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THE BARE NECESSITIES*

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We talk of material bodies being situated *in space* and of events as occurring *at times*. And once we are taught to think four-dimensionally, we talk of bodies having trajectories *through spacetime*. But how seriously are we to take this apparent reference to space, time or spacetime? Very seriously, according to a view known as substantivalism. On this view, the material history of the world plays out in a container that exists independently of its material contents. Substantivalists may disagree about the structure of this container, but they all agree that there is such a thing.

Is substantivalism true? This is in part an empirical question and some physical theories are considered more hospitable to substantivalism than others. So rather than ask whether substantivalism is true, many philosophers ask whether we should believe it conditional on the truth of this or that physical theory. Recent work has tended to focus on the issue as it arises in the context of the General Theory of Relativity (GTR) and in this context substantivalism is by far the received view.

Against this consensus, my aim here is to argue that substantivalism in GTR faces far more serious difficulties than has been recognized and that an adequate substantival theory fit to deal with these difficulties has not yet even been *formulated*, let alone defended. I will end with some suggestions about how we might formulate such a theory. So my aim is not to argue that substantivalism is false but rather that its status as the received view is premature: even if some substantivalist thesis does turn out to be correct, we have not yet seen what that correct thesis is. My claim generalizes to substantivalism in the contexts of other physical theories, but in keeping with the recent literature I focus on the case of GTR.

Why is substantivalism in GTR currently considered so unproblematic? I suspect it is because the objection to the view that is most often discussed is the Hole Argument, and this argument is widely agreed to fail. In particular, the Hole Argument makes assumptions about modality and determinism, and substantivalists have denied these assumptions by endorsing a modal view known as anti-haecceitism or else a certain conception of determinism (the former move

being the most popular). I agree that these are both reasonable responses to the Hole Argument. But the problem is that there are other serious objections to substantivalism that make no assumptions about modality or determinism at all. Defending substantivalism against these objections requires developing the view in a way that has not yet been done.

The idea behind these other objections will be familiar to many readers. For in the context of classical physics it is well known that various substantival views (such as Newton's) bring with them a commitment to *unobservable* and *physically redundant* structure, and this is universally regarded as reason to reject those views in favor of a weaker substantival view that dispenses with the offending structure (such as "Galilean substantivalism"). I will argue that analogous objections apply to the received substantival view in GTR. This suggests that we should develop a weaker substantival view that stands to the received view just as Galilean substantivalism stands to Newton's view. My claim, then, is that the received substantival view in GTR is no better than the Newtonian view of space is in classical physics.

Why have these objections that are familiar in other contexts been overlooked in the case of GTR? Perhaps because they are often presented as making modal assumptions that the substantivalist can deny by endorsing anti-haecceitism. So I will argue that when properly understood the objections make no essential appeal to modal assumptions and that even a substantivalist who endorses anti-haecceitism is vulnerable to them.

Indeed, one of the general morals of this paper is that modal considerations are largely irrelevant to the question of substantivalism, whether in the context of GTR or other physical theories. Admittedly, substantivalism has sometimes been characterized in modal terms. But I will argue that substantivalism (in any physical theory) is not at core a modal thesis but rather a thesis about *ground*. This much is often recognized in the literature. But what remains unappreciated is that if substantivalism is not a modal thesis then the best objections to it will not appeal to modal assumptions, and so modal claims like anti-haecceitism will not constitute responses to those objections. So the recent focus on modal considerations and the rush by substantivalists to endorse anti-haecceitism is, I think, something of a red herring.

I have tried to write for metaphysicians new to the literature on substantivalism in GTR, and also for philosophers of physics who are unfamiliar with recent developments in metaphysics that I will make use of. The result is a longer paper than I would have liked. But since much depends on how the question of substantivalism is understood, it makes sense to build the issue from the bottom up.

The paper is organized into four parts. Sections 1–2 argue that substantivalism is a thesis about ground. Sections 3–5 then discuss the Hole Argument and describe the standard substantivalist responses to it, all of which deny its assumptions about either determinism or modality. Sections 6–9 then show that substantivalism is vulnerable to other arguments that do not make those

assumptions about determinism and modality. Finally, Sections 10–11 suggest how we might go about formulating a new kind of substantivalism in light of these other arguments.

1. Newtonian Substantivalism

What is substantivalism in GTR? It will help to abstract away from the technicalities of GTR and revisit the well known debate between Newtonian and Leibnizian views of space in classical physics. Once that issue is properly understood, it will be easy to carry it over into GTR.

What then is the issue dividing the Newtonian and the Leibnizian? The Newtonian is said to think that space is a real substance: a three-dimensional, Euclidean object in which matter is situated. Against this substantivalist view, the Leibnizian thinks that reality of space as a substance is an illusion: all there really are, on this view, are bits of matter spatially related in certain ways, and any talk of space itself is to be understood in these terms.[1]

But what exactly is the disagreement between these two positions? Not whether space *exists*, for the Leibnizian may agree that space exists so long as she insists that it is somehow constructed or derived from the pattern of spatial relationships between material bodies. Instead, the disagreement is whether space is in some sense *independent* of the matter situated within it. This is a familiar point. As Sklar characterizes it, Newtonianism is the view that space 'can be said to exist and to have specified features *independently* of the existence of any ordinary material objects'.[2] But how is this notion of independence to be understood?

It is often understood in modal terms. Thus, the issue is sometimes said to be whether it is possible for space to exist without matter, with the Newtonian affirming and the Leibnizian denying this possibility. Alternatively, the issue is sometimes said to be whether it is possible for the entire material history of the world to have unfolded three feet to the right of where it actually did, again with the Newtonian affirming and the Leibnizian denying the possibility.[3]

But this does not adequately characterize the issue. For one of the main arguments for the Newtonian position is the famous 'Bucket Argument', according to which inertial effects can be explained only if the motion of a material body is understood to be motion relative to space rather than relative to other material bodies. Whatever the merits of this argument, the fact that the Newtonian uses it shows that the core of her view is that there are facts about a body's motion through space that are in some sense over and above the totality of facts about its motion relative to other bodies. But someone might agree with the Newtonian on this point and yet have other views about modality that have nothing to do with space *per se* but that nonetheless force her to deny the above possibilities that were said to be definitive of the Newtonian position.

For example, she might be a Spinozist who believes that everything true is necessarily true. The Spinozist I have in mind believes this not because of anything she believes about space but rather because she believes that all truths follow from the essence of God and that God is a necessary being.[4] This theorist would clearly deny that it is possible for space to exist without matter and deny that a uniform shift of all matter is possible, simply because her (perhaps quirky) views about religion imply that *nothing* non-actual is possible! Still, her Spinozist views have nothing to do with the issue that divides the Newtonian and Leibnizian and so need not prevent her from being led to think by the Bucket Argument that space is independent of matter in the relevant sense. Therefore, we should not define the Newtonian position as a belief in the above possibilities.

Or, to take a perhaps less extreme example, a Newtonian might also be a Quinean and deny that there is any such thing as *de re* possibility and necessity. On this view it makes no sense to say, of an object, that it is possibly F or necessarily G. The Quinean I have in mind believes this not because of anything she believes about space *per se* but rather because of general considerations about the logic and metaphysics of modality. Such a theorist would clearly not assert that uniform shifts are possible, for that would be to make a *de re* modal claim: it would be to say, of space, that it is possible for matter to be distributed over it in a certain way. But once again, her (perhaps outdated) views about the nature of modality have nothing to do with the nature of space *per se*, so she may perfectly well be convinced by the Bucket Argument that space is independent of matter in the sense that is important to the Newtonian. So a belief in the possibility of uniform shifts should not be definitive of the Newtonian position.

If there is a grain of truth in the modal characterization of the views, it is that the Leibnizian view of space *implies* that rigid spatial shifts are impossible since the spatial relationships between bodies would be the same in the shifted scenario as they actually are, while the Newtonian view is *consistent* with their possibility. But since a Newtonian may have other views about modality which imply that the shifts are impossible, such as Spinozism, it is a mistake to define the issue in the modal terms described above.

How then should the issue be understood? There is a growing literature in metaphysics that develops a variety of non-modal notions that may be of some use. These include ground, ontological dependence, truth-making (at least, in some of its incarnations), and Sider's notion of a metaphysical semantics, amongst others.[5] We might therefore understand the Leibnizian as claiming that facts about space are grounded in facts about matter, that space ontologically depends on matter, that truths about space are made true by facts about matter, or that sentences about space have a metaphysical semantics in terms of notions to do with matter. For our purposes any of these would do. But for the sake of definiteness it will be useful to pick one of them and I pick the characterization in terms of ground.[6]

What does 'ground' mean? Following Fine, I use it to label a distinctively non-causal, metaphysical mode of explanation: to say that X grounds Y is just

to say that X *explains* Y in this metaphysical sense.[7] To illustrate, imagine being asked what explains Europe's being at war in 1939. A causal explanation might describe a sequence of events over the preceding 50 years that led Chamberlain to declare war on Germany. But there is another kind of explanation that would try to say what goings on in Europe at that time made it count as a continent at war in the first place. Regardless of what caused Chamberlain to declare war in 1939, someone in search of this second explanation recognizes that its being at war was not a *sui generis* state of the continent and that there must therefore be something about it *in virtue of which* it counted as being a continent at war. Here we might say that it was at war in virtue of how its citizens were acting, for example that large numbers of people mobilized and fired guns at each other. As I use the term, an explanation of this second kind is a statement of what *grounds* Europe's being at war in 1939. I take this kind of explanation to be reasonably intuitive: regardless of the truth of this claim about what grounds Europe's being at war, we seem to understand it reasonably well.

Now ground is an explanatory notion, and explanations are typically expressed with the sentential operator 'because': Europe was at war in 1939 *because* its citizens were acting in certain ways. This suggests that the logical form of a claim about ground is:

S because Γ

where S is a sentence, Γ is a list of sentences, and 'because' is read in the metaphysical rather than causal sense.[8] Alternatively, one might treat ground as a relation between facts. On this approach, the logical form of a grounding claim becomes

the Xs ground Y

where 'Y' is a singular variable and 'the Xs' is a plural variable, both ranging over facts.[9] Officially I endorse the former option and think of ground as a sentential operator, but it is often convenient as a shorthand to treat it as a relation between facts so I will do that here.

I assume that ground is transitive and irreflexive.[10] I also assume the principle of Necessitation that if the Xs ground Y, then it is metaphysically necessary that if all the Xs obtain then Y obtains too.[11] This principle is standard and plausible: if it were possible for the citizens of Europe to act in a certain way in 1939 and yet for the continent to be in a state of peace, then those actions would not be the complete explanation of why the continent counted as being in a state of war. However, it is important in what follows to note that the reverse principle is not true since there can be necessary connections without grounds. For example, it is metaphysically necessary that if Obama exists then $2+2=4$, but it is not the case that $2+2=4$ *because* Obama exists. Claims of ground are therefore stronger than claims of necessary connection: the former imply the latter (by Necessitatation), but not *vice-versa*.

I suggest that we understand the issue that divides the Newtonian and the Leibnizian in terms of ground. On this approach, the Newtonian view is that facts about the spatial relationships between material bodies are grounded in facts about which regions of space they are situated in and how those regions are spatially related. For example, if asked to explain (in the metaphysical sense) why two material bodies m_1 and m_2 are 3 meters apart, the Newtonian may answer that m_1 is located at a region of space r_1, m_2 is located at a region of space r_2, and r_1 is 3 meters from r_2. She need not claim that these latter facts about space are groundless. She might for example ground the fact that r_1 is 3 meters from r_2 in terms of facts about the distances between regions in between r_1 and r_2, and perhaps so on *ad infinitum*. Or, if she is a Spinozist, she might ultimately ground *all* facts, including those about space, in the essence of God. What is important is that on her view those facts about space are not grounded back in the spatial relations between material bodies.[12] I believe that it is this thesis that Sklar implicitly had in mind when he said that the Newtonian takes space to be "independent" of matter.

In contrast, the Leibnizian reverses the order of explanation. Insofar as she recognizes facts about space she will explain them (in the metaphysical sense) in terms of facts about how material bodies are spatially related to one another. Thus, the Leibnizian takes on the challenge of accounting for inertial effects ultimately in terms of the spatial relations between bodies, and the considerations rehearsed in the Bucket Argument show that this is no easy task.

As I understand them, Newtonian and Leibnizianism are each necessarily true if true at all. Thus it is more accurate to describe the Newtonian as claiming that, *as a matter of necessity*, the spatial relationships between bodies are grounded in facts about space; and similarly for the Leibnizian.[13] This means that the Leibnizian view is not the Newtonian view's negation. But discussing the corresponding contingent claims introduces needless complications, so it is convenient to discuss these two necessary claims for simplicity since the main morals carry over.[14]

We can now draw a distinction that will be crucial in what follows. Consider two theorists: a Leibnizian, and a Newtonian who is also a Spinozist. By the principle of Necessitation, it follows straight from Leibnizianism that that the uniform spatial shifts discussed earlier are impossible. To be sure, the Newtonian Spinozist agrees that the shifts are impossible, but only the Leibnizian thinks that this follows from the correct answer to the question of substantivalism. For the Newtonian Spinozist, the impossibility of shifts has nothing to do with the question of substantivalism *per se* and instead follows from entirely independent facts—in this case, facts about religion and modality. To mark the distinction, I will say that the Newtonian Spinozist makes a *bare* modal claim.[15] One of my central claims in what follows will be that in the case of GTR, subtantivalists have tended to defend their view with a bare modal claim when what is really needed is a modal claim that follows (by Necessitation) from a view about the nature of spacetime.

