A literary approach to scientific practice

Hughes, R. I. G. (2010). *Theoretical practices of physics: philosophical essays.* Oxford University Press. 289 pp, £35.00, US$75.00 HB

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R.I.G. Hughes' book *The Theoretical Practices of Physics* presents an interesting approach to the philosophy of science, by analysing particular texts in the physics literature (journal articles, textbooks, classic works) in much the same way literary criticism analyses novels, poems and so on. Often when philosophers look at scientific texts, they seem to abstract away from what is actually said in order to extract the "theory" and then philosophise on the basis of this rarified object. Hughes' approach is to look at what physicists really write and see what conclusions to draw on that basis. In his own words: "I shall examine the theoretical practices as they appear in physics journals... I treat the publications as texts; and thereby cast the philosopher of science in the role of critic" (p.5). What then, is the purpose of this exercise in criticism? Hughes suggests that this approach allows us to address the following question: "given these practices are successful, what is the nature of their success?" (p.6). His project is descriptive, namely to analyse what it is that physicists are actually doing when they are theorising. This serves as a compelling corrective to philosophical reconstructions of science. For example, the idea of a physical theory as a set of sentences in a logical language is simply not borne out by theoretical practice. So in studying how physicists really behave, incorrect philosophical theories, such as this one, can be ruled out.

There are a couple of clarifications to make regarding the subject of this book: it is more philosophy of science than it is philosophy of physics. That is, despite its exclusive reliance on examples from physics, the conclusions drawn are certainly more "general philosophy of science" rather than, say, foundations of quantum mechanics. Another point to make is that the book relies almost entirely on theoretical physics; this is something Hughes is explicit about. A final point to make before going into detail is that the book does not aspire to be an exhaustive overview of theoretical practices in physics. For example, Statistical Mechanics (apart from Condensed Matter Physics) and Dynamical Systems Theory are almost entirely neglected. This isn't supposed to be a

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criticism, just a warning that the book does not provide a systematic overview of theoretical practices.

The first of the eight chapters introduces the project of "philosopher of science as critic" and discusses Einstein's explanation of the perihelion of Mercury using relativity. The second chapter is an extended case study of theoretical practice. It discusses condensed matter physics in excruciating detail. It focuses on four papers by David Bohm and David Pines, called collectively the "Bohm-Pines quartet". Bohm's and Pines' aim was to explore the behaviour of electrons in metals: how the conductive properties of metals arise out of the interactions of the individual electrons in them. Hughes discusses in great depth the various moves that Bohm and Pines make in their papers: the assumptions they rely on, the idealisations they make, the abstractions they use, their various simplifying moves and rhetorical shifts. Chapter 3 uses parts of Newton's Principia to discuss various views on laws of nature. Hughes favours a view of laws that depends on his views on models and representation, and he argues that Newton's remarks in the Principia on the laws of motion can be read this way. Drawing on Ronald Giere's "semantic approach" (See Giere, 1985, for example), a theory consists of "a specification of a class of models... and the hypothesis that a certain part of the world... [is] adequately represented by a model from this class." (Hughes p.104). Newton's laws of motion are then understood as saying something about this collection of models, and thereby rise above the standard criticisms of lawhood. Chapter 4 tackles the disunity of physics by looking at how physicists actually dealt with it in various historical episodes. These various coping strategies are assessed in reference to some remarks of Decartes' on scientific method, namely the suggestion that one can reason backward from effects to causes when one cannot derive what is needed from first principles. Chapter 5 discusses Hughes' preferred account of representation: the DDI account. This stands for Denotation, Demonstration and Interpretation. Hughes identifies three components of scientific modelling and builds an account of representation that takes these processes as its basis. Hughes uses an example from Galileo's *Discourses Concerning Two New Sciences*: Galileo's geometrical demonstration that a uniformly accelerating object covers the same distance in the same time as that object moving uniformly, provided that the final velocity of the accelerating object is twice the velocity of the one moving at a constant rate. Chapter 6 explores critical point phenomena and the Ising model. Hughes discusses the increasing use of computers in physics, as calculating tools but also as modelling tools for developing simulations. One of Hughes' aims in this chapter is to show how simulation fits into the DDI account of modelling given in chapter 5. Chapter 7 tackles another big philosophy of science question: theoretical explanation. Arguably explanation has already been discussed on a few occasions in the book: Einstein on Mercury's perihelion in chapter 1 and Galileo's geometrical proof in chapter 5 at least. Hughes makes explicit some things left implicit in those earlier discussions. He uses Newton's explanation of the rainbow in terms of geometrical optics as a case study. The final chapter analyses a famous paper by Aharanov and Bohm in which they predicted what became known as the "Aharanov-Bohm effect".

