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The physical salience of non-fundamental local beables

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ABSTRACT

I defend the idea that objects and events in three-dimensional space (so-called local beables) are part of the derivative ontology of quantum mechanics, rather than its fundamental ontology. The main objection to this idea stems from the question of how it can endow local beables with physical salience, as opposed to mere mathematical definability. I show that the responses to this objection in the previous literature are insufficient, and I provide the necessary arguments to render them successful. This includes demonstrating the legitimacy of dynamical considerations in the derivation of local beables and responding to the threat stemming from the availability of different sets of local beables in the context of the GRW theory.

1. Introduction

A central issue in the debate on the ontology of quantum mechanics concerns the status of objects and events situated in three-dimensional space, the so-called *local beables*. According to one camp in the debate, to which I will refer as *primitivist*, local beables need to be postulated at the fundamental ontological level, thus specifying what has come to be known as the *primitive ontology* of the theory (see Allori, 2015 for an up-to-date review of this approach). Its opponents, whom I will call *reductionists*,[1] deny the need for such postulates, because they hold that insofar as we need local beables to account for our experience of a three-dimensional world, they are reducible to a fundamental ontology that does not include them. This fundamental ontology is given by the quantum state of the world and its temporal evolution, and the reductionists claim that certain features of this evolution manifest themselves as three-dimensional structures.

Some reductionist approaches appeal to functional roles of (parts of) the quantum state (Albert, 2015, chaps. 6 & 7), some to real patterns in its evolution (Wallace, 2012, chap. 2), and some to symmetries (Ney, forthcoming), but these differences do not matter here. My purpose in this paper is rather to defend the general idea of non-fundamental local beables against some criticism from primitivists, in particular the critique by Maudlin (2007). I do not advocate any particular account of how to reduce local beables to the quantum state, but I aim to show that some of the principled worries voiced by primitivists against these accounts are unfounded.

The paper is structured as follows: In Section 2, I will clarify the different positions in the debate and spell out what I take to be the main challenge for reductionism about local beables, namely the need to account for the physical salience of (non-fundamental) local beables. Sections 3 and 4 then discuss two responses to this challenge, the first one based on dynamical considerations, the second one on the empirical significance of local beables. In each of these two sections, I will first show why earlier responses along the same lines were incomplete, and then provide the necessary arguments to render them convincing. This will lead to the conclusion (in Section 5) that the reductionist can successfully deal with the challenge issued by the primitivist.

2. Preliminary distinctions

2.1. Informational vs. ontological completeness

In order to analyze the ontological status of local beables in

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[1] I introduce this label because all the other labels that have been attached to this camp in the previous debate strike me as somewhat inaccurate. For example, the position is often dubbed "wave function realism", but this obscures the fact that also the primitivist approach is compatible with some varieties of realism about the wave function (or more precisely, about the quantum state represented by the wave function; see Belot, 2012; Egg & Esfeld, 2015). The term "wave function monism" would be more accurate, but it would exclude Albert's (1996, 2015) version of Bohmian mechanics, which is explicitly opposed to primitivism. The recently proposed term "3N-fundamentalist" (Chen, forthcoming) is almost perfect, but it fails to capture Wallace's (2012) spacetime state realism, which is another important foil for primitivism.

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relation to the quantum mechanical wave function, Maudlin (2007) introduces the crucial distinction between *informational* and *ontological* completeness. A description is informationally complete "if every physical fact about the situation can be recovered from the description" (p. 3151). By contrast, "an ontologically complete description of a physical situation should provide —in a relatively transparent way—an exact representation of all of the physical entities and states that exist. … [It] should say just what there is and no more" (p. 3154). As an initial illustration of this contrast, Maudlin mentions the scalar and vector potentials of classical electrodynamics, which furnish informationally complete descriptions, but are usually not taken to directly describe the physical ontology of the classical electromagnetic theory (p. 3152).

To further clarify the relevant distinction, Maudlin shows that it can also be framed in terms familiar from other philosophical debates, namely *nomic supervenience* and *ontological reduction*[2] (pp. 3152–3153): Let A be an informationally complete part of a description B of a certain situation. Then B nomically supervenes on A in the sense that there cannot be a difference in what is described by B without a difference in what is described by A. This is to be distinguished from the claim that the referents of B are ontologically reducible to the referents of A, which is to say that A is ontologically complete.