Admittedly, some participants to the substantivalism debate may find this talk of ground "metaphysical" in the pejorative sense. One source of skepticism might be my reference to abstracta like facts and grounding relations between them. But if so the skepticism is unwarranted, for as emphasized above my talk of facts is just a shorthand: grounding claims are strictly speaking nothing other than explanatory claims using the word 'because' which involve no reference to facts at all. To my mind, that mode of explanation is just as intuitive and no more problematic than causal explanation. But this is not the place to mount a full defense of ground, and in any case I am happy for the notion to be judged by its fruits. Skeptics can therefore read this paper as asking what progress can made in the substantivalism debate *if* we accept the notion. If progress is made, this is reason to take the notion seriously.

2. Substantivalism in GTR

How does the issue just characterized carry over to the case of GTR? Well, the models of GTR are triples $\boldsymbol{M} = (M, g, T)$, where M is a four-dimensional differentiable manifold of points, and g and T are a metric tensor field and a mass-energy tensor field, respectively, defined on M.[16] Now these models are mathematical objects used to represent physical systems, not physical systems themselves. What then are those physical systems composed of? This is a matter of considerable controversy, and the question of substantivalism in GTR is just one part of it. Taking the models at face value, it is natural to interpret M as representing a physical manifold of regions and g and T as representing some kind of physical object or structure distributed over the physical manifold—let us call them the *physical* metric and mass-energy fields to distinguish them from their mathematical representatives. The question of substantivalism is then the question of the status of the physical manifold of regions represented by M. But as before, the interesting question is not whether such a manifold exists but rather whether it exists *independently* of other elements of the system. Again, this is a reasonably familiar point. As Hoefer characterizes it, the issue is whether the manifold exists '*independently* of material things . . . and is properly described as having *its own* properties, *over and above* the properties of any material things that may occupy parts of it'.[17] But how is the notion of independence to be understood? As before, I propose to understand the issue in terms of ground. Thus, all parties to the debate may agree that physical systems governed by GTR contain a physical manifold of regions. The question is whether facts about that manifold are grounded in other facts about the system, or *vice-versa*. I take substantivalism in GTR to be the latter view.

Let us spell this out a little. The issue is the status of facts about the manifold, but what sort of facts are these? We can represent them abstractly as facts of the form

$$\phi(r_1, r_2, \ldots)$$

where the r_i are regions of the manifold and ϕ describes them. I place very few restrictions on ϕ. In some cases ϕ will describe the manifold's intrinsic topological structure, but in other cases ϕ will describe how the physical metric and mass-energy fields are distributed over the manifold. Exactly what ϕ describes in these latter cases depends on one's metaphysics of physical fields. If you think that a physical field is an instantiation of a property at each region or a pattern of relationships between the regions, then ϕ would express those properties and relations. If instead you think of a physical field as an extended object with parts, then ϕ would describe which parts of the fields are located at each region r_i.[18]

However one understands them, these facts about the manifold play the same role for the substantivalist in GTR as facts about space (i.e. its geometry and where material bodies are located in it) played for the Newtonian. In both cases, these facts are said to ground all other facts about the physical system. For the Newtonian, those other facts concerned the spatial relationships between material bodies. What are the other facts for the substantivalist in GTR? They are many and varied, but most perspicuous are facts that characterize the space-time interval between different parts of the physical mass-energy field.[19] The substantivalist will claim that they are grounded in (i.e. explained by, in the metaphysical sense) facts about the manifold, including how the fields are distributed over it. That is the core substantivalist view, but of course it may be developed in all sorts of ways. To take just one (extreme!) example, our substantivalist need not think that facts about the manifold are groundless: if she is a Spinozist she may ground them in the essence of God. The important point is that she does not ground them back in terms of the space-time intervals between bits of matter.[20]

The issue I just described is clearly an extension of the original issue of Newtonianism vs Leibnizianism into the context of GTR. But it is not the only extension. For example, the original Newtonian vs Leibnizian debate is sometimes characterized as a debate about the nature of *space*, yet I have not said anything about what space or spacetime is in GTR. One could of course ask whether spacetime in GTR is to be identified with the physical manifold alone or the manifold along with the physical metric field, but that is not the question I ask here.[21] No doubt there are yet other questions about GTR systems that are an extension of some aspect of the Newtonian vs Leibnizianism issue, but here I focus on the issue described above.

3. The Hole Argument

So far I have argued that substantivalism in GTR should be understood as a claim about *ground*. Even though it is rarely stated explicitly in these terms, I believe that it is what theorists like Hoefer implicitly have in mind when they describe substantivalism as the thesis that the manifold exists "independently" of

material things. And as I said at the outset, substantivalism is the received view these days.

I now turn to motivating my central claim, namely that substantivalism faces far more serious difficulties than has been recognized and that an adequate response to these difficulties has not yet been formulated, let alone defended. Now one difficulty with substantivalism that *has* been widely discussed is brought out in Earman and Norton's Hole Argument. Indeed, most contemporary substantivalists have developed their view primarily as a response to that argument. So my aim in the next three sections is to describe exactly what those responses are so that we understand what kinds of substantivalist views constitute the received wisdom. Then in Sections 6–9 I will argue that these received views are all vulnerable to other objections.

What then is the Hole Argument? Earman and Norton's basic idea was that substantivalism implies that GTR is indeterministic. They took this to be a bad consequence and reason to think that substantivalism is false.

What does it mean to say that a theory is deterministic? Standard definitions these days are given in terms of possible worlds. For example, a theory T might be said to be deterministic iff any two possible worlds in which T is true and which agree in all respects at one time agree in all respects at all later times. Now in GTR this definition should really be rephrased in a relativistically acceptable way by avoiding reference to times. Moreover, even in classical contexts this definition is subject to certain kinds of counterexamples.[22] But none of these issues are relevant to our purposes so it pays to ignore them and work with this definition for simplicity.

Why is substantivalism thought to imply that GTR is indeterministic? To describe the argument we need the notion of a diffeomorphic shift. To this end, recall that the intended models of GTR are of the form (M, g, T). For simplicity we can assume that all intended models have the same manifold of points M, though of course different models will differ in the fields g and T. Now, take a model $\boldsymbol{M} = (M, g, T)$ and consider a diffeormophism $d{:}M \rightarrow M$, a bijection from M to M such that it and its inverse are both differentiable. Such a function on the manifold induces a function on models, whereby a model $\boldsymbol{M} = (M, g, T)$ is mapped to a "drag along" structure $d(\boldsymbol{M}) = (M, d(g), d(T))$, where $d(g)$ is a tensor field that results from "dragging" the value of g at each point in M along to its image under d. Formally: for all x in M, the value of the field $d(g)$ at the point $d(x)$ is $g(x)$. The field $d(T)$ is defined similarly. Such a function on models is called a *diffeomorphic shift*. Now I called $d(\boldsymbol{M})$ a structure rather than a model, since for all I have said there is no reason to think that it will satisfy the laws of GTR. But it turns out that $d(\boldsymbol{M})$ is a model of GTR iff $\boldsymbol{M}$ is, for any model $\boldsymbol{M}$ and any diffeomorphism d. Let us call this property of GTR *diffeomorphism invariance*.[23]

Diffeomorphic shifts are somewhat analogous to the rigid spatial shifts I mentioned while discussing Newtonianism and Leibnizianism. For we can think of a rigid spatial shift as a function on classical models that maps each model to

one that differs only in the fact that all the matter is displaced by some uniform distance in some uniform direction. In some sense, the most direct analogue of this in the case of GTR would be the result of just dragging the mass-energy field over the manifold. But in GTR the metric field varies from model to model and the equations of GTR state how it relates to the mass-energy field. So just dragging the mass-energy field around will not (in general) preserve the equations of GTR since the resulting mass-energy field will (in general) be out of kilter with the metric field. If we are interested in functions that preserve the truth of the equations of GTR, we must consider functions of the form $d(\boldsymbol{M})$ in which the metric field is dragged along with the mass-energy field.

Returning to the Hole Argument, consider an arbitrary model $\boldsymbol{M} = (M, g, t)$ of GTR and a diffeomorphism d that is identity on all of $\boldsymbol{M}$ save for a bounded region R, the "hole". Let us call any such diffeomorphism a "hole diffeomorphism". By diffeomorphism invariance, $d(\boldsymbol{M})$ is also a model of GTR. Since d was identity outside R, $\boldsymbol{M}$ and $d(\boldsymbol{M})$ are exactly the same outside R. The only difference is that in $d(\boldsymbol{M})$ the fields g and T have been shifted around together within R. The idea is then to use $\boldsymbol{M}$ and $d(\boldsymbol{M})$ to show that GTR is indeterministic. After all, if R is chosen wisely it will only contain events that occur after a specific time, in which case the models would agree in all respects at that time and diverge thereafter. But the definition of determinism was given in terms of possible worlds, and yet $\boldsymbol{M}$ and $d(\boldsymbol{M})$ are models. What then is the link between models and possible worlds that might complete the argument?

This issue has been the source of much controversy. Earman and Norton used the premise that if substantivalism is true, then given any model $\boldsymbol{M}$ and any diffeomorphism d, $\boldsymbol{M}$ and $d(\boldsymbol{M})$ represent distinct possible worlds W and d(W) respectively.[24] By writing d(W), we are now using d to represent a function on *worlds* that is induced by a diffeomorphism on the *physical* manifold (as opposed to when we write $d(\boldsymbol{M})$, where d is used to represent a function on *models* that is induced by a diffeomorphism on the *mathematical* manifold $\boldsymbol{M}$). Intuitively, d(W) differs from W only in the fact that the physical metric and mass-energy fields have been uniformly dragged over the physical manifold in accordance with the diffeomorphism on the manifold. Since d is a hole diffeomorphism, this means that the fields are dragged around within the hole but left alone outside. The idea behind Earman and Norton's premise, then, is that if (as the substantivalist claims) the manifold exists *independently* of the fields, it must surely be possible to redistribute the fields over the manifold in this way.

It is important to understand exactly how W and d(W) differ. To this end, let us distinguish between *individualistic* and *qualitative* facts. I suspect that the distinction resists being defined in other terms, but it is reasonably intuitive and can be illustrated with examples. Roughly speaking, a fact is individualistic when it concerns a particular individual. For example, consider the fact that *this very book* (pointing to a book on my table) is blue. This is an individualistic fact since

it concerns that particular book. In contrast, a qualitative fact does not concern any particular individual at all. The fact that there exists a book on my table is qualitative because it does not concern any particular book and would obtain even if a different book was on the table. More generally, qualitative facts include all those facts that can be expressed in predicate logic with identity but without constants, such as

$$(\exists x)\, Fx$$
$$(\exists x)\,(Fx \,\&\, (\forall y)\,(Fy \supset y = x))$$

so long as F and G express qualitative properties. Of course, this now raises the question of what a qualitative property is, but again the idea is reasonably intuitive: qualitative properties do not concern any particular individual. Thus, the property of being green is qualitative, but the property of being Socrates is not. Note that the property of being a sibling is qualitative: having it might imply the existence of other individuals, but it is qualitative because (roughly speaking) your having it does not depend on any particular person being your sibling and just depends on your having some sibling or other.[25]

Now I said that W and d(W) differ only in the fact that both physical fields have been uniformly dragged over the manifold. Importantly, both worlds agree on all *qualitative* facts about the distribution of the fields over the manifold, for example that there exist various regions propertied and related in certain ways. They disagree only on individualistic facts of the form

$$\phi(r_1, r_2, \ldots)$$

concerning which particular regions within the hole play which qualitative roles. To complete the Hole Argument, then, we pick a time t to the past of the hole. By construction, W and d(W) agree on all facts at t and yet diverge thereafter, namely with respect to those facts within the hole just mentioned. By the above definition of determinism, it follows that GTR is indeterministic.

Why is this a problem for the substantivalist? Earman and Norton do not take it to be apriori that GTR is deterministic. Instead, their idea is that if GTR is indeterministic this should follow from facts about the physics, not from metaphysical theses such as substantivalism. As they put it, 'determinism may fail, but if it fails it should fail for reasons of physics . . . '.[26] This raises the question of what makes something a reason of physics rather than a reason of metaphysics, but I will not discuss this aspect of their argument further.

We can now represent their argument explicitly as follows:

(H1) If substantivalism is true then given any model $\boldsymbol{M}$ and any hole diffeomorphism d, $\boldsymbol{M}$ and $d(\boldsymbol{M})$ represent distinct possible worlds W and d(W) respectively. (Premise)

(H2) W and d(W) are both worlds in which GTR is true. (By the fact that GTR is diffeomorphism invariant)[27]
(H3) If W and d(W) are both worlds in which GTR is true, then GTR is indeterministic. (By the definition of determinism)
(H4) Therefore, if substantivalism is true then GTR is indeterministic. (By (H1), (H2) and (H3))
(H5) (H4) is unacceptable: indeterminism should not follow from a metaphysical theory such as substantivalism. (Premise)
(H6) Therefore, substantivalism is false.

4. Standard Responses

The Hole Argument is the only serious objection to substantivalism in GTR that has received much attention recently. And it is widely agreed to fail, since most theorists either reject (H1) or (H3). As a result, substantivalism in GTR is considered reasonably unproblematic. But in the next two sections I will try to get as clear as possible about *how* substantivalists have responded to the Hole Argument, for I will then argue that their resulting views are vulnerable to other objections.

