition to the kinetic theory of gases did not originate from a positivistic philosophy of science; instead, it was the scientific problems faced by the atomic theory of gases that gave rise to positivistic or instrumentalist attitudes towards physical theories.⁸

This traditional debate concerning the nature of 19th century atomic debates has recently become more complicated due to historiographical developments concerning the status of chemical atomism. Historians have challenged the traditional account which saw the determination of relative atomic weights as the main requirement for 19th century chemical atomism and took the resolution of the debate about the correct method for arriving at definitive atomic weights in the 1860s as providing strong evidence for the molecular constitution of matter. They have dissociated the atomic hypothesis from the development of unique atomic formulae and the determination of 'atomic weights'. Alan Chalmers, for example, argues that "developments in 19th century chemistry paved the way, rather than constituted a case, for an experimentally based and testable version of atomism."⁹ According to Chalmers, "nineteenth century chemistry made less experimental contact with atoms than typically supposed."¹⁰ Paul Needham has gone one step further claiming that, during the course of the nineteenth century, Daltonian atomism was mostly an ad-hoc, non-explanatory theory that lacked any empirical evidence in its favor besides

the phenomena it was purported to explain. For Needham, the phenomena of isomerism and the notion of atomicity were not predictions of the atomic hypothesis, but discovered and developed empirically; moreover, they could be explained and endorsed at the time without any commitment to atomism.¹¹

Another related historiographical development has to do with a relatively recent challenge of the traditional portrayal of Duhem's philosophy as positivist or instrumentalist of a conventionalist type. Roberto Maiocchi, for example, has argued that the main intent of Duhem's philosophy of science "was to oppose instrumentalism, subjectivism, and the devaluation of the cognitive power of science."¹² At the heart of this reinterpretation of Duhem's philosophy lies his concept of 'natural classification' (*classification naturelle*). It is true, argue the proponents of the new interpretation, that Duhem repeatedly insisted that physical theories are not an explanation but a classification of experimentally established laws; however, he explicitly maintained that the ultimate aim of physical theory is to establish a *natural classification* of these laws. That is to say, for Duhem, physical theory is converging towards a natural classification of experimental laws which, by reflecting the underlying metaphysical order, provides us with information regarding the unobservable realities.¹³ Indeed, in *La Theorie Physique* Duhem also claimed that:

physical theory is not merely an artificial system, suitable today and useless tomorrow, but ...an increasingly more natural classification...the aim of physical theory is to become a natural classification, to establish among diverse experimental laws a logical coordination serving as a sort of image and reflection of the true order according to which the realities escaping us are organized.¹⁴

If Duhem was a conventionalist, some scholars argue, why was he so strongly opposed to the instrumentalist use of models in physics? If a positivist, why was he insisting in the existence of an underlying metaphysical order and arguing that physical theories should reflect the true relations among unobservable realities? They also call attention to the fact that Duhem's resistance to atomism, at least during the first phase of his career (1892–1902), was based on scientific argumentation. Their conclusion is that Duhem's concept of natural classification was compatible with knowledge of unobservable entities. For them, Duhem's critique of atomic theories was not directed to scientific explanation and scientific atomism *per se*, but against a non-scientific, a priori, metaphysical atomism, on the one hand, and the use of atomistic models as heuristic instruments, on the other.¹⁵

It is a mistake to trace Duhem's hostility to atomism and mechanism to his rejection of the conception of physical theories as explanations.... He did not think that atomism and mechanism could not possibly be made good, only that they have not been (and that there was a better alternative available)¹⁶ [i.e., generalized thermodynamics].

For these authors, Duhem's philosophy of physics was fully compatible with belief in hidden entities and his resistance to atoms was not due to any opposition to scientific explanation or obsession with observability, but to the fact that, at the time, both physical and chemical atomism did not play any explanatory in

⁵ Nyhof (1988), p.82.

⁶ For an overview of the problems facing the kinetic program see Clark (1976) and Fleck (1963).

⁷ Clark (1976).

⁸ Clark (1976), p.44.

⁹ Chalmers (2009), p.188; see also Klein (2003).

¹⁰ Chalmers (2009), p.215.

¹¹ Needham (2004).

¹² Maiocchi (1990); see also Maiocchi (1985), especially the Introduction.

¹³ Lugg (1990).

¹⁴ Quoted in Lugg (1990), p.410.

¹⁵ Maiocchi (1985, 1990) and Lugg (1990).

¹⁶ Lugg (1990), p.412.

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