The relation between informational and ontological completeness (or, equivalently, between nomic supervenience and ontological reduction) is a complex one, as Maudlin (2007, p. 3153) illustrates by giving some examples of informationally complete descriptions which differ radically with regard to ontological completeness. On one end of the spectrum are cases where informational and ontological completeness clearly go hand in hand, as when the tables in a room are described in terms of the distribution of atoms in the room: not only are all the facts about tables recoverable from a complete description of the atoms, but the tables "are nothing *over and above* the atoms" (Maudlin, 2007, p. 3153). On the other end of the spectrum is the case of a deterministic universe, where the entire history of the world supervenes on the global physical state of the world at one particular moment (given the dynamical laws), but no one would claim that this history is nothing over and above the state at that one moment. In other words, the description of the state of the world at one particular instant is informationally but not ontologically complete. Between these two extremes, there are controversial cases such as the description of the electromagnetic field in classical electrodynamics: it is informationally complete in the sense that all the facts about the charge distribution can be recovered from a full description of the electromagnetic field (given Maxwell's equations), and this might suggest, but does not imply ontological completeness. As Maudlin puts it: "The attempt to somehow reduce charges or charged particles to nothing but states of the field does not seem crazy, but neither does it seem inevitable" (Maudlin, 2007, p. 3153).

Applying this distinction to versions of quantum mechanics without additional variables, we may (neglecting some subtleties mentioned in (Maudlin, 2007, footnote 3) assume that the description given by the wave function is informationally complete. The central question then is whether it is ontologically complete as well. Maudlin's negative answer to that question is based on two claims: (1) a reasonable ontology for a physical theory must contain local beables and (2) it is not clear how local beables could be ontologically reduced to (or derived from) the quantum state.

[2] Neither Maudlin nor the other participants in the debate are very explicit about the notion of reduction they presuppose (Ney, 2013 being an exception). The common practice of using "reduction" and "derivation" interchangeably (which I will also adopt in what follows) indicates that some broadly Nagelian picture constitutes the background for the debate.

2.2. Eliminative vs. conservative reductionism

The three basic options regarding the ontological status of local beables are summarized in the following table:

	Local beables exist:	They are fundamental:
Eliminative reductionism	No	No
Conservative reductionism	Yes	No
Primitivism	Yes	Yes

The distinction between eliminative and conservative reductionism is not always properly drawn, because there is some ambiguity in the notion of "ontology". On a restrictive reading, the ontology of a theory only includes what is fundamental. On a more liberal reading, it includes whatever is real, be it fundamental or derivative. At some points Maudlin clearly adopts the second reading, otherwise the very notion of "derivative ontology" (discussed in p. 3161 of his paper) would be oxymoronic. But then sometimes he also sympathizes with the restrictive reading, according to which, unless one introduces local beables as elements of fundamental ontology, they "do not really exist" (p. 3163) and "all of this talk of local beables in ordinary space is just a fiction" (p. 3165).

One might think that this is just a verbal issue: The primitivist's core claim is that local beables are ontologically fundamental, and both brands of reductionism deny this. Does it then really matter that one of them still calls the local beables "real" (or "existing"), while the other one views them as fictions? I think it does, but I also think that there is a legitimate way of treating eliminative and conservative reductionism together in the present context. So let me first explain why we must acknowledge the difference between these two reductionist positions, before I argue (in the next subsection) that the difference can be neglected for the rest of this paper.

Notice first that the debate about the ontological status of local beables is a debate between scientific realists, who generally believe that the entities we posit in our successful scientific explanations really do exist (although they disagree sharply about which entities are actually posited by quantum mechanical explanations). Now since most of our scientific explanations seem to involve local beables, eliminativism about them has not been a very popular position in the debate.[3] I am not here concerned with the question whether this lack of popularity is justified or not, but I want to highlight a consequence of this situation for the debate between primitivists and reductionists: under such circumstances, primitivism can be made to look much more convincing if it is presented as an alternative to eliminative reductionism than if the foil is conservative reductionism. But this would be an illegitimate move, because it would allow the primitivist to attack reductionism by means of arguments that only work against its eliminative variant.

Unfortunately, this is precisely what happens in the following passage, where Maudlin (2007, p. 3166) mistakes an argument in favor of the *reality* of local beables for an argument in favor of their *fundamentality*:

[3] I know of only two instances in the literature where eliminativism about local beables is advocated, namely Albert (1996) and Ney (2015, Section 7). But even these authors, in other parts of their work, at least implicitly acknowledge the relative attractiveness of conserving local beables instead of eliminating them (see, in particular, Ney, forthcoming, p. 1 & fn. 10).