Substantivalists who deny (H3) concede for the sake of argument that $\boldsymbol{M}$ and $d(\boldsymbol{M})$ represent distinct possible worlds W and d(W) in which GTR is true. But they deny that it follows that GTR is indeterministic because they think that the definition of determinism used by Earman and Norton is too strong. They claim that since W and d(W) agree in all qualitative respects and diverge only with respect to *individualistic* facts, this should not count as a failure of determinism. For our purposes there is no need to discuss the details of their alternative conception of determinism; it suffices to say that it implies that GTR is deterministic even if $\boldsymbol{M}$ and $d(\boldsymbol{M})$ represent distinct possible worlds W and d(W).[28]

But by far the more popular response is to deny (H1) and insist that the substantiavlist need not take $\boldsymbol{M}$ and $d(\boldsymbol{M})$ to represent distinct possible worlds W and d(W) after all. Now if (H1) is taken literally, this response is obviously correct. For a substantivalist might grant that there are distinct worlds W and d(W) but simply deny that they are represented by $\boldsymbol{M}$ and $d(\boldsymbol{M})$ respectively. After all, models are just representational tools, not our masters, so even a substantivalist who recognizes distinct possible worlds W and d(W) is free to ignore one of them and use $\boldsymbol{M}$ and $d(\boldsymbol{M})$ to represent the same world if she pleases! But equally obviously, pointing this out is futile. For once it is granted that there are distinct worlds W and d(W), indeterminism follows regardless of how they are represented (at least, it follows on the definition of determinism that Earman and Norton use).[29]

This shows that Earman and Norton's premise (H1) is ill formulated. Since the definition of determinism is put in terms of possible worlds, the important

question is whether the substantivalist must say that there are distinct possible worlds like W and d(W) regardless of whether she chooses to represent them with $\boldsymbol{M}$ and $d(\boldsymbol{M})$ respectively. Thus the first premise should really be

(H1*) If substantivalism is true then given any GTR world W and any diffeomorphism d on the physical manifold of W, there is a distinct possible world d(W).

and the argument goes through just as it did before.[30] The popular response, then, is to deny (H1*). Indeed, to call this response popular may be an understatement. As Pooley puts it, 'there is close to a consensus in the philosophical literature on Earman and Norton's hole argument that there is nothing anti-substantival about denying that there can be such distinct possible worlds'.[31]

Given the discussion in Sections 1 and 2, it should be obvious that (H1*) is false. For as we saw there, the substantivalist might also be a Spinozist who thinks that everything true is necessarily true, in which case she will deny that diffeomorphic shifts are possible because she denies that *anything* non-actual is possible in the first place! Such a theorist holds a perfectly consistent view: that facts about the manifold ground other physical facts about a GTR system (this is her substantivalism), but that all facts are ultimately grounded in the essence of God, a necessary being, so that nothing non-actual is possible (this is her Spinozism).

Now Spinozism is of course not a popular view these days (to put it mildly!). But there are many popular views about modality that imply that diffeomorphic shifts are impossible even if substantivalism is true. For example, consider the modal thesis of *anti-haecceitism*, which we can state as the view that qualitatively identical possible worlds are identical in all respects. If anti-haecceitism is true, there do not exist worlds like W and d(W) that differ only in a diffeomorphic shift (since if there were such worlds they would be qualitatively identical). So if anti-haecceitism is true, substantivalism does not imply that GTR is indeterministic after all (at least, not in the way that Earman and Norton claimed). Unsurprisingly, then, the popular substantival response to the Hole Argument is to endorse anti-haecceitism.

Now the substantivalist might endorse anti-haecceitism as a brute thesis about modality. Alternatively, she could propose deeper theses about the nature of modality that imply anti-haecceitism. For example, Brighouse writes that 'what a substantivalist should say about the way we individuate space-time points or regions across possible worlds is that we individuate according to qualitative similarity'.[32] Now this talk of "individuating" points across possible worlds is widespread but can mean several things. One thing it could mean (which was not Brighouse's intention) is the view that each point p has an *individuating qualitative role*, by which I mean a qualitative role such that, necessarily, a point q instantiates the role iff q is identical to p. If there were diffeomorphically shifted worlds, certain qualitative roles would be instantiated

by one individual in one world and a distinct individual in the other. The view that points have individuating qualitative roles therefore implies that diffeomorphic shifts are impossible. Thus, the substantivalist could endorse the modal view that regions have individuating qualitative roles and thereby deny that GTR is indeterministic.[33]

Another view about modality—this time one that Brighouse may have intended to encompass by her talk of individuation—is counterpart theory. On this view, no individual exists in more than one possible world. However, an object in one world is a counterpart of an object in another iff they resemble each other in certain (contextually determined) qualitative respects. An object x is then said to be possibly F (in a context) iff there is a possible world W that contains an individual y which is F and which is (in that context) a counterpart of x. Now on this view, the possibility of a diffeomorphic shift would be witnessed by a qualitatively identical possible world. But, as Brighouse puts it, 'the counterpart of any given point in any of the qualitatively indiscernible worlds will have all the same qualitative properties as that point has', in which case the possible world will not represent the possibility of a *shift* after all.[34] I should say that it is not entirely clear whether Brighouse is using Lewis' own counterpart theory or modifying it for her own purposes.[35] But the issues here are tricky, and since I have no desire to object to this strategy of responding to the Hole Argument let me concede that some version of counterpart theory implies that diffeomorphic shifts are impossible. Butterfield (1988) also uses counterpart theory to similar effect, and Teller agrees that this is a legitimate move in his Teller (2001).

These are not the only modal views that imply that diffeomorphic shifts are impossible. But there is no need to describe every conceivable view. It is enough to point out with Pooley, that it is an almost universal consensus on the Hole Argument that (H1*) is false: the substantivalist may endorse one of these modal views that imply that diffeomorphic shifts are impossible and thereby deny that GTR is indeterministic.

But while this may be close to a consensus, what has not been sufficiently appreciated is that the substantivalist might claim that diffeomorphic shifts are impossible for two very different reasons. On one approach, the claim follows from her views about the nature of the manifold. But on another approach, it is a *bare* modal claim, a claim that does not follow from the nature of the manifold but rather from independent facts about the nature of modality.

The distinction here is crucial to what follows, so let me say more about it. Recall that the substantivalist grounds facts about the space-time intervals between bits of matter in facts about the manifold of the form

$$\phi(r_1, r_2, \ldots)$$

where $r_1, r_2, \ldots$ are particular regions of the manifold. These are individualistic facts since they concern those particular regions $r_1, r_2, \ldots$. But the substantivalist may wish to go on and ground these individualistic facts in qualitative facts. Let

us call the view that they are qualitatively grounded *thin* substantivalism, and the view that they are not *thick* substantivalism. Like substantivalism in general, we will take each variety to be a necessary claim.

Now if thin substantivalism is true then it follows straight from the principle of Necessitation (the principle that the ground metaphysically necessitates what it grounds) that qualitatively identical worlds agree on all individualistic facts about the manifold and therefore that there do not exist worlds like W and *d*(W) that differ only in a diffeomorphic shift. Thick substantivalism does not have this implication: since it holds that individualistic facts about the manifold are "over and above" the qualitative facts in the sense of not being grounded in them, it allows that qualitatively identical worlds like W and *d*(W) can differ just with respect to which regions of the manifold play which qualitative role. But *must* the thick substantivalist think that there are distinct possible worlds like W and *d*(W)? Not at all, for she might endorse any of the modal views just discussed, such as Spinozism or anti-haecceitism, as a bare modal claim, a claim that has nothing to do with the nature of the manifold *per se* but which implies that shifts are impossible.

It is obvious that if the thick substantivalist is also a Spinozist, her denial that diffeomorphic shifts are possible follows not from her specific views about the nature of the manifold but rather from independent views about religion and modality. Like the thin substantivalist, this theorist agrees with Pooley's consensus that diffeomorphic shifts are impossible. But while the thin substantivalist takes this claim to follow (by Necessitation) straight from her views about the nature of the manifold, this thick substantivalist takes it to be a bare modal claim.

What might be less obvious is that the thick substantivalist may endorse any of the above anti-haecceitistic views as a bare modal claim too. For example, she may endorse counterpart theory as a thesis about the nature of modality, a theory about what it is for a given individual to be possibly F or necessarily G. This theorist holds a perfectly consistent view: that individualistic facts about the manifold ground other physical facts about a GTR system (this is her thick substantivalism) but that counterpart theory is the correct theory of what it is for an object to have a modal property. To be sure, her counterpart theory may imply that individualistic facts are necessitated by qualitative facts. But this does not mean that she believes the former to be grounded in the latter, for as we saw earlier modal claims do not imply grounding claims (mathematical facts are necessitated by the fact that Obama exists, but the former are not grounded in the latter). Thus even though her views about *modality* imply that diffeomorphic shifts are impossible, she nonetheless insists (as a thick substantivalist) that individualistic facts about the manifold are something "over and above" the qualitative facts in the sense that the former are not grounded in the latter. Counterpart theory may differ from Spinozism in many respects (including its plausibility!), but one point of similarity is that the thick substantivalist can endorse it as a bare modal claim in order to respond to the Hole Argument.

Similarly, the thick substantivalist may endorse the modal view that regions of the manifold have qualitative individuating roles as a bare modal claim. She will then deny that diffeomorphic shifts are possible, but will nonetheless insist that individualistic facts are something "over and above" the qualitative facts in the sense that the former are not grounded in the latter.

These then are the two ways that a substantivalist can deny the possibility of diffeomorphic shifts that I want to distinguish. On the one hand, she might be a thin substantivalist in which case the impossibility of diffeomorphic shifts follows (by the principle of Necessitation) from her view that individualistic facts about the manifold are grounded qualitatively. On the other hand, she might be a thick substantivalist in which case the impossibility of diffeomorphic shifts is a bare modal claim and follows from her independent views about the nature of modality.

So far I have not said anything about which approach the theorists described above took. But I will argue in the next section that thin substantivalism remains undeveloped. Thus, insofar as substantivalists have presented clearly formulated theories on which diffeomorphic shifts are impossible, they are thick substantivalist views on which the impossibility is a bare modal claim. Then in the subsequent sections I will argue that thick substantivalism is subject to serious objections. The charge will be that if individualistic facts about the manifold are something "over and above" the qualitative facts (as the thick substantivalist insists), they are redundant and undetectable in GTR in just the same sense that absolute velocity is redundant and undetectable in classical physics. I will argue that this is true regardless of whether diffeomorphic shifts are possible, and that this is good reason to reject thick substantivalism. That will constitute my argument for my central claim, namely that an adequate substantival view has not yet even been formulated and that substantivalism's status as the received view is premature.

5. The Elusive Thin Substantivalist

I want to argue that no workable version of thin substantivalism has yet been proposed. Even though some authors may appear at first to have thin substantivalist leanings, on further examination no thin substantivalist theory is forthcoming. Admittedly, this is somewhat delicate since most participants to the debate have not explicitly written in terms of ground, the notion in terms of which I defined thin substantivalism. So I will first say what would have to be done in order to propose a workable thin substantivalist theory, and then argue that nothing like that has been done.

We may start by noting that out of thick and thin substantivalism, thick substantivalism is surely the default substantival view. After all, it is overwhelmingly natural to suppose in general that qualitative facts are grounded in individualistic facts. We naturally think that there being a book on the table is grounded

(i.e. explained, in the metaphysical sense) by the fact that *this very book* is on the table. The latter individualistic fact is, we like to think, that in virtue of which the former obtains. So the the onus is very much on the thin substantivalist to motivate her view.

Moreover, my description of thin substantivalism so far is no more than the vaguest of hand gestures. I described it as the view that individualistic facts about the manifold are grounded qualitatively, but this says nothing about what kinds of qualitative facts are taken to provide the ground. So before motivating her view the thin substantivalist must tell us what the view is. Specifically, she must (1) clearly articulate what the underlying qualitative facts are like, and (2) show that they are sufficient to explain (in the metaphysical sense) individualistic facts about the manifold. Until she does this, there is no thin substantival view on the table to assess.

It is important to understand what is required to complete task (1). One way to attempt it would be to endorse the traditional bundle theory of individuals, according to which all facts about the world are ultimately grounded in facts of the form

F, G, . . . are compresent

where F, G, . . . are intrinsic, monadic, qualitative properties and 'compresent' is a primitive, plural predicate. Here we are being told explicitly what kinds of items the world contains at the fundamental level (qualitative properties), and what can be true of them (they can be compresent). Now, when substantivalists discuss the traditional bundle theory they usually reject it. The typical complaint is that it cannot make sense of symmetric physical systems in which more than one individual has the same intrinsic, monadic, qualitative properties. The famous Max Black world in which there are two qualitatively identical spheres of iron 3 meters apart is often used as an example of such a system. I agree that this is good reason to reject the traditional bundle theory; my point here is just that it is at least a theory that attempts task (1). As we will see, this is more than can be said for other proposals that might sound, on the surface, like an expression of thin substantivalism.

Note that the thick substantivalist who endorses anti-haecceitism faces no task comparable to (1). For as we saw earlier, qualitative facts include all those facts that can be expressed in the language PL of predicate logic with identity but without constants, so long as the predicates express qualitative properties.[36] So an anti-haecceitist might express her view as follows: any two worlds that agree on all facts expressible in PL agree simpliciter. Regardless of whether it is true, it is a view on the table that we can now assess. But the thin substantivalist does not have it so easy. For suppose she proposes that all individualistic facts are grounded in facts expressible in PL.[37] The trouble is that it is not clear what this could mean. For it is arguably analytic of the existential quantifier that existentially quantified facts are grounded in their instances.[38] Indeed, this

understanding of the quantifier is arguably implicit in the standard Tarskian semantics for PL. So if we are now being told, say, that the fact that (∃x)Fx is fundamental, I need to be re-taught how to interpret PL. Which parts of '(∃x)Fx' are referential? Which are predicational? Or does it have some other structure altogether? The bundle theorist did better in this regard, since she clearly told us what kinds of things the world contains and what can be true of them. The trouble with the current suggestion is that we are being told nothing similar. This does not refute the suggestion, but it does show that much more needs to be said before a view has even been stated.

