NON-SPATIAL MATTERS
ON THE POSSIBILITY OF NON-SPATIAL MATERIAL OBJECTS

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ABSTRACT: While there is considerable disagreement on the precise nature of material objecthood, it is standardly assumed that material objects must be spatial. In this paper, I provide two arguments against this assumption. The first argument is made from largely *a priori* considerations about modal plenitude. The possibility of non-spatial material objects follows from commitment to certain plausible principles governing material objecthood and plausible principles regarding modal plenitude. The second argument draws from current philosophical discussions regarding theories of quantum gravity and the emergence of spacetime. When it is appreciated what possible worlds these current theories commit us to, the possibility of non-spatial material objects will follow. Thus, either route will lead us to the possibility of non-spatial material objects. The significance of this result is that we need to revise our accounts of material objecthood to both accommodate these possibilities and the theories that lead to them.

Keywords: Nature of Materiality – Material Object Metaphysics – Location – Modal Plenitude – Emergent Spacetime

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Consider the following claim:

> **Standard View of Material Objects (SVMO)**
> Necessarily, anything that is a material object has a location in space.[2]

The claim made here by the standard view of material objects draws a necessary connection between two properties that can be instantiated by an object. It tells us that whenever the property of *being material* is had by an object, that object also instantiates the property *being spatial*. SVMO, as I understand the claim, is *not* a stipulation about the circumstances under which it is appropriate to call an object 'material'. Neither do I take the claim to be about the contingent social facts about how we fix the meanings of our terms. Rather, it is a metaphysically robust claim about how two properties are related. So understood, the question about the truth of SVMO is a deep question about whether or not we can have objects made up of the same stuff as the material objects in our world that fail to have spatial locations. On this understanding, the question of the SVMO's truth invites us to consider what constitutes the natures of things in the material world.

One more clarificatory remark is in order. As I've stated SVMO, I talk about locations in space instead of regions in spacetime. There are two reasons for why I do this. First, some of the prominent defenders of views that entail SVMO, such as Ned Markosian, adopt a presentist metaphysics of time. Accordingly, it is possible for spatial and temporal locations to come apart in

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[2] Three comments. First, having a location in space will include having a location in a space or spacetime of any arbitrary number of dimensions and regardless of whether or not the space is flat or exhibits positive or negative curvature. I will specify below what classes of structures I take to be representative of the classes of possible physical spaces. Second, throughout this paper I freely help myself to substantivalist 'talk', but my conclusions don't rely at all on whether or not substantivalism or relationism is true. This will become clear at the end of §2.3.

their metaphysics. As such, an argument against SVMO that presupposed the falsity of presentism wouldn't be dialectically effective against them. Second, if the argument I gave was merely against the necessity of material objects having spatiotemporal locations because they could also have spatial locations in some presentist world structure, then I don't think that the argument would be all that satisfying. Consequently, I leave the notion of 'spatial location' ambiguous between having a spatiotemporal location and a metaphysics which allows spatial and temporal locations to be treated separately in some presentist-friendly way.[3]

I imagine that SVMO, so understood, would strike most of us as intuitively true. Indeed, the SVMO, or something that entails it, has enjoyed some popularity in recent and historical discussions on the metaphysics of material objects and has played an important role in distinguishing material objects from other categories such as disembodied minds, abstract objects, and so on as well. For example, in the early modern era, Descartes took *being material* to be the same as *having extension* and, thus, material objects would have to have some location.[4] And, Hobbes took material objects to be those things which are coincident or coextended with some space. In the analytic tradition, Markosian (2000) and Hudson (2005) defend the view that being material is just to bear some locative relation to a region of space. Quine (1976) understands material objects as "...the aggregate material content of any portion of space-time however ragged and discontinuous."[5] And contemporary supersubtantivalists understand material objects just to be identical with or constructed out of regions of spacetime. The SVMO has also played important dialectical roles in metaphysics as well. For example, it is a key premise in one of Schaffer's (2009) arguments for supersubstantivalism.[6] Thus, it can be seen that SVMO enjoys a venerable tradition. Contrary to this, however, there are good grounds, stemming from principles in modal epistemology and certain considerations from work in fundamental physics, for rejecting SVMO.

In this paper I present two arguments for this conclusion. The first argument makes use of two distinct principles of plenitude. One principle tells us which recombinations of objects are permissible within logical space. The other tells us what the classes of possible world structures are. Both principles are required to get the possibility of non-spatial material objects. The second argument employs a different tactic. A surprising trend in work on quantum gravity tells us that the world lacks spatiotemporal structure at the fundamental level. Instead, the spatial, temporal, and spatiotemporal features of the world are emergent. The second argument proceeds from

[3] Thanks to an anonymous referee for discussion on this point.