Here Hughes' quirky take on things comes to the forefront: the structure of the paper is compared to the structure of a popular song, and scientific discourse is likened to commedia dell'arte.

The "philosopher of science as literary critic" idea is an interesting one. I think it is important that philosophers of science allow themselves to be influenced by what it is scientists actually *do*. For example, the second chapter, on the Bohm-Pines quartet, lists a great many assumptions, idealisations, abstractions and the like that the authors help themselves to in order to make the problem tractable. This seems to tell against simple philosophical accounts of explanation, since the conclusions they draw based on the heavily idealised systems do seem to help explain the phenomena despite the many layers of abstraction. Hughes' discussion of the Ising model (chapter 6) is also relevant to philosophical discussions of models and idealisation. Through studying the physics in detail, Hughes can make clearer what sort of philosophical claims are or aren't warranted by the theoretical practices under consideration. Newton's explanation of the rainbow in chapter 7 in terms of a particle theory of light is an interesting example of how an obsolete theory can still help us understand phenomena, and this gives the lie to the idea that superseded paradigms are completely intellectually barren. These are, I think, interesting contributions to philosophy of science.

What strikes me as a little strange about this book is that there are places where Hughes could have (or perhaps even should have) discussed some standard philosophical subjects. The book is subtitled "Philosophical Essays" and there are some strange omissions in Hughes philosophical treatment of the areas he considers. Take, for example, his discussion of the DDI account of theoretical representation. While it's true that Denotation, Demonstration and Interpretation do, on some level, cut theoretical practice at the joints, there is no argument that this particular classification of procedures involved in representation is somehow privileged. That is, nowhere does Hughes argue that DDI is the best way to precisify what it is that happens when we represent a system. But more troubling than this is that Hughes doesn't attempt to answer the real question driving the philosophical discussion of representation: "How are we able to represent the world in such a way that we can successfully predict its future and manipulate it?" Denotation, Demonstration and Interpretation are three things scientists do, but that doesn't explain why these things help us learn about the world. Philosophers are interested in what kind of things models are. They are interested in how models help us learn about the world. And these questions don't seem to be addressed. And given that Denotation, Demonstration and Interpretation are all things scientists do to the world, as it were, it doesn't look like this is a promising approach if what we want to know is how these sorts of procedures are successful. One of Hughes' stated aims was to study the question "given these practices are successful, what is the nature of their success?". So it is unsatisfying that Hughes stops short of saying much in this regard.

Another example of the same reluctance to engage with standard debates is the case of scientific realism. In several places Hughes mentions that physi-