Given what it takes to complete task (1), it is reasonably clear that no thin substantival view has yet been proposed. I do not claim that it cannot be done—in Section 11 I will make a start at formulating such a view—just that we have yet to see what a developed thin substantivalist view looks like. This is most clear with the substantivalists discussed in the last section. For while Brighouse, Butterfield and Pooley all take great care to develop their preferred version of anti-haecceitism, they do not engage in task (1). This is not to say that they are committed to rejecting thin substantivalism. Indeed, Pooley explicitly considers the possibility that anti-haecceitism follows from some thesis about what grounds individualistic facts about the manifold. My point is just that this thesis about ground is not developed.

Other substantivalists make comments that sound like they might have thin substantivalism in mind. But if so, they seem not to have appreciated what it takes to develop such a view since they have not made any attempt at task (1). For example, Hoefer says that we should reject 'the ascription of *primitive identity* to space-time points'.[39] Now I am not entirely sure what he means by this, and sometimes when clarifying his view he seems to be proposing a bare modal thesis such as anti-haecceitism.[40] But at other times he seems to have something like thin substantivalism in mind. If so, it is striking that he does not develop a positive theory of what the underlying qualitative facts are like and rests for the most part on negative claims such as that quoted above. Similarly, Baker says that we should 'reject the possibility of [haecceitistic] facts', and by a haeeceitistic fact I take it that he means an individualistic fact without a qualitative ground.[41] But again, this is a purely negative claim and not a positive theory of what the underlying qualitative facts are like.

Am I demanding too much of the would-be thin substantivalist? I think not. After all, consider what we demand from the Leibnizian in a classical context. We characterized Leibnizianism as the view that all facts about space are grounded in facts about how material bodies are related to one another, but that was just a vague hand gesture and not a specific proposal. What we need from a would-be Leibnizian is (1) a specification of what kinds of relational facts she takes as basic, and (2) a demonstration that those relational facts are indeed sufficient to explain (in the metaphysical sense) all facts about space—or at any rate all facts about space needed to make sense of classical physics. It is precisely when we suspect that she is not able to do this (perhaps for the kinds of

considerations outlined in the Bucket Argument) that we reject Leibnizianism. Thus it is clearly not sufficient for a would-be Leibnizian to make the negative statement 'I reject Newtonian space' and leave it at that. This point is particularly important if one's argument for Leibnizianism is not that its competitors are somehow incoherent but rather that they score badly on a particular theoretical virtue such as ontological parsimony. For even if its competitors score badly on that one virtue, we should only endorse Leibnizianism if it does better than its competitors overall, once all virtues are considered. But obviously we can have no idea whether Leibnizianism does better until we have the theory on the table to assess!

Similarly in the case of thin substantivalism. We can have no idea whether thin substantivalism is our all-things-considered best theory until we develop the theory and see what it looks like. Purely negative statements to the effect that there are no "primitive identities" or "haecceities" are simply not enough to go on, but those sorts of remarks are all we get from Hoefer and Baker.[42]

Other people who sound like they might have thin substantivalism in mind are the so-called "structuralists". But again, when they express their views they make no attempt at task (1). For example, Ladyman and Ross said that 'the *structure* of spacetime [should be] accepted as existent despite its failure to supervene on the reality of spacetime points', and that we should think of spacetime points as 'entities whose identity and individuality are secondary to the relational structure in which they are embedded'.[43] These sound at first like the remarks of a thin substantivalist, but we are never told what kinds of qualitative facts constitute that underlying relational structure. At other times, structuralists say that spacetime points are "individuated" by their role in a qualitative structure. But what does this mean? On one interpretation, it means that regions of the manifold have the individuating qualitative roles discussed in the last section. But as we saw, that is a purely modal claim that can be endorsed by the thick substantivalist, not a statement of thin substantivalism. If this talk of individuation is intended to be a statement of thin substantivalism, we need to be told what the underlying qualitative facts are like before there is a view on the table to assess.

At yet other times, structuralists have expressed their view by talking about invariances. To see what the idea is here, consider rational choice theory in which an agent's preferences over options are represented by a utility function assigning a number to each option. It is sometimes said that a utility representation is invariant under positive monotonic transformations, and this often taken to communicate something about the underlying psychological facts: namely that an agent can meaningfully be said to prefer x over y, but not to prefer x twice as much as y. With this in mind, a would-be thin substantivalist might attempt to express her view that the underlying facts about the manifold are all qualitative by saying that the models of GTR are "invariant under diffeomorphism", i.e. that for all models M and diffeomorphisms d, M and $d(M)$ represent the same possible world.[44]

But this does not constitute a thin substantival theory, for two reasons. First, it does not even imply thin substantivalism: as noted in the last section *any* substantivalist—including the thick substantialist who thinks that diffeomorphic shifts are *possible*—can interpret her models in this way since models are our tools not our masters. But second (and more importantly), talking of invariances does nothing to tackle task (1). In the case of rational choice theory this does not really matter, for the analogue of task (1) is trivial. We have a firm grasp of the kinds of facts that might be psychologically basic—perhaps they are facts to the effect that an agent prefers x over y, or perhaps that she prefers x twice as much as y—and so it is harmless to use talk of invariances to communicate which of these are indeed psychologically basic. But in the case of thin substantivalism we have not yet been told what kinds of qualitative facts might be taken to be basic—that is precisely what task (1) is. It is no good simply saying 'they are the sorts of facts that $\boldsymbol{M}$ and $d(\boldsymbol{M})$ agree on', for one kind of fact they agree on are existentially quantified facts and as I emphasized earlier it is not clear what it could mean for these to be basic.

Finally, at other times structuralists talk of discernibility. Call two objects *absolutely discernible* iff there is a qualitative formula with one free variable that is satisfied by one but not the other. The spheres in a Max Black world, for example, are not absolutely discernible. It is widely agreed that the traditional bundle theory implies that distinct objects are absolutely discernible and that this is a serious problem for the view. However, it was then noticed that there is a weaker notion of discernibility: two objects are *weakly discernible* iff there is an irreflexive qualitative formula with two free variables that they satisfy.[45] The spheres in the Max Black world, notice, are weakly discernible, and the thesis that distinct individuals must be weakly discernible is considered by some to be far less problematic than the thesis that they must be absolutely discernible. Thus, some theorists who sound like they have thin substantival leanings have claimed, as an alternative to the bundle theory, that, necessarily, distinct objects (including regions of the manifold) are weakly discernible.[46]

But I find all this talk of discernibility a red herring. For the thesis that, necessarily, distinct regions are weakly discernible does not even imply thin substantivalism, since the former is a purely modal thesis that a thick substantivalist may accept as a bare modal claim. It might be objected that the claim of interest is not this modal claim but rather the claim that the distinctness between two regions a and b is *grounded* in the fact that they are weakly discernible. But the fact that a and b are weakly discernible is an individualistic fact, concerning (as it does) a and b respectively, so this does not constitute a view on which the distinctness of a and b is grounded qualitatively. And in any case, there is still the question of what grounds all the other individualistic facts about them, facts that seem to go undiscussed in the literature on weak discernibility. But the most important problem is that none of this talk of weak discernibility does anything to tackle task (1): nowhere in the literature on weak discernibility have I seen an attempt to clearly articulate what the

underlying qualitative facts might be that are taken to ground individualistic facts about the manifold.

Moreover, in Section 11 I will outline an approach to grounding individualistic facts qualitatively that has no implications about discernibility at all, and in particular allows that distinct objects can be weakly indiscernible. So I worry that the recent focus on discernibility is doubly misplaced: not only do claims about discernibility fail to imply thin substantivalism, they are not implied by thin substantivalism either.

I suspect that the intense focus on discernibility recently is the result of conflating two traditional claims about the Max Black world: first, that it shows that the bundle theory is false; and second, that it shows that distinct objects can be indiscernible. It is correct to point out that this second claim is false given that the two spheres are weakly discernible. But it is hard to see how this is relevant to the thin substantival project, for it remains the case that the only live theory about how individualistic facts might be qualitatively grounded (i.e. the traditional bundle theory) cannot make sense of symmetric systems like the Max Black world. What the thin substantivalist needs to do is present a clear theory about what the underlying qualitative facts are like in a Max Black world, but this talk of weak discernibility makes no progress on that.

I have argued that formulating a thin substantival theory requires work that has not been done. Thus insofar as we can extract clear, fully formulated theses from the literature that deny (H1*), they are all theses that endorse thick substantivalism plus some kind of bare modal claim such as anti-haecceitism.

Now these modal theses are (in my opinion) perfectly legitimate responses to the Hole Argument. But the trouble is that there are other arguments which purport to show that thick substantivalism should be rejected in favor of thin substantivalism that do not make modal assumptions in the first place. So the problem with the modal theses is not that they are wrong, but rather that they do not constitute a serious defense of substantivalism.

6. Two Occamist Arguments

Philosophers of physics should find these other arguments compelling, for they are analogues of widely accepted arguments that are used to reject Newtonianism in the context of classical physics. Roughly speaking, these arguments go like this. First, note that if Newtonianism is true then there is a fact of the matter as to the velocity of a given body that is independent of its velocity relative to other material bodies, namely its velocity through Newtonian space. Call this its "absolute velocity". The first argument is then that a body's absolute velocity is *redundant* to classical physics, and the second argument is that absolute velocity is *undetectable* according to classical physics. In both arguments an Occamist principle is then wielded stating that (all else being equal) we should prefer theories about the structure of the material world that dispense with

redundant or undetectable structure; thus, (all else being equal) we should reject the Newtonian view of space. I personally prefer the second argument, but I will discuss them both here for the benefit of those that prefer the first.[47]

These arguments are normally used to motivate what is known as Galilean substantivalism. On this view, facts about the spatio-temporal relations between material bodies and events are grounded in facts about where those bodies and events are situated in Galilean spacetime, a 4 dimensional array of regions organized as an ordered set of 3 dimensional simultaneity slices. Importantly, there is no fact of the matter as to the spatial distance between two non-simultaneous points, so no fact of the matter as to the spatial distance traversed by a body over an interval of time, and so no fact of the matter as to its absolute velocity. There are facts about a body's velocity relative to other bodies just like there are according to Newtonianism. But while the Newtonian grounds these in facts about the absolute velocities of each body, the Galilean substantivalist grounds does not. Thus, Galilean substantivalism dispenses with precisely those facts that were shown to be redundant and/or undetectable by the Occamist arguments.

I believe that precisely analogous arguments militate against thick substantivalism. Call an individualistic fact *thick* iff it does not have a qualitative ground. In the next three sections I will argue (first) that analogous arguments show that thick individualistic facts are redundant to GTR and undetectable according to GTR; and (second) that these Occamist arguments make no essential appeal to assumptions about modality or determinism that are denied by the substantivalists considered earlier. Thus, just as the Occamist arguments motivate us to dispense with absolute velocity and reject Newtonianism in favor of the Galilean view, they should also motivate us to dispense with thick individualistic facts and reject thick in favor of thin substantivalism. At the very least, on pain of inconsistency the contemporary substantivalist faces a dilemma: either reject thick substantivalism in GTR, or else reject the kinds of arguments used to motivate Galilean substantivalism over Newtonianism in the classical case. I suspect that few would be willing to embrace the second horn.

The Occamist arguments in the classical case use a notion of invariance analogous to the notion of diffeormorphism invariance in GTR. To set this up, consider the laws of Newtonian Gravitation Theory (NGT), by which I mean his three laws of motion and the inverse-square gravitational force law. Let us assume that there is some way of expressing these laws that is independent of the question of Newtonian substantivalism.[48] The models of NGT will therefore be many and varied: some will contain a manifold of regions isomorphic to Newtonian space, others will contain a manifold of regions isomorphic to Galilean space-time, and so on. Now, let a uniform boost v be a function that takes as input any model and outputs a structure that differs only by adding a uniform absolute velocity to each body at each time. Such a function will be identity of all models with a manifold isomorphic to Galilean spacetime and will only map models with a notion of absolute velocity to distinct models. It then turns out that given any

model M of NGT and any uniform boost v, $v(M)$ is also a model of NGT. Let us call this property of NGT *velocity invariance*.

7. The Argument from Redundancy

So much for the set-up; we must now examine the Occamist arguments in more detail.

As I said, the idea behind first argument is that absolute velocity is "physically redundant" in NGT. But redundant to what? It is easy to make a false accusation here. Sometimes the accusation is that facts about the particular absolute velocities of things make no difference to *how a system evolves* according to NGT.[49] Now it is true that the absolute velocities of bodies at a given time make no difference to, say, the future inter-particle distances between things. After all, a uniformly boosted world is a world in which current absolute velocities are different but future inter-particle distances are the same; and since the laws of NGT would obtain in this boosted world (by velocity invariance) this shows that according to NGT the specific absolute velocities of things make no difference to future inter-particle distances. But while true, the point does not have the required generality. For according to NGT, the current absolute velocities of things make a difference to *some* aspects of how a system evolves such as the future absolute velocities of things. After all, if everything were uniformly boosted, the laws of NGT imply that things will have different future velocities than they actually will.[50] It would be question begging to ignore these ways in which absolute velocity makes a difference to how a system evolves.