[4] This is a bit fast. The question depends on whether or not we understand Descartes as a relationalist or substantivalist. If we take him to be a relationalist, then the material cosmos itself wouldn't have a spatial location, because the cosmos itself wouldn't be circumscribed by some further body. However, something very close to SVMO does follow from this and Descartes' commitment to every material object having proper parts. Namely, that, necessarily, all material objects have proper parts with locations. This thesis will also come out as false given my arguments.

[5] Quine then goes on to replace material objects with regions of spacetime and then further goes to say that commitment to regions of spacetime can be eliminated in favor of or reduced to the ontology of pure set theory (1976 pp. 500-501). So, ultimately material objects for Quine end up bottoming out into pure sets. However, the connection between material objects and space remains.

[6] Schaffer (2009, p. 141).

considerations from these theories to the possibility of non-spatial material objects. I conclude with a brief discussion about how the two arguments interplay with one another and the overall significance of the arguments. But, before moving on to these arguments, some preliminaries.

1. PRELIMINARIES: MATERIALITY AND SPATIALITY

SVMO, as I understand it, provides us with a partial account of the nature of material objects. The argumentative strategy that I take moves from principles in modal metaphysics and considerations from contemporary physics to the conclusion that there is possibly something that is both material and that lacks a spatial location. Two questions arise. First, how are we to ensure that the possibility being described is one in which the object or objects under consideration are *material*? Second, what does it mean to say that the object or objects under consideration don't have a *spatial location*? In this section, I answer these questions in turn.

1.1. Constraints on Materiality

One way to argue against SVMO would be to provide an account of materiality that does not require spatial location and to argue that it better captures our intuitions and practice with regards to the concept. Alternatively, we could proceed by finding some principles that place constraints on materiality that are both independently plausible and shared by defenders of SVMO. Since my goal is to show that SVMO is false, it would be nice to provide some relatively neutral way of discussing the limits of what is possible for material objects. So, I'll take the latter strategy.

There are three principles that my arguments will make use of. The first is a principle about the kind of property *being material* is. The second and third are constraints about how the property *being material* is inherited from one object to another.

The first principle constraining materiality is that the property *being material* is an intrinsic property, which I understand in the following way:

> **INTRINSICALITY OF MATERIALITY (IM)**
> Any qualitative duplicate of a material object is a material object.

Here I follow Lewis (1986a) in his analysis of duplication in terms of perfectly natural properties.[7] The perfectly natural properties are those that carve nature at its joints in that the sharing or not sharing of perfectly natural properties makes for objective similarity and difference, and provide us with the sparse qualitative base needed to characterize the rest of reality without redundancy.[8] Given this, one thing is a *duplicate* of another just in case they have all of the same perfectly natural properties and there is a one-to-one correspondence between the parts of the one and the parts of

[7] See Langton & Lewis (1998) for a slightly different definition. My arguments will go through regardless of which definition we use, however.
[8] See Lewis (1983) for a characterization of natural properties and the roles that they can play.

the other such that the parts of each have the same perfectly natural properties and stand in the same perfectly natural relations.[9, 10]

Here's why I think IM is plausible. We might think that the properties which make for deep distinctions between kinds of objects in the world are intrinsic properties. This is because the deep distinctions in the world are due to the *natures* of those entities being distinguished. Importantly, the natures of entities are given by their intrinsic properties. Given that we think of the distinction between the material and non-material as deep, we should think that the properties which divide the material and the non-material are intrinsic. Given the important roles that materiality has played in our philosophical theorizing (in debates about the mind, human persons, and so on), it seems that we should think that the distinction between what is material and what is not material is a deep one.

The second and the third principles tell us about how materiality is shared between composite material objects and the objects which compose them. It is important here to restrict the mode of composition under consideration. We don't want it to be the case that *any* entities whatsoever inherit materiality *via* composition. For according to some theories objects decompose into entities like properties, bare particulars, and (neo-)Aristotelian forms this would entail that those objects are material. The same goes for theories which take sets to be composed of objects. So instead, *we should restrict the principle to only include some parts of material objects and only some composites of them*. The appropriate restriction will likely vary depending on one's metaphysics, but I think some candidate options would be that we restrict the principle to concrete particulars (understood in a relatively wide sense) or something that plays a similar role.[11] For lack of a better term, let's just call anything that plays a role of this type a 'thing'. As I'm conceiving of this category, *things* include property instances, thick particulars, particular event tokens, and other similar entities.[12] What don't count as things are entities like sets, universals, formal parts, and, perhaps, event/state of affairs types. This restricts the relevant sense of composition under consideration so we don't have to worry about the entities other than *things* coming out as material.