cists often talk and behave in naively realist ways: they use causal talk and they write and behave to all intents and purposes as if their ontology included electrons, fields and so on. Since Hughes' project involves taking seriously what physicists say and do, then not properly commenting on this near universal sociological fact seems strange. In chapter 8 he does indirectly comment on the issue, suggesting that naive realism is a way to facilitate discussion between, say, theorists and experimenters. What this amounts to is the idea that what a theorist really means by "electron" differs from what an experimenter really means by "electron", and the naive realist talk is a way to facilitate discussion between them. So a theorist thinks of electrons as some theoretical-mathematical construct with certain properties like spin, momentum, mass, charge and so on. An experimental physicist might have in mind a rather different idea of an electron; perhaps as some cluster of experimental phenomena like particular interference fringes, ammeter readings or what have you. Hughes, borrowing from Galison (1997), suggests that naive realist talk plays the role of a pidgin language in "trading zones". This seems a nice idea, but does it really apply across all of science discourse? And is this all there is to say on the realism debate in the light of the practices of physicists? Does this explication of scientists' realism give us any insight on the "no miracles" intuition that is often cited as a motivation for being a realist? It has always struck me as unsatisfying to respond to this challenge of scientists' naive realist talk by saying "OK, but we don't need that stuff in our ontology, so we should be able to paraphrase away everything they say about electrons". That seems to be totally unmotivated. If philosophy of science is going to be informed by science at all, I think we have to take scientists' realist talk seriously. Hughes is certainly in the business of taking scientists' practices seriously, so it seems that there is more he should say on this topic.

Another example of this problem is the discussion of disunity in chapter 4. Hughes spends a lot of time classifying different types of disunity that appear in physics and how physicists deal with them. Is there any philosophical import to the distinctions he draws? He does not say, and it is difficult for me to judge without a better understanding of the physics. Since Hughes has clearly done the work to understand the physics, it seems odd that he is so reluctant when it comes to drawing these kinds of philosophical conclusions. That's not to say that the clarifications of different notions of disunity isn't useful in itself, but Hughes seems to be pulling his philosophical punches.

It seems that the high level of physical knowledge required to follow large parts of the book is not proportional to the extra philosophical insight thereby gained. That is, simpler physical examples would have made the same philosophical points. The discussion of the Bohm-Pines quartet is especially redolent of this sort of overkill. The main philosophical points one can draw — that scientists are often naively realist, that theorising involves a whole host of simplifying moves, but is none the less explanatory for it — are points that could be made without pages of heavy duty physics exposition.

Perhaps I am being uncharitable. Maybe we should see this book, not as philosophy per se but as being in the neighbourhood of the project that Chang

(2004) calls "complementary science". Complementary science is supposed to be continuous with science, and this seems to fit with Hughes' own sensibilities; his own apparent straddling of the area between philosophy of science and the science under study. Hughes' project is not the same as Chang's: Chang is interested in exploring unfashionable ideas from the history of science, whereas Hughes is exploring successful ideas in current science (or old ideas still considered respectable by modern standards). But in each case, the aim is to have philosophically literate engagement with science with the hope of advancing our understanding of it. So the focus is on understanding science in its own right, with philosophical concerns being only secondary.

The order of the chapters sometimes creates difficulties. For instance, given that the DDI account is central to chapter 3, it seems strange to only have it properly introduced in chapter 5. This undermines the force of Hughes' discussion of Newton on laws of motion, since too much of the work is deferred to chapter 5 for it to make sense on its own. There are also a couple of places in the book where Hughes refers to a ninth chapter that does not appear in the book. At the end of the first chapter (p.26) he refers to Essay 8 "and those on either side of it". The eighth essay is the last one. The blurb on the dust jacket refers to a final essay that "draws out the implications of the earlier essays for the thesis of scientific realism" but no such essay exists.

People familiar with Hughes' work may notice that some of these chapters are just reworked versions of his published papers. Chapter 5, for example, shares the majority of its content with his 1997 paper "Models and Representation". Chapter 4 in a slightly earlier form was available in Earman and Norton (1998). Chapter 6 appears in Morgan and Morrison (1999). The fact that these substantial chunks of the book appear elsewhere is not recognised anywhere in the book.

Despite these quirks, this is an interesting book. Hughes has an ability to explain physics, and has chosen examples outside the normal physics examples that philosophers discuss. So as a philosophically informed introduction to condensed matter physics or critical point phenomena this is a good book. As a novel take on classics like Newton's Principia or Galileo's Discourse, there is also new material here. But as I said, the approach taken isn't orthodox philosophy of science. I'm not completely sold on the "philosopher as literary critic" idea, but despite that Theoretical Practices of Physics is an engaging and illuminating read.

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