A more accurate accusation is that facts about the particular absolute velocities of things make no difference to *whether NGT obtains*. I will discuss what this amounts to in some detail, but roughly speaking the idea is this. Consider an arbitrary model $\boldsymbol{M}$ of NGT and an arbitrary uniform boost v. Since NGT is velocity invariant, we know that $v(\boldsymbol{M})$ is a model of NGT. But in $v(\boldsymbol{M})$ the absolute velocities of things are different than they are in $\boldsymbol{M}$ (except for the trivial case in which v is identity). So whether material bodies have the velocities that are assigned to them in $\boldsymbol{M}$ or in $v(\boldsymbol{M})$ makes no difference to whether NGT is true. Since $\boldsymbol{M}$ and v were arbitrarily chosen, this shows that the particular absolute velocities that things have make no difference to whether NGT is true. Roughly speaking, this is what I mean when I say that absolute velocity is redundant to NGT. The same is not true, note, about relative velocity. For uniformly changing the relative velocities between things will not, in general, preserve the truth of NGT. This then is the argument from redundancy:

(R1) Absolute velocity is redundant to NGT. (By the fact that NGT is velocity invariant)

(R2) If a theory about the metaphysics of the material world implies that it contains features that are redundant to the truth of the true and complete physical laws, that is reason to think it is false. (Premise)

(R3) Therefore, if the laws of NGT are true and complete, there is reason to think that Newtonianism is false.

I take this to be one of the standard arguments that motivate many people to reject Newtonianism in favor of the Galilean view in a classical context.[51] I will argue (first) that *if* you find it compelling in the case of NGT, a precisely analogous argument should motivate you to reject thick substantivalism in favor of thin substantivalism, and (second) that it makes no essential appeal to assumptions about determinism or modality that substantivalists described in Sections 4 and 5 deny.

The analogous argument in the case of GTR appeals to

(R1*) Thick individualistic facts about the manifold are redundant to the truth of GTR. (By the fact that GTR is diffeomorphism invariant)

Along with (R2), this implies that if the laws of GTR are true and complete, there is reason to think that thick substantivalism is false. But what is the motivation for (R1*)? Following the rough idea described above, it goes like this. Consider an arbitrary model $\boldsymbol{M} = (M, g, T)$ of GTR and an arbitrary diffeomorphism d on M. By diffeomorphism invariance, $d(\boldsymbol{M})$ is a model of GTR. But $d(\boldsymbol{M})$ differs from $\boldsymbol{M}$ with respect to thick individualistic facts concerning which particular regions play which particular qualitative role. Since $\boldsymbol{M}$ and d were arbitrarily chosen, this shows that those individualistic facts make no difference to whether GTR is true in the same sense as facts about the absolute velocities of things make no difference to whether NGT is true.

It should be uncontroversial that *some* kind of argument like this can be run against thick substantivalism, and that the argument makes no controversial assumptions about determinism. The question is whether it makes controversial assumptions about modality. For the thick substantivalist might object that when I talked of $\boldsymbol{M}$ and $d(\boldsymbol{M})$ in the rough description of the argument above, I implicitly assumed that they represent distinct possible worlds that differ only in a diffeomorphic shift. And as we know, the thick substantivalist may endorse anti-haecceitism as a bare modal claim and thereby deny that possible worlds can differ in this way. But I will now argue that, properly understood, the argument from redundancy makes no contentious modal assumptions. If this is right, then even though the thick substantivalist can legitimately respond to the Hole Argument by endorsing anti-haecceitism, she cannot respond to this argument similarly.

To this end, it helps to return to the case of NGT and the redundancy argument against the Newtonian. I gave a quick argument for (R1) earlier in terms of models, but according to the objection this was just shorthand for a modal argument that goes like this. We first note that given any NGT world W

in which Newtonianism is true and any absolute velocity v, there is a distinct possible world v(W) that differs from W by a uniform boost of v. We then show that v(W) is an NGT world by the velocity invariance of NGT. But the absolute velocities of things in v(W) are all different than they are in W. Since this is true for any NGT world in which Newtonianism is true and any boost v, it shows that the particular absolute velocities that things have make no difference to whether NGT is true.

Grant that (R1) *can* be motivated in these modal terms. The important point is it does not *need* to be. To see this, imagine a Spinozist who has recently become a Newtonian. Suppose we try to convince her to give up Newtonianism in favor of the Galilean view of spacetime by presenting her with the argument from redundancy. And suppose we motivate (R1) with the modal argument just described. She could then reasonably reply "Wait, you assume that there are distinct possible worlds W and v(W), but I reject the assumption. Therefore your argument for (R1) is unconvincing and I retain my belief in Newtonianism." As a response to our modal argument for (R1) in the last paragraph, this is perfectly fair. But does it suffice to put the argument from redundancy to bed? It seems to me that it does not. For in denying that there are distinct worlds like W and v(W) our Spinozist makes a *bare* modal claim, a claim that follows not from her views about he metaphysics of space *per se* but rather from independent views about modality. Thus, as a Newtonian she still insists that there are facts about the absolute velocities of things that are "over and above" the relationships between bodies in the sense of not being grounded in those relationships. And we would not take the Spinozist's curious modal views to imply that—surprise surprise!—those facts about the absolute velocities of things are suddenly relevant to the truth of NGT in just the same way as, say, facts about relative velocities are! So regardless of whether uniform boosts are genuinely possible our Spinozist should agree that, given the structure of the laws of NGT, the particular absolute velocities of things make no difference to whether those laws obtain. Intuitively, then, the Spinozist's bare modal claim simply has no bearing on whether absolute velocity is redundant to NGT.

If this is right, then even a Newtonian who denies that there are distinct worlds like W and v(W) should accept (R1). This is not to deny that (R1) *can* be motivated in modal terms. Indeed, the sense in which absolute velocity is redundant to NGT is particularly vivid when presented in modal terms; and since most of us do not share the Spinozist's quirky views it is not surprising that one often hears the argument presented in that way. But still, the modal argument is optional and not essential to the argument from redundancy.

How else might one motivate (R1)? The natural answer is to use models, just like I did originally. There I considered an arbitrary model $\boldsymbol{M}$ of NGT and an arbitrary boost v and noted (by velocity invariance) that $v(\boldsymbol{M})$ is also a model of NGT. But the question then is what the models represent, for if they are taken to represent possible worlds the Spinozist may object that I am sneaking in modal assumptions by the back door.

There are a few options here. One is to interpret the models as representing counterfactual truths. Thus, we might take the fact that $v(\boldsymbol{M})$ is a model of NGT whenever $\boldsymbol{M}$ is to represent the fact that if everything's velocity *were* to differ in a certain uniform way, NGT *would* still be true. The Spinozist thinks that the antecedent of this counterfactual is necessarily false, but she might nonetheless agree that the counterfactual is non-trivially true. If so, then the sense in which absolute velocity is redundant to NGT is that the truth of NGT is not counterfactually dependent on the particular absolute velocities that things have.

Alternatively, one might interpret the models as representing explanatory patterns. The idea is this. The equations of NGT are universal generalizations, so it is plausible that their truth is grounded in (i.e. explained by, in the metaphysical sense) their instances, in this case facts about the trajectories of particular particles.[52] But what facts about their trajectories are relevant to that explanation? That $v(\boldsymbol{M})$ is a model of NGT whenever $\boldsymbol{M}$ is might be taken to show that the absolute velocities of things are not relevant to the explanation in the sense that they do not "make a difference" to whether or not the laws obtain. If so, then the sense in which absolute velocity is redundant to NGT is that the particular absolute velocities of things are not relevant an explanation of why NGT is true.

What then is the correct argument for (R1)? This is a bad question, for we should not expect there to be an argument that *all* Newtonians will accept. The modal argument will be rejected by a Newtonian who is also a Spinozist; the counterfactual argument will be rejected by Newtonians with quirky views about counterfactuals; and so on. Indeed, attempting to shoehorn the argument into a pre-specified template is likely to make it look weaker than it is, for there will inevitably be some quirky Newtonian who rejects that template's presuppositions. Instead, we should tailor an argument for (R1) to the particular Newtonian we are faced with.

The point of the discussion, of course, is that the lesson carries over to the case of GTR when we use the argument from redundancy to argue against the thick substantivalist. To be sure, we *can* motivate (R1*) using a modal argument. If we choose to do so, we will assume that for any GTR world W and any diffeomorphism d there is a distinct possible world d(W) in which the fields are shifted over the manifold in accordance with d. We will point out that d(W) is a GTR world (by diffeomorphism invariance), and then conclude that the thick individualistic facts that distinguish W and d(W) are redundant to the truth of GTR.

But what if the thick substantivalist also happens be a Spinozist? Or what if she happens to be an anti-haecceitist like Brighouse? She will then deny that there are distinct worlds like W and d(W) and therefore object to our modal argument for (R1*). But does that mean that the argument from redundancy must be abandoned? I think not. For when the thick substantivalist denies that there are worlds like W and d(W) because of her Spinozism or her anti-haecceitism, she makes a *bare* modal claim: a claim that follows not from her

views about the metaphysics of the manifold but rather from her independent views about modality in general. As a thick substanativalist, she still insists that the individualistic facts about the manifold are "over and above" the qualitative facts in the sense that the former are not grounded in the latter. And we would not take the Spinozist's quirky modal views to imply that—surprise surprise!—those thick individualistic facts are suddenly relevant to the truth of GTR in just the same way as (say) qualitative facts are! Similarly, we should not take our anti-haecceitist's bare modal views to imply that those thick individualistic facts are suddenly relevant to the truth of GTR either. So regardless of whether diffeomorphic shifts are possible our Spinozist and anti-haecceitist should agree that, given the structure of the laws of GTR, the thick individualistic facts detailing which particular regions of the manifold play which qualitative role do not make a difference to whether the laws obtain. The bare modal claims made by our Spinozist and anti-haecceitist therefore have no bearing on whether those thick individualistic facts are redundant to GTR.

Thus, if faced with a thick substantivalist who makes either of these bare modal claims, we should simply run the argument by appealing to models as illustrated above. We could take the models to represent counterfactual truths, or perhaps patterns of explanatory relevance, or perhaps something else. Whatever works for the thick substantivalist in question.

Admittedly, the interpretation of models as representations of possible worlds is deeply entrenched. Indeed, one sometimes hears that the very *content* of GTR is that a certain set of possible worlds are physically possible.[53] But the fact that a Spinozist could be found working in a GTR laboratory suggests to me that this interpretation of models is entirely optional and that they could be taken by a proponent of GTR to represent counterfactual truths or explanatory patterns instead.

In any event, I conclude that the argument from redundancy makes no essential appeal to assumptions about modality that anti-haecceitists deny. It also (clearly) makes no assumptions about determinism. The standard ways of defending thick substantivalism from the Hole Argument therefore do nothing to defend it from the argument from redundancy.

8. The Argument from Undetectability

That is the first Occamist argument against thick substantivalism. The second is an argument from undetectability. Again, it will again be useful to discuss it in the context of classical physics in which it is used to argue against Newtonianism. In that case the argument is this:

(U1) If the laws of NGT are true and complete, then if there is any such thing as absolute velocity it is undetectable.

(U2) If a theory about the metaphysics of the material world implies that it contains features that are undetectable, that is reason to think it is false.

(U3) Therefore, if the laws of NGT are true and complete, there is reason to think that Newtonian substantivalism is false.

It is important to guard against misconceptions of the Occamist principle stated in premise (U2). It is not a verificationist principle since it does not state that it is meaningless to talk of undetectable structure. The thought is just that it is a virtue of one's theory of the material world if it does not posit undetectable structure. Moreover, it uses the term 'undetectable' in a very specific way. If the term were used to apply to anything that we cannot see with the naked eye, (U2) would recommend that we become radical scientific anti-realists and dispense with so-called "theoretical" entities such as electrons. But that is not the intended meaning of the term. As it is used in (U2), something is undetectable if, roughly speaking, it follows from the laws of motion governing our world that it is physically impossible for it to have an impact upon our senses. Electrons are therefore detectable in this sense because there are physically possible processes, such as those that occur in particle accelerators, by which the presence of an electron can be made to have an impact on our senses via its impact on (say) the movement of a dial. So (U2) cannot be used to motivate scientific anti-realism of an objectionable sort. I therefore take (U2) to be reasonably weak and acceptable by most.

This then is the other standard argument that motivates many people to reject Newtonianism in favor of the Galilean view in a classical context. As before, I will argue (first) that *if* you find it compelling, a precisely analogous argument should motivate you to reject thick substantivalism in favor of thin substantivalism, and (second) that it makes no essential appeal to assumptions about determinism or modality that the thick substantivalists described in Sections 4 and 5 reject.

