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Michael Esfeld & Dirk-André Deckert, *A Minimalist Ontology of the Natural World*. New York /Abingdon: Routledge, 2018.

An aesthetic preference for the minimal is widespread within contemporary metaphysics: consider Sider's mereological nihilism, Paul's mereological bundle theory, Lewis's Humean Supervenience, Quine's desert landscapes. Even in this climate, the ontology proposed in *A Minimalist Ontology of the Natural World* is strikingly austere. It is also strikingly ambitious: Michael Esfeld and Dirk-André Deckert (along with their collaborators Dustin Lazarovici, Andrea Oldofredi, and Antonio Vassallo) propose a systematic metaphysics of nature and argue that it will be adequate to underwrite any possible future physics. The basic elements of the system, which they call Super-Humeanism, are indestructible featureless objects (referred to as "matter points", though there is little recognisably material about them) that are related together in (and individuated by) a changing pattern of spatial distances.[1] Everything else reduces to, or is grounded in, that pattern. The view is squarely in an atomist tradition that the authors trace back via Feynman and Newton to Democritus and Leucippus.

The book proceeds through dauntless construction of the positive Super-Humean view. Arguments for the view are offered, but theory-building is the main focus. In Chapter 2, the authors set out a sparse framework of primitive metaphysical ingredients, and outline a general recipe for interpreting physical theories in terms of that framework. This recipe is illustrated by application in Chapter 3 to Newtonian gravitational theory, classical electrodynamics and non-relativistic quantum particle dynamics, and — most courageously — in Chapter 4 to quantum field theory. Chapter 5 explains how relativistic physics is handled.

1 The book's cover evokes one such pattern, featuring a sparse network of yellow and blue nodes linked by yellow and blue lines. Even this sparse image overstates the content of the super-Humean ontology, however; Esfeld and Deckert allow only for one kind of basic entity standing in one kind of basic relation.

As already noted, the Esfeld-Deckert framework has a strikingly minimalist aesthetic. This is not, however, the same sense of "minimalist" intended in the book's title. Super-Humeanism is represented as minimal in a more literal way: it is argued that there is no way to reduce the ontology further while remaining empirically adequate. As I shall explain, however, this claim is less ambitious than it may first appear. The proposed framework is put forward as a local minimum in theory space rather than as a global minimum. Moreover, the very idea of a global minimum is of dubious coherence, since different dimensions of minimality may be incommensurable. I shall return to these points below.

What then is the world like according to Esfeld and Deckert? It consists of "matter in space and time", "subject to certain laws, explain[ing] the observable phenomena". Matter is taken to be basic: no reduction of it to anything else (such as quantum field configurations) will be countenanced, and matter can neither be created nor destroyed. Spatial relations are likewise taken to be basic: no reduction of them to anything else (such as spin networks in loop quantum gravity) will be countenanced. Temporal relations are not quite basic, though change is. The choice of spatial relations and change as distinct basic notions renders the view non-relativistic at the deepest level, though relativistic physics is emulated at a non-fundamental level. This is a significant point of departure from other versions of Humeanism in the literature (such as those of David Lewis and Barry Loewer) that generally take spatio-temporal relations as basic, and are formulated in a timeless (eternalist) fashion. Super-Humeanism, in contrast, incorporates a form of presentism.

Why assume changing spatial configurations of objects as the basic ingredients? The authors' primary reason lies in a distinctive conception of our evidence: "We adopt an empiricist attitude in insisting on the fact that all the experimental evidence consists in relative particle positions and motion" (12). The idea is that spatial distance has a unique epistemological role: any evidence (or at least, any evidence that we can obtain) ultimately boils down to evidence about spatial arrangements of particles. The idea is that when we take readings from an analogue instrument, what we are really doing is comparing the position of a pointer with the position of markings on a background scale, and that when we take readings from a digital instrument we are really comparing the relative positions of bright and dark pixels. Even observation of the colours of things is explained in terms of positions of particles: "the frequencies that we usually identify with red light or blue light or green light are taken to refer directly to accelerations of particles" (136). In

prioritising the epistemic role of position, Esfeld and Deckert align themselves with a tradition that has come to prominence in recent philosophy of physics, inspired in large part by the work of the physicist John Bell: the so-called *primitive ontology* programme. According to primitive ontologists, the physical world consists of what Bell called "local beables" — localized definite states of affairs, independent of goings-on at other locations. Bell endorsed the epistemic primacy of position measurements, and this line of thought has influenced the work of philosophers such as Valia Allori, Sheldon Goldstein, and Tim Maudlin.

