Old Quantum Theory and Theory Pursuit

Abstract

The development of quantum mechanics was clearly one of the great breakthroughs in the history of physics. However, the 'old quantum theory' of 1900–1925 was plagued by uncertainties, and even inconsistencies. Despite these problems, scientists became very interested in pursuing the theory, to our great benefit. The study of this period should thus help us to identify and understand the factors that contribute to scientists' decisions for pursuing a developing theory and the kinds of theoretical factors that indicate that a theory is promising. Although the history is well-documented, there has been less in the way of philosophical discussion of the old quantum theory in this context. This paper is intended to contribute to the topic of what makes a developing theory worth pursuing, even if the theory is unacceptable in its current form. I argue that a reconstruction of the theory's development in those stages reveals that the unificatory power of the quantum hypothesis provided an epistemically significant reason for pursuing the old quantum theory though not necessarily for accepting it, where 'the quantum hypothesis' refers to the hypothesis that quantities of "action" (given in units of energy*time) come only in integral multiples of a fundamental discrete quantity, now called Planck's constant h.

The idea that unification is a virtue of a scientific theory has a long history, and has been presented in several guises, from William Whewell's work on the Consilience of Inductions, to Michel Janssen's account of common origin inferences. While the details of such discussions may differ, some version of this notion has clearly played a role in several important episodes of scientific theorizing. An examination of the particular kind of unification that was in play during the development of old quantum theory caan provide us with an analysis of the kinds of unificatory features that are important to pursue in developing theories. By drawing on William Harper's characterization of Newton's scientific method, I will argue that we can understand the appearance and use of Planck's constant in several different contexts in physics as an instance of agreeing theory-mediated measurements of a theoretical parameter, and that the idea of this new theoretical parameter — the quantum of action — as a fundamental physical quantity gained ground when there were multiple agreeing measurements of and constraints on the value of this parameter coming from different areas of physics. I will discuss what I take to be an important feature of these various lines of evidence, which is that they

possessed varying degrees of independence from one another, which strengthened the case for the quantum hypothesis. That such agreeing measurements are epistemically significant is supported by the existence of elements of the old quantum theory that were retained in the new quantum mechanics, *e.g.* the appearance and numerical value of h.

The literature on theory pursuit tends to follow a tradition that treats scientific theories more holistically. I would like to follow a turn in confirmation theory which evaluates individual elements of theories rather than entire theories as units, but to consider this in the context of theory pursuit rather than in a context of acceptance and non-acceptance. I hope to contribute to the literature on theory pursuit by helping to determine how it is possible to consider individual elements of a theory as being worthy of pursuit in certain contexts, rather than evaluating a developing theory as an entire framework.