The crucial premise is (U1). I should say at the outset that there is widespread agreement that this is true. For example, Earman writes that 'because Newton's laws of motion and gravitation have (Gal) as their dynamic symmetries [in particular, because they are velocity invariant], no feature of the lawlike behavior of gravitating bodies can be used to distinguish an absolute frame: in that sense, absolute space is unobservable', and it is reasonably clear from the context that by 'absolute space is unobservable' he means what I mean when I say that absolute velocity is undetectable.[54] Earman offered no argument for his claim, but there turns out to be a reasonably well known argument for it. It is most vivid when presented modally, so I will first present it in those terms and then show that it can be run without recourse to modality.[55]

We first note that given any NGT world W in which Newtonianism is true and any absolute velocity v, there is a distinct possible world v(W) that

differs from W by a uniform boost of v. We then note two things: (i) that v(W) is an NGT world (by the velocity invariance of NGT), and (ii) that v(W) is indiscernible from W. Precisely what 'indiscernible' means is an delicate issue that I will discuss a little later, but the intuitive idea is just that everything looks and feels and tastes and smells exactly the same in v(W) as it does in W. Now since W was arbitrarily chosen, we can imagine that it contains organisms like us performing an experiment designed to reveal the absolute velocity of a given body. v(W) then contains those organisms performing the same experiment too. Now, the absolute velocity of that body is different in v(W) than it is in W (except in the trivial case that v is the 0 velocity boost). But we know by (ii) that the experiment's outcome in v(W) is indiscernible from its outcome in W. Finally, we know by (i) that the outcome in v(W) is the outcome predicted by NGT in the situation in which everything's velocity is uniformly boosted at the beginning of the experiment. Thus, if NGT is true and complete, there is no physically possible experiment we could run that would reveal the body's absolute velocity to us.

I find this argument compelling, but I will not defend it here. Instead, I want to show that a precisely analogous argument can be given in support of

(U1*) If the laws of GTR are true and complete, then if there are thick individualistic facts they are undetectable.

Along with (U2), this implies that if the laws of GTR are true and complete then there is reason to think that thick substantivalism is false.[56]

What is the argument for (U1*)? If run analogously to the above, we would assume that given any GTR world W and any diffeomorphism d there is a distinct possible world d(W) in which the fields are dragged over the manifold in accordance with d. We would then note (i) that d(W) is a GTR world (by diffeomorphism invariance), and (ii) that W and d(W) are indiscernible in the sense that things would look and feel and taste exactly the same the latter as they do in the former. Then by exactly the same reasoning as above, it would follow that if GTR were true and complete then there is no physically possible experiment we could run that would reveal the thick individualistic facts concerning which particular region of the manifold plays which qualitative role.

Now there is a subtle issue about my claim that W and d(W) are indiscernible that I will discuss in the next section. But putting that aside, it should be uncontroversial that *some* kind of argument from undetectability can be run against thick substantivalism. The question is whether the argument makes essential appeal to the assumption that there are distinct worlds like W and d(W), for thick substantivalists who are anti-haecceitists will reject the assumption.

The answer is 'no': like the argument from redundancy, the argument from undetectability is not essentially a modal argument and makes no contentious modal assumptions. To see this, return to the argument from undetectability in the case of NGT. Imagine you were using it to try to convince a Spinozist who

had recently endorsed Newtonianism to give up the latter view. And suppose you motivated (U1) with the modal argument described above, in which you assumed that there are distinct worlds like W and v(W). She would of course deny the modal assumption. But does that mean that the argument from undetectability has no force against her? Surely not. For in denying that there are distinct worlds W and v(W), the Spinozist makes a *bare* modal claim, a claim that follows not from her views about the metaphysics of space *per se* but rather from independent views about modality. As a Newtonian, she still believes that there are facts about the absolute velocities of things "over and above" the relationships between bodies in the sense of not being grounded in those relationships. And surely we would not take her quirky modal views to imply that—surprise surprise!—those facts about the absolute velocities of things are revealed to us in experience after all! So the Spinozist should agree that absolute velocity is undetectable, even if the modal argument fails to establish the point. Thus, the Spinozist's curious bare modal views intuitively have nothing to do with the question of whether absolute velocity is detectable or not.

How then can (U1) be established without the modal assumption? The obvious move is to use models $\boldsymbol{M}$ and $v(\boldsymbol{M})$ rather than worlds W and v(W). But what would those models be taken to represent? As before, I do not want to recommend any fixed template. One approach would be to take parts of the models to represent observable features, and then say that two models are indiscernible if they agree on what they represent *vis a vis* the observables. One could then take the models themselves to represent counterfactual truths. On this approach, the fact that $v(\boldsymbol{M})$ is indiscernible from $\boldsymbol{M}$ and is a model of NGT whenever $\boldsymbol{M}$ is would be taken to represent the fact that if the individualistic facts *were* to differ in a certain way, any experiment devised to reveal them to us *would* yield an indiscernible outcome. Alternatively, one could take the models to represent patterns of causal dependence, in which case these facts about models would represent the fact that the observable outcomes of experiments do not causally depend on individualistic facts concerning which regions of the manifold play which qualitative role.

This is not to deny that there is a certain vividness to running the argument for (U1) in modal terms, describing the boosted possible worlds and seeing in one's mind that they are indistinguishable. But this modal description is not essential to the argument.

The point, of course, is that what goes for (U1) goes for (U1*). True, if the thick substantivalist is also a Spinozist or an anti-haecceitist, she will deny the assumption I made in my modal presentation of the argument, namely that there are distinct worlds like W and d(W) that differ only in a diffeomorphic shift. But in denying this the thick substantivalist makes a bare modal claim that follows not from her view about the metaphysics of the manifold but rather from independent modal views. As a thick substantivalist, the Spinozist agrees that there are individualistic facts concerning which particular regions of the manifold play which qualitative role that are "over and above" the qualitative

facts in the sense that the former are not grounded in the latter. And surely we would not take her quirky modal views to show that—surprise surprise—those individualistic facts are revealed to us in experience after all! The same goes for the anti-haecceitist. Thus, the bare modal views endorsed by the Spinozist and the anti-haecceitist have nothing to do with the question of whether thick individualistic facts are detectable or not. Even the anti-haecceitists discussed in the last section, then, should agree that the thick individualistic facts are undetectable. Or, more precisely, if they do not, this should not be because of their bare modal views.

9. Easy Detection?

It is worth saying a little more about the assumption that $\boldsymbol{M}$ and $d(\boldsymbol{M})$ are indiscernible models. When the argument is presented modally this is the assumption that W and d(W) are indiscernible. Even if she grants that there are such worlds the thick substantivalist might object to the claim that they are indiscernible.

The issue here is analogous to one that arises in the case of NGT. Just as absolute velocity would be undetectable if the laws of NGT were true and complete, so it has been traditionally thought that our position in Newtonian space would be undetectable too. The argument has traditionally been thought to be precisely analogous: if run modally, one would note that possible worlds which differ only in a rigid spatial shift of all matter, say, 3 feet to the right are indiscernible, and also that the shifted world is an NGT world if the original world is. By the same reasoning as was rehearsed above, one would then argue that there is no physically possible experiment which could be used to reveal our position in Newtonian space.

That is the traditional idea. But Maudlin has argued that while the argument in the case of velocity is sound, its "analogue" in the case of position is not:

> Various positional states of the universe as a whole are possible: It could be created so my desk is here, or three meters north of here, or 888 meters from here in the direction from Earth to Betelgeuse, and so on. Which is the actual state of the world? . . . the answer is easy: In its actual state, my desk is here, not three meters north of here or anywhere else . . . To even formulate the appropriate question . . . one must indexically pick out a spatiotemporal location, and it is then no great trick to observe what material body that location actually contains.[57]

Maudlin's idea is this. In the case of velocity, we can ask the question 'Am I in a state of absolute rest or a state of uniform motion?' and the argument outlined in the last section purports to show that according to NGT it is physically impossible to give a reliable answer. Maudlin's observation is that in the case of location there is no analogous question: given the resources we have by which

to ask the question of where we are in Newtonian space, the only questions we can ask are questions we can readily settle. The point might be put like this. Call a question about our absolute location or velocity *open* if it cannot be reliably answered by verifying facts about the relative positions or relative velocities of material bodies. Then Maudlin's point is that we have the conceptual resources to ask an open question about or velocity through Newtonian space but not about our location in Newtonian space. It is clear how this carries over the case of GTR, for we lack the conceptual resources to ask open questions about which individualistic facts about the manifold obtain in just the same way that we cannot ask open questions about our position in Newtonian space.

Let us grant Maudlin all this. What follows? Maudlin concludes that our location in Newtonian space is detectable after all. After all, if there are no unanswerable questions about our position in space, in what sense could our position be said to be undetectable? On this view, our epistemic situation *vis a vis* our location in space is much better that our epistemic position *vis a vis* our velocity through space. But Maudlin's conclusion does not follow from what we are granting him. For another conclusion one might draw is that our position in space is undetectable, and moreover that we cannot even express what it is that we cannot detect. On this view, our epistemic situation *vis a vis* our location in space is much *worse* than our epistemic position *vis a vis* our velocity through space, since in the former case we cannot even formulate questions about what it is we cannot detect! Both conclusions are entirely consistent with Maudlin's insight, which I am granting for the sake of argument. But which is correct?

Surprisingly, Maudlin himself did not offer any reasons for drawing his conclusion. And there are reasons to reject it. For one thing, when one remembers that there are uncountably many shifted worlds that would all look and feel and taste exactly the same as the actual world, there is a clear feeling that our location in space is therefore in some sense beyond our epistemic grasp. And (speaking for myself) this feeling is not dissipated by being told that one cannot formulate an unanswerable question about one's position in space. Indeed, the mere fact that one can answer questions such as 'Am I here or 3 feet to the right of here' seems like a cheap conceptual trick which does not speak to the intuitive question of where in absolute space one is.

Moreover, Maudlin's view implies that whether something is detectable depends on factors that are, intuitively, entirely irrelevant to the matter. For on his view, whether our location in Newtonian space is detectable depends on whether or not we can ask open questions. So, for example, suppose that God had a favorite point in space. Then we would be able to ask open questions about our location in space, for example 'Am I 3 feet or 6 feet from God's favorite point?' On Maudlin's view, it would then turn out that location is undetectable after all. So on Maudlin's view, whether absolute position is detectable or not depends on whether God had a favorite point. And that seems clearly false: whether or not God has a favorite point is surely irrelevant to my epistemic situation *vis a vis* our position in space![58]

Maudlin is right that there is an interesting disanalogy between absolute velocity and absolute position: we can ask open questions about the former but not the latter. But I believe that he was wrong to conclude that our location in absolute space is detectable. Similarly, even if we cannot ask open questions about which regions of the manifold play which qualitative role, it would be wrong to conclude that those facts are detectable.[59]

10. Towards a New Metaphysics of Manifolds

I have argued that the traditional Occamist arguments used to motivate rejecting Newtonianism in favor of the Galilean view of spacetime also motivate rejecting thick in favor of thin substantivalism. I also tried to show that those arguments make no essential appeal to modal assumptions that a thick substantivalist might deny by endorsing anti-haecceitism. But in Section 5 I argued that a thin substantivalist theory has not yet been properly formulated. That is my reason for claiming that substantivalism's status as the received view is premature.

I have focused on substantivalism in GTR, but the same point applies to substantivalism in classical contexts. For example, similar Occamist arguments should motivate our grounding individualistic facts about regions in Newtonian space or Galilean space-time qualitatively. The idea is that if individualistic facts about which particular region a given body is located at in Newtonian space or Galilean space-time were ungrounded, they would be redundant and undetectable. Rather than appealing to diffeomorphic shifts, these arguments would appeal to the rigid spatial shifts described earlier. Now it is often thought that these Occamist arguments assume that rigid spatial shifts are metaphysically possible and that they can therefore be refuted by endorsing anti-haecceitism.[60] But if I am right this is a mistake, as the arguments make no essential appeal to modal assumptions after all.

How then might we develop a thin substantival theory? I will end by suggesting how the task might be approached. For reasons that will become apparent I do not yet have a completed theory to offer, but I can offer a toy model that might be a helpful guide to the sort of theory we should be looking for.

The thin substantivalist claims that individualistic facts about the manifold are grounded qualitatively. As I said in Section 5, developing this idea requires that we (1) clearly articulate what the underlying qualitative facts are like, and (2) show that they are sufficient to explain (in the metaphysical sense) individualistic facts about the manifold. We saw that one theory that at least attempts task (1) is the traditional bundle theory on which all facts about the world are ultimately grounded in facts of the form

F, G, . . . are compresent

where F, G, . . . are intrinsic, monadic, qualitative properties and 'compresent' is a primitive, plural predicate. Thus, consider a given individual *a* and suppose we would ordinarily say that it has qualitative properties F, G, ... The bundle theorist says that the underlying qualitative fact about this situation is that F, G, . . . are compresent. She is usually said to then identify the individual *a* with the set of compresent properties, but for now I am just concerned with her account of what the underlying qualitative facts are and not how she makes sense of individuals. So the thin substantivalist might try being a bundle theorist about the regions of the manifold.

But the traditional bundle theory is not well suited to her needs. For one thing, it is highly unclear what the intrinsic, monadic properties of regions of the manifold could be.[61] But even if this were clarified, the proposal cannot make sense of symmetric physical systems. In order to make progress, let us be clear on why it cannot and why this is a problem.