I am sceptical of the arguments offered, in this book and elsewhere, for the epistemic primacy of position. Obviously, once we accept the Super-Humean ontology all evidence becomes evidence of relative position of particles: if everything is made of spatially-arranged particles, then there is nothing else for evidence to be about. Just as obviously, it would be problematically circular to use this point to argue for the Super-Humean ontology. For those who don't antecedently accept a particle-only ontology, it seems that our evidence might in principle take many forms: an example which sometimes comes up in conversation is a measurement device which encodes its readings in the frequency of light that it emits. The epistemic primacy of position requires that we reconceptualize all such evidence as being evidence of position in disguise (as in the quote above from p. 136); however, the same trick could equally be turned to prioritize other physical properties. When we give priority to evidence about position, what we are doing is picking out a particular feature of a long causal chain from measurement to conscious perception and identifying that particular feature — the positions of some key particles — as what the evidence really consists in. But other features of the chain might be prioritized instead, features more congenial to non-particle ontologies. For instance, essentially every causal chain that results in a conscious perception involves electromagnetic interactions at the boundaries of some neurons. Why not identify the electromagnetic field in some suitable region as what our evidence really consists in? While this line of objection could be pursued further, I shall set it aside for the remainder of this review. It is, after all, commendable that the authors should be so clear about the intended epistemological foundation for their metaphysical constructions.

Another component of the Esfeld-Deckert framework seems to have purer metaphysical motivations. The framework is relationist, in the sense that space and time themselves do not exist as independent entities. What we have is a pattern of spatial relations connecting objects. But the objects thus

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connected are not conceived as existing independently of the relations they stand in; rather, their existence and identity depend upon their position in the network of relations. The authors thus defend the "moderate structural realism" familiar from Esfeld's previous work with Vincent Lam (2008). According to moderate structural realism, objects and relations are mutually dependent: the basic objects are dependent upon relations (which individuate them), while the basic relations are dependent upon those very objects (in order to have something to hold between). This view, while interesting, is considered speculative even within the open-minded field of metaphysics of science. It has some peculiar consequences, including the exclusion — as metaphysically impossible — of globally symmetrical patterns of spatial relations (mirror universes). Most of the physical theories which the authors consider would seem to have models corresponding to these mirror scenarios, and ruling them out as metaphysically impossible (essentially on grounds of convenience) strikes me as rather ad hoc or at least as a departure from the naturalistic outlook. There is also a hint of a double standard when proposals by Belot and Barbour are criticized for excluding the apparent physical possibility of the universe having non-zero angular momentum (67). Fortunately, moderate structural realism only plays a limited role in the overall framework, and it can be factored out of the view relatively straightforwardly if desired, as George Darby (2018) has argued.

It is no great surprise that an ontology of persistent particles fits well with Newtonian mechanics: Newton imagined a world composed of particles (or corpuscles), and presented his mechanics as a theory of such a world. Although the application of a particle-only ontology to non-relativistic quantum mechanics might seem much more surprising (what about the quantum state?), it will be familiar to philosophers of physics from versions of Bohmian mechanics which regard the wavefunction as nomological in nature.[2] It is even more of a surprise to find a particle-only ontology paired with quantum field theory, and indeed the interpretation of QFT that is offered by Esfeld and Deckert (building on the Wheeler-Feynman absorber theory) has some very strange features. There are no such things as photons, or Higgs bosons, or indeed any bosons at all; there are only distinctive patterns of motions of fermions. Fermions are never in fact created or annihilated: they only become detectable or undetectable. The number of particles is fixed and finite; making