To see why it cannot make sense of such systems, consider the simple "Max Black world", a world containing just two spheres of iron 5 feet from each other which share all their intrinsic, monadic, qualitative properties (they are exactly the same mass, color, shape, etc). How can the bundle theorist characterize this world? Suppose that the Fs are the intrinsic, monadic qualitative properties of each sphere. Then she can only say that the Fs are compresent (to account for the first sphere), and then say that the Fs are compresent (to account for the second). But saying something twice over does not make it true twice over! Her description of this world is therefore the same as her description of a world with just one of the spheres. Returning to the case of GTR, if we tried to be a bundle theorist about regions of the manifold we would not be able to make sense of symmetric GTR worlds in which distinct regions of the manifold play the same qualitative role.[62]

Why is this a problem? It might be said that it is "intuitively possible" for there to be such worlds, in which case the charge is that bundle theory runs up against intuition. But a better charge is that ruling out such worlds was never motivated by the Occamist arguments. The lesson of those arguments, remember, is that we should ground facts about the manifold qualitatively. But symmetric worlds can be characterized in purely qualitative terms. For example, the Max Black world can be characterized as a world in which

$$(1)\quad (\exists x)(\exists y)(Fx \,\&\, Fy \,\&\, Rxy \,\&\, Ryx \,\&\, x \neq y)$$

where F expresses the collection of intrinsic, monadic properties of each sphere and R expresses the distance between them.[63] Thus, by failing to make sense of symmetric worlds the bundle theory implies that certain qualitative states of affairs are impossible, and this goes beyond what the Occamist arguments purport to show. Indeed, for all we know on the basis of those arguments, we live in a symmetric world ourselves! Endorsing the bundle theory on the basis of those Occamist arguments is therefore akin to responding to the Occamist argument

in NGT by rejecting Newtonianism in favor of a metaphysics of motion that can make no sense of certain patterns of relative velocities. Such a metaphysics might succeed in dispensing with facts about absolute velocities, but it would be a perverse over-reaction to the Occamist arguments.

There is a general moral here. Consider a language PL of predicate logic with identity but no constants, in which every predicate expresses a qualitative property or relation.[64] Every fact that can be expressed in PL is a purely qualitative fact. So our new metaphysics of the manifold should be capable of making sense of any physical system that we can express in PL; if it cannot, it is an over-reaction.[65]

In other work I have described an approach that tries to do exactly this.[66] The idea is that the bundle theorist went wrong by trying to construct the underlying qualitative description of the world by considering each individual one by one. It is this "localist" strategy that means she cannot account for symmetrical systems like the Max Black world in which more than one individual plays the same qualitative role. But this localist strategy was not enforced. Starting with an ontology of qualitative properties, we could simply try to construct the qualitative nature of the entire world all at once, as it were, rather than considering each individual in turn. It turns out that this "holistic" approach can then account for any physical system described in PL, including symmetric ones.

11. An Algebraic Approach

This globalist approach can be developed in a number of ways, but elsewhere I presented one toy model.[67] We start with a domain D of simple qualitative properties and relations each of a given adicity greater or equal to 1, denoted with terms of the form P^n (I will call them all properties, for short). We then construct more complex properties out of this basis. To describe these more complex properties we introduce six term functors: &, $\sim$, c, p, ι, and σ. For example, if R^1 is the 1-place property of being red and S^1 is the 1-place property of being square, then $\sim\mathrm{R}^1$ is the 1-place property of being not red and $(\mathrm{R}^1 \,\&\, \mathrm{S}^1)$ is the 1-place property of being red and square. The functors σ and ι are "permutative" functors. For example, if L^2 is the 2-place property of loving, which we ordinarily think of as being instantiated by x and y iff x loves y, then $\sigma\mathrm{L}^2$ is the 2-place property of being loved, which we ordinarily think of as being instantiated by x and y iff y loves x. $(\mathrm{L}^2 \,\&\, \sim\sigma\mathrm{L}^2)$ is then the 2-place property of loving unrequitedly. We also let our domain $\boldsymbol{D}$ include the simple property I of "identity", i.e. the 2-place property we ordinarily understand as holding between x and y if and only if x is identical to y.

The functor c is known as a "cropping" functor. If L^2 is the 2-place property of loving, then $c\mathrm{L}^2$ is the 1-place property of being loved by someone, the property we ordinarily think of as being instantiated by an individual x iff someone loves x. Roughly speaking, c takes an n-place property P^n and yields the

(n-1)-place property $c\mathrm{P}^n$ we would ordinarily think of as holding of $x_2, \ldots x_n$ iff there is something x_1 such that P^n holds of $x_1, x_2, \ldots x_n$. I leave a more complete description of the term functors to a footnote.[68]

Now, applying c again to $c\mathrm{L}^2$ gives us a 0-place property, i.e. a state of affairs that we would ordinarily describe as the state of someone's loving someone. To say what the world is like we say which states of affairs obtain. So on this view the underlying qualitative facts are of the form

P^0 obtains

where P^0 is a 0-place property constructed out of the simple, qualitative properties by successive applications of the term functors. Now let AG be the language consisting of terms that denoting properties, the six term-functors, the predicate 'x obtains', and the normal sentential connectives. One can define a consequence relation on the sentences of the language AG. Now, let ***AG*** be the set of equivalence classes of sentences of AG (under the relation of logical equivalence in AG). And let ***PL*** be the set of equivalence classes of sentences of PL (under the relation of logical equivalence in PL). Then one can prove the central theorem of interest, namely that there exists an isomorphism between ***AG*** and ***PL*** that preserves logical equivalence.[69]

This means that we can make sense of any physical system that we can express in PL, as desired. For example, if the Max Black world is characterized in PL to be a world in which

(1) $(\exists \mathrm{x})(\exists \mathrm{y})(\mathrm{Fx} \,\&\, \mathrm{Fy} \,\&\, \mathrm{Rxy} \,\&\, \mathrm{Ryx} \,\&\, \mathrm{x} \neq \mathrm{y})$

then we can take the basic qualitative fact about this world, which will ground the individualistic facts, to be the fact that

(1*) $cc(\mathrm{F}^1 \,\&\, p\mathrm{F}^1 \,\&\, \mathrm{R}^2 \,\&\, \sigma\mathrm{R}^2 \,\&\, \sim\mathrm{I}^2)$ obtains.

By the central theorem just mentioned, (1*) is logically *in*equivalent to a sentence of AG that would characterize a world in which there is just one sphere. Thus, unlike the Bundle Theory we can make sense of the Max Black world.

Now the spheres in a Max Black world are weakly discernible (in the sense defined in Section 5) since they stand in the irreflexive relation R. But the current approach can also make sense of symmetric systems with weakly indiscernible spheres. For suppose that R were reflexive. The resulting system can be described in PL just by adding a couple of conjuncts to the matrix in (1), so by the central theorem mentioned above there is a corresponding statement of the qualitative nature of the system in AG. As I said, this is one reason why I find the recent literature on weak discernibility a red herring. For if I am right we can ground individualistic facts qualitatively regardless of whether objects are weakly discernible.

The key to all this is our holistic approach. For in constructing the state of affairs that is said to obtain in (1*), there was no attempt to *first* construct the qualitative nature of one sphere and *then* construct the qualitative nature of the second, as the Bundle Theorist would. Rather, we constructed a "world-state", a state of affairs that completely characterizes the entire world all at once; in this case a state that we would ordinarily describe as the state of there being exactly two iron spheres.[70] The fact (1*), that that world-state obtains, is therefore the most fundamental fact about that world. Other qualitative facts, such as that there is at least one iron sphere, are then grounded in the fact that this world-state obtains.

So far we have only described an attempt at task (1), i.e. an attempt to state what the underlying qualitative facts are like. What about task (2), the task of saying how they are to explain the individualistic facts? It is not obvious how to do this. For note that if a given individualistic fact has *any* qualitative ground, it follows from the holistic approach just outlined and the transitivity of ground that it is ultimately grounded in the fact that the entire world-state obtains. I argue elsewhere that that is an undesirable consequence.[71] Very briefly, the worry is that it is implausible that the qualitative nature of the *entire cosmos* must be cited in order to explain, say, my own meager existence. The solution, I argue, is to recognize that ground is irreducibly plural, in the sense that sometimes a collection of facts Y *are* grounded in another collection X even though no Y taken on its own is grounded in anything.[72] We may then say that the individualistic facts *together* are grounded in the fact that the qualitative world-state obtains even though no individualistic fact has a qualitative ground when taken on its own. On this approach we avoid the undesirable consequence that my existence is grounded in the qualitative nature of the entire cosmos since we deny that my existence (taken alone) has a qualitative ground in the first place! Still, we remain faithful to the idea that the world is fundamentally qualitative since the individualistic facts are together grounded qualitatively.

The result is a radically "structuralist" view of individuals. On this view an individualistic fact such as my existence is not fundamental, but nor is there any qualitative matter of fact that accounts for it—not even a highly relational or extrinsic one. My existence only comes into view, as it were, when considered alongside all individualistic facts about all individuals, for it is only when those facts are taken together that they can be explained in qualitative terms. That at least is the view; in other work I have tried to argue in its favor.[73]

So far I have just described a general framework for grounding individualistic facts qualitatively. How might the thin substantivalist make use of it? The natural idea would be to let the domain D of simple properties be the properties and relations that the thick substantivalist believes to hold of the regions of the manifold. They might be topological properties, space-time intervals, the properties of points that are taken to constitute the physical mass-energy field, or whatever. The idea would then be to use the term functors described above to construct a world-state W^0 that characterizes the entire qualitative nature of

the manifold without mentioning any specific individuals. And she may then use the fact that W^0 obtains to ground all other facts about the system. In the first instance, she will say that the plurality of all individualistic facts about the manifold of the form

$$\phi(r_1, r_2, \ldots)$$

are, together, grounded in the fact that W^0 obtains even though no one of them has a ground on its own.[74] By the principle of Necessitation (modified slightly given our new pluralist logical form of ground) it then follows that any two worlds in which W^0 obtains agree on which individualistic facts obtain. So this view about what grounds individualistic facts about the manifold implies, given the principle of Necessitation, that diffeomorphic shifts are impossible. That is why it counts a thin substantivalist view, as opposed to a thick substantivalist view on which the impossibility of diffeomorphic shifts is a bare modal claim.

Note that we do not deny that there are regions of the manifold, we just (plurally) ground facts about them in qualitative terms. Since there are such regions, and since we are used to thinking about the world in terms of it containing a domain of individuals propertied and related in various ways, it is no surprise that we tend to represent GTR systems with models $\boldsymbol{M} = (M, g, T)$, where M is a manifold of individuals. This method of representation is not incorrect, so long as it makes no claim to represent GTR systems in their most fundamental respects. But since the fundamental facts about these systems are qualitative, it makes sense to ignore differences between $\boldsymbol{M}$ and $d(\boldsymbol{M})$, for any diffeomorphism d. Thus, if one takes the space of models to represent the space of physically possible worlds, it makes sense to then interpret $\boldsymbol{M}$ and $d(\boldsymbol{M})$ as representing the same possible world.

12. Conclusion

The above is just a toy model, not a completed thin substantivalist theory. To take just one issue, the equivalence theorem stated above only says that AG is equivalent to PL. But PL is a finitary language, and the thin substantivalist will likely need to construct a more sophisticated algebra of states of affairs for which there is an equivalence to an infinitary first-order language. Second-order languages might also be necessary. Still, my point here is just that insofar as the Occamist arguments motivate a rejection of thick in favor of thin substantivalism, it is precisely this sort of work that the substantivalist needs to do. The result will be a substantival view that stands to thick substantivalism just as the Galilean view of spacetime stands to Newtonianism: it will dispense with the kinds of facts that were shown by the Occamist arguments to be redundant and/or undetectable.

One might wonder whether a thin substantivalist view along the above lines ultimately deserves the title 'substantivalism'. After all, any reference to the manifold on this approach will ultimately be grounded in facts that do not concern the manifold at all—at least, not when it is conceived of as an individual bearer of properties. This is to some extent a verbal issue, and the meaning we pre-theoretically attach to the word 'substantivalim' might not be clear enough to yield a determinate answer. I am inclined to count it as substantivalism because it is constructed by putting thick substantivalism through a general recipe that removes reference to underlying individuals from *any* theory, but I am not attached to the term. In any event, if this is substantivalism, it is substantivalism exorcized of redundant structure and stripped to its bare necessities.

Notes

∗ Many thanks to David Baker, John Morrison, Jill North and David Plunkett for their extremely helpful feedback on earlier drafts of this paper.

1. The way this debate is characterized in the literature—and the way I characterize it here—is not obviously faithful to the views of these historical figures. But our concern here is not with historical accuracy so I will not elaborate on this point.
2. Sklar 1974, p. 161; my emphasis.
3. Earman and Norton claim that affirming this sort of possibility is the 'acid test' of substantivalism (see their 1987, p. 521). Belot agrees in his 2000.
4. I am told that this is something like Spinoza's actual view. But I am not qualified to defend this interpretive point, so I use the term 'Spinozist' as a label for a view which may or may not have been Spinoza's.
5. For discussions of ground see Fine 2001 and MS, and Rosen 2010. For some recent literature on ontological dependence see Fine 1995, Lowe, 2006 and Koslicki MS. For a notion of truth-making that is understood non-modally see Cameron MS. And see Sider 2011 for a development of metaphysical semantics.
6. I choose ground because I believe that it does a better job at capturing many issues in metaphysics than the other notions, but I will not argue this here.
7. This is how I interpret Fine as using the term in his influential papers 2001 and MS. Not all recent philosophers use the term in the same way; see Schaffer 2009 for a different idea under the same name.
8. This is how Fine characterizes the logical form in his 2001 and MS. Γ is taken to be a list and not a conjunction so as to allow one to make sense of the plausible view that a conjunction is grounded in its conjuncts without it collapsing into the view that the conjunction grounds itself.
9. This is how Rosen characterizes the logical form in his 2010.
10. Transitivity: if the Xs ground Y* and the Ys along with Y* ground Z, then the Xs along with the Ys ground Z. Irreflexivity: for any X, there are no Ys such that X along with the Ys ground X. Strictly speaking I consider these principles to be open for dispute, but it will smooth the presentation that follows to presume them.

11. This statement of the principle quantifies over facts, so it breaks down in modal frameworks in which the notion of a fact's obtaining in a world is not well defined (e.g. Lewisian counterpart theory). So it is sometimes better to revert to our official way of talking of ground as a sentential operator and state Necessitation as the scheme

    If S because Γ, then it is metaphysically necessary that if $\wedge\Gamma$ then S.

    where $\wedge\Gamma$ is the conjunction of the sentences in Γ. But for our purposes we can largely ignore this complication.
12. This follows from my original statement of the view by the transitivity and irreflexivity of ground.
13. Though this allows that the fact that m_1 is 3 meters from m_2 is grounded in different facts about space in different possible worlds.
14. Moreover, it follows from what I take to be the correct view about what grounds the grounding facts that the corresponding contingent claims are false (see Dasgupta MSa). But there is no space to discuss this here.
15. This terminology is perhaps a little misleading since the second theorist's modal view follows from *something*, namely her views about religion. But our topic here is the nature of space, and the point is that her modal view does not follow from her views about *that*.
16. Precisely how these notions are defined will not matter to us here. See Geroch 1978 for details.
17. Hoefer 1996, p. 5; my emphasis.
18. One might have a different account of each field, for example that g represents space-time intervals between regions while T represents an extended object with parts. And of course this does not exhaust the options. Maudlin 2007 intriguingly suggests that the correct metaphysics of fields will place them in some new category as yet undreamt of by armchair metaphysicians. By placing so few constraints on ϕ I take the last paragraph to be consistent with Maudlin's suggestion.
19. Again, how one thinks about these facts depends on ones metaphysics of the mass-energy field. If one thinks of it as an extended object with parts, these facts can be taken to consist of space-time relationships between its parts. Alternatively, if one thinks of it as an instantiation of properties by the manifold, these facts will consist of facts about the space-time intervals between different instantiations of those properties, for example that property F and property G are exmplified a certain space-time interval apart.
20. Again, this is implied by my original statement of the view given the transitivity and irreflexivity of ground.
21. It is tempting to interpret the debate between so-called manifold substantivalists and metric substantivalists as a disagreement on precisely this question. For a defense of the former view, see Earman 1989 chapter 9. For a defense of the latter view see Maudlin 1988 and Hoefer 1996. (I would add parenthetically that I doubt the question of what counts as spacetime in GTR has a determinate answer, since I doubt that the meaning we attach to 'spacetime' is determinate enough to withstand such close scrutiny.)
22. See Earman 1986 for counterexamples involving so-called "space-invaders". See Norton 2008 for another kind of counterexample.

23. This property of GTR is sometimes known as General Covariance. However, there is some controversy over how General Covariance should be understood, so to remain neutral on that issue I use the term 'diffeomorphism invariance' stipulatively to label the property I am interested in. See Rynasiewicz 1999 for a good review of the literature on General Covariance.
24. In their 1987, their premise that substantivalists must deny a principle they call Leibnizian Equivalence is equivalent to my statement of the premise above.
25. I should add that I do not count the property of Socratizing as qualitative. I do not count the property of having a particularized trope as qualitative either. Thus, even if the property of being green is qualitative, the particular greenness of this apple is a particularized trope and the property of having this particular greenness is then not qualitative since it concerns a particular individual, namely this particular greenness.
26. Earman and Norton 1987, p. 524.
27. Well, (H2) is not justified by diffeomorphism invariance alone. For diffeomophism invariance was defined to be a property of GTR that concerns its *models*, while (H2) is a statement about *worlds*. To bridge the gap, we need the assumption that if $\boldsymbol{M}$ is a model of GTR and represents a possible world W, then W is a world in which GTR is true. But this is granted by all parties to the debate so I will not discuss it further.
28. See Melia 1999 and Skow 2005 for a motivation and defense of this approach.
29. Thus I take it that Caulton and Butterfield were speaking loosely when they said 'the correct response is to consider diffeomorphically related histories [i.e. models] as representatives of the *same* physical state of affairs' (MSb, p. 9). What they surely meant to say is that, in addition, the correct response denies that there are distinct possible worlds like W and d(W). Without the addition, their claim about the representational properties of models is consistent with the claim that GTR is indeterministic.
30. I point this out because there was a lively debate in the literature as to whether the substantivalist should, when denying (H1), say that $\boldsymbol{M}$ and $d(\boldsymbol{M})$ represent the same possible world or that just one of them represents a possible world (see Brighouse 1994 and Maidens 1992 for a defense of the first view, and Butterfield 1988 and Maudlin 1988 for a defense of the latter view). But this issue is largely irrelevant to the matter, since it is (H1*) rather than (H1) that does all the work in the argument and (H1*) says nothing of the representational properties of models at all.
31. Pooley 2006, p. 101. Theorists who respond in this way include Brighouse 1994, Butterfield 1988, Caulton and Butterfield MSb, Hoefer 1996, Maidens 1992, Maudlin 1988 and Pooley 2006. This response constitutes a position sometimes known as 'sophisticated substantivalism', though that term is also used to describe the conjunction of denying that there are such worlds as W and d(W) *and* asserting that $\boldsymbol{M}$ and $d(\boldsymbol{M})$ represent the same possible world. For reasons just mentioned I do not consider the second conjunct particularly important.
32. Brighouse 1994.
33. Finer distinctions are of course possible. One might wish to replace the 'iff' in the definition of an individuating qualitative profile with 'only if', since that is enough to imply that diffeomorphic shifts are impossible. Maudlin 1988 endorses a view similar to that which would result by replacing 'iff' with 'if',

though the details of his view are subtle and there is no space to discuss them here.

34. Brighouse 1994, p. 122.
35. I have in mind Lewis' idea that counterpart theory can often mimick the sort of modal claims that the haecceitist makes. See Lewis 1986, Chapter 4.
36. Thus the language I have in mind does not contain substitutes for constants such as '*x* Socratizes'.
37. It is tempting to read some "structuralists" as implicitly having this sort of thesis in mind, though it is hard to say for sure since they are typically wary of using the notion of ground in the way I do.
38. Specifically: that if (∃x)Fx, then for any individual *a* that is F, the fact that (∃x)Fx is grounded in the fact that *a* is F.
39. Hoeffer 1996, p. 4 (his emphasis).
40. For example, Hoefer sometimes sounds like he is proposing the purely modal thesis that some modal questions are unintelligible.
41. Baker 2010, p. 1163.
42. Of course, I am being a little unfair here since both these authors go on to expand on what I quoted above. I do not believe that what they say amounts to an attempt at task (1), but I leave this for the reader to judge for herself. Similar remarks apply to Caulton and Butterfield MSa when they express their view QII as the denial that there are haecceitistic properties, for this is a purely negative thesis and does not tell us what the underlying qualitative facts are like.
43. Ladyman and Ross 2007, pp. 143 and 144 respectively.
44. Steven French once suggested this line to me in conversation, though I do not know if he would defend it. This might be what Caulton and Butterfield had in mind when they wrote that they consider 'diffeomorphically related histories [i.e. models] as representatives of the *same* physical state of affairs' (MSb, p. 9).
45. See Saunders 2003b and 2003a.
46. Ladyman and Ross explore this approach in their 2007, as does Ladyman in his 2007.
47. The two arguments here correspond to two different approaches to thinking about the how symmetry in general bears on metaphysics. I discuss the two approaches at length in Dasgupta MSc. We can perhaps see these arguments as distant descendents of Leibniz's arguments that he described in the Leibniz-Clark correspondence, but I will not trace out this historical point here. For more on this see Pooley MS.
48. This is analogous to our implicit assumption in the case of GTR that both the substantivalist and the anti-substantivalist use 'GTR' to refer to the same set of laws. In both cases the discussion should really be made without this assumption, but it is somewhat cumbersome to do so.
49. See, for example, Baker 2010, p. 4.
50. Sklar made a similar point in his 1974, p. 180.
51. For example, (R2) is implied by Earman's more general principle of using symmetry considerations to derive metaphysical conclusions. As he puts it on p. 46 of his 1989,

> The motivation [for dispensing with features that are altered by the symmetries of our laws] derives from combining a particular conception of the main function of laws of motion with an argument that makes use of Occam's razor. Laws of motion, at least in so far as they relate to particles, serve to pick out a class of allowable or dynamically possible trajectories. If [there are features that are altered by the symmetries of our laws], the same set of trajectories can be picked out by the laws working in the setting of a weaker space-time structure. The theory that [posits these features] is thus using more space-time structure than is needed to support the laws.

More recently, North defended a principle like (R2) when she advised that 'we should not posit structure beyond that which is indicated by the fundamental dynamical laws' (North 2009, p. 9).

52. This is not to presuppose a Humean conception of laws. The question of Humeanism vs Anti-Humeanism is the question of what grounds the fact that those equations *are laws*, whereas here I am just asking what grounds the fact that those equations *are true*.
53. Thanks to David Baker for explaining this worry to me.
54. Earman 1989, p. 48.
55. Here I will just present the argument in barest outline. Roberts presents perhaps the most developed version of it in his 2008. I have also heard oral presentations of it in seminars given by David Albert and Tim Maudlin. I have presented versions of it in Dasgupta 2009 and 2013.
56. Earman and Norton presented a similar argument in their 1987 that they called "The Verificationist Dilemma", but the argument was largely ignored in the subsequent literature. Perhaps one explanation for that is the misleading title they gave the argument; as emphasized above, the argument as I understand it here does not appeal to verificationist principles at all.
57. Maudlin 1993, p. 190.
58. Thanks to Gideon Rosen for a helpful conversation on this point.
59. While I do not think that Maudlin's insight has the consequences he thinks it does, I do believe it has profound consequences about the nature of inquiry and ignorance that have not yet been fully appreciated. For example, according to the conclusion I draw from Maudlin's insight, the sort of epistemic state we attempt to attain when engaging in an inquiry is *not* merely the ability to knowledgeably answer questions. Moreover, I think that Maudin's insight shows that it is extremely difficult to see what sort of epistemic state we *do* hope to attain as a result of our inquiries, at least when we try to analyze the state in the terms normally used in the contemporary epistemology literature such as truth, justified belief, knowledge, reliability, and so on. I hope to develop these consequences of Maudlin's insight in other work.
60. Pooley explores this approach in his MS.
61. See Maudlin 2007 for more on this issue.
62. Parsons and McGivern (2001) offer a bundle theory about regions of the manifold according to which the properties that are said to be compresent are particularized tropes rather than repeatable properties. They advertise that

this approach can make sense of symmetrical systems. But even if they are right, it does not count as a thin substantival view since facts about particularized tropes are not qualitative facts (see footnote 25). The point here is not just terminological, for the kinds of Occamist arguments that motivate rejecting fundamental individualistic facts about the manifold also motivate rejecting fundamental facts about particularized tropes.

63. One may insist that a "totality clause" be added to this characterization of the world, to the effect that nothing else exists and that the spheres instantiate no other properties or relations. But I ignore this complication for ease of prose.
64. Note then that PL does not contain substitutes for constants such as 'x Socratizes'.
65. At this point the thin substantivalist might suggest that we ground individualistic facts about the manifold in facts expressible in PL, such as that expressed by (1). But as I argued in Section 5, it is unclear what this could mean.
66. See Dasgupta 2009.
67. The following few paragraphs are based on Dasgupta 2009. The approach is based on work in formal logic by Quine 1976, Kuhn 1983, and others.
68. If F is the n-place property we ordinarily understand as holding of individuals $x_1 \ldots x_n$ just in case $\phi(x_1 \ldots x_n)$, and G is the m-place property we ordinarily understand as holding of individuals $y_1 \ldots y_m$ just in case $\psi(y_1 \ldots y_m)$, then
    1. $\sim$F is the n-place property we ordinarily understand as holding of $x_1 \ldots x_n$ just in case it is not the case that $\phi(x_1 \ldots x_n)$;
    2. (F &G) is the $max(n, m)$-place property that we ordinarily understand as holding of $x_1 \ldots x_k$ just in case $\phi(x_1 \ldots x_n)$ and $\psi(x_1 \ldots x_m)$, where $k = max(n, m)$;
    3. σF is the n-place property we ordinarily understand as holding of $x_1 \ldots x_n$ if and only if $\phi(x_n x_1 x_2 \ldots x_{n-1})$;
    4. ιF is the n-place property we ordinarily understand as holding of $x_1 \ldots x_n$ if and only if $\phi(x_2 x_1 x_3 \ldots x_n)$;
    5. pF is the (n+1)-place property that we ordinarily understand as holding of $x_1 \ldots x_{n+1}$ if and only if $\phi(x_2 \ldots x_n x_{n+1})$.
    6. If n is greater than or equal to 1, then cF is the (n-1)-place property that we ordinarily understand as holding of $x_2 \ldots x_n$ if and only if there is something x_1 such that $\phi(x_1 \ldots x_n)$; otherwise cF is the 0-place property F.
69. See Kuhn 1983 for these results.
70. Here again I am slurring over the issue that one might have wished to add a "totality fact" to (1), stating that there are no other objects and that the two spheres have no other properties.
71. See Dasgupta MSb.
72. Here I am modifying the proposed logical form of a grounding claim that I stated in Section 1.
73. See Dasgupta MSb.
74. She may then ground the facts expressed by PL, such as existentially quantified facts, in those individualistic facts just as we would normally do. I was not clear about this in my 2009. For given that AG is difficult to read (for most of us), and given that it is isomorphic to PL, it was convenient when discussing AG there to write in PL instead. Unfortunately, it gave some readers the impression that

my view was that those facts expressed by PL were themselves fundamental. As I hope is clear here, that is not my view.

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