2 Indeed some extant versions of Bohmianism come very close to the Super-Humean position — see for example Miller (2014) and Bhogal and Perry (2017).

it variable or infinite introduces deep pathologies into the theory. Here is not the place for a thorough assessment of the proposed particle-based approach to QFT; for critical discussion, see Caulton (2018). Still, it is worth noting how radically QFT is here being reimagined. If Esfeld and Deckert are correct then the large majority of foundational work on QFT (in regarding particles as emergent and quantum fields as basic) is misconceived, and the intuitive pictures used by working quantum field theorists are deeply mistaken. Unfamiliar though the particle-based approach is, the application of the primitive ontology picture to QFT is developed in an admirably clear and thorough way by Esfeld and Deckert, and it is one of the most significant contributions of the book.

I return now to the question of ontological minimality and how to assess it. Distinguish two senses in which a philosophical proposal can be minimalist: minimalist in the design sense and minimalist in the literal sense. Minimalist in the design sense is the meaning of the term that will be familiar to a general readership: an aesthetic preference where less is more. Minimalist in the literal sense, by contrast, is a bold theoretical claim: to say of a metaphysical system that it is minimal in this sense is to say that no system is objectively more parsimonious than it is, that no system entails the existence of objectively less stuff than it does. While it is undeniable that the Esfeld-Deckert view is design-minimalist — there is austere beauty in their image of the world as an intricate dance of particle motions, a silent choreography of changes in relative position of pointlike elements —, it is open to question to what extent it is literal-minimalist. On closer inspection, it emerges that the positive claim that the authors wish to make is more restricted than some of the very ambitious claims that might be attributed to them based on the book's title. Esfeld and Deckert argue that subtracting any elements from their view renders it inadequate (which is plausible) and that taking their view and adding additional elements won't help (which I think is doubtful,[3] but which I will grant for present purposes). Even if they are correct about both these points, though, what this shows is that Super-Humeanism is a local minimum of complexity in the space of empirically adequate fundamental theories. It does not establish the stronger claim that the view is the global minimum of that

3 My main reason for doubt is that the book contains no sustained argument that the Super-Humean system is adequate to support the explanatory needs of higher-level science. Indeed, there is prima facie reason to suspect that it is unable to recapture the full explanatory role of physical state spaces. I say more about this problem in Wilson (2018), a companion paper to the present review; see also Lazarovici (2018).

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space — if such a minimum even exists. In discussions with the authors, they have clarified that only the local-minimum claim is intended; but for purposes of fundamental ontology, the global-minimum claim is of primary interest. To make a case for Super-Humeanism as a global minimum, it would have to be compared in some way with rival frameworks. This task is not attempted in the book; Esfeld and Deckert justify this via the claim that no fully-developed field-theoretic alternative fundamental ontology has been set out in the literature. Whether or not this is true, at least the general shape of such views is familiar from foundational discussions, and they can be compared in schematic ways with particle-based approaches. Nor do the authors provide any substantive discussion about what it takes to be minimal, and in particular they say nothing about how to compare minimality for theories that employ different kinds of entities. Super-Humeanism is undoubtedly more minimal than a view that encompasses everything asserted by Super-Humeanism, and in addition recognizes seventeen further scalar fields over spacetime, none of which interact with anything else. But the most interesting questions in the vicinity are not about how these two theories compare, but about how Super-Humeanism compares with other systematic proposals with a wholly different fundamental ontology — with a field-theoretic realism along the lines of Wallace and Timpson's "spacetime state realism" (2010), for example.

Overall, this book is a significant achievement and it will be a standard reference point in the literature on fundamental ontology. The Super-Humean view is set out with clarity, precision and honesty, and new ground is broken in the application of the primitive ontology programme to quantum field theory. The natural world as Esfeld and Deckert conceive it may seem a barren place to live, but careful attention to their vision is still likely to bear philosophical fruit.

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