The second principle requires that materiality is inherited from the parts that compose an object to the composed object:

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[9] Note that, on this account, all perfectly natural properties come out as intrinsic but not all intrinsic properties are perfectly natural (Lewis (1983, pp. 27-8), Lewis (1986a, p. 61).

[10] Admittedly, Lewis's account of intrinsicality is controversial (*e.g.* see Eddon (2011)) and more fine-grained approaches are on offer. That said, the argument I give needn't depend on whether or not Lewis's analysis is precisely correct. What *is* important for the argument is the way in which Lewis's account illuminates which properties "go with" individuals as they are recombined into different possibilities. I think Lewis's account of intrinsicality fairs perfectly well on this front. As such, I will leave the complicated issue of the proper analysis of intrinsicality aside.

[11] I am hesitant to use the word 'concrete' here to capture the kinds of entities that I want to capture. This is both because of the difficulties found in Lewis (1986a, pp. 81-6) and for issues with understanding concreteness that arise in the context of quantum gravity (see Norton (2017) and Lam & Wüthrich (2018, p. 40)). In particular, with respect to the latter worry, causal and locative criteria for concreteness seem to fail in these cases.

[12] Allowing for a wide array of entities (*e.g.* property instances and events) to be candidate material objects fits with the way that other authors, such as Markosion (2000), approach the issue.

MATERIAL INHERITANCE PRINCIPLE (MIP)

Any thing that is composed entirely out of material things is a material object.

So for any objects, $o_1, \ldots, o_n$, that compose a further object, o^*, such that o^* is a *thing*, and each of $o_1, \ldots, o_n$ are things, if each of $o_1, \ldots, o_n$ are material, then o^* is material as well. In other words, if we exhaust all of the parts of a thing (understood in the sense defined above), which are themselves things, and each of those are material, then the composite is material as well.

I take MIP to be a highly plausible principle and don't think it needs further defense. Nonetheless, there are further reasons to accept it. Most importantly, MIP plays an important role in understanding what it is for an object to count as material.[13] Composite things are material when they are entirely made up of other material things. As such, it plays an important role in articulating materialist theses which take all contingent concreta to be material things. Moreover, Iaquinto and Torrengo (2022) point out, the rejection of MIP leads one to posit brute connections between materiality and other properties. Due to the fact that MIP plays these important theoretical roles, I assume its truth throughout the rest of the paper.

The third principle requires that materiality of a composite thing is also had by its parts:

MATERIAL DECOMPOSITION PRINCIPLE (MDP)

Each of the things that compose a material object are themselves material.

So for any objects, $o_1, \ldots, o_n$, that compose an object o^*, such that $o_1, \ldots, o_n$ are *things*, if o^* is material, then each of $o_1, \ldots, o_n$ are material objects as well. In other words, for any composite object that is a thing (in the sense defined above) and material, if it has parts that are things, they are also material.

Like MIP, I take MDP to play an important theoretical role in our understanding of the nature of *materiality*.[14] For example, principles much along these lines have been important in articulating materialist theses.[15] Further, a principle much like MDP has played a dialectical role in defending accounts of materiality that entail SVMO. For example, Markosian argues in favor of his preferred account (which takes material objects just to be those objects with spatial locations) against others because it entails that point-sized subatomic particles are material objects while the other accounts do not. The principal reason for why he thinks that this is a good result is because it obeys a decomposition principle which is more general than MDP.[16] Due to these considerations, MDP seems to me to be an acceptable assumption to take on.

Lastly, one assumption I will make throughout the paper is that there are objects which are material. Here I think we should take the quantifier seriously. That is, I am assuming that we are

[13] See Bailey (2019) for a thorough discussion and definition of *material* that entails MIP.

[14] Again see Bailey (2019).

[15] See Crook and Gillett (2001) for discussion.

[16] Markosian makes use of the following principle "… surely this is a good principle concerning the mereology of [material] objects … *If x is a [material] object, and y is a part of x, then y is a [material] object too*." (2000, 383-4).

genuinely ontologically committed to material objects. Thus, I will assume that eliminativism about material objects is false from the start.

1.2. The Limits of Spatial Possibility

SVMO states that, necessarily, all material objects have a spatial location. To show this is false we need to show that, possibly, there is a material object without a spatial location. Note that this doesn't require that we show that there are material objects without any locations whatsoever. Just that there are material objects without *spatial* locations. It will suffice to show that there is a duplicate of a material object located within a world that has a structure that is not spatial.

This raises the following question. "Just what is it for a world to have a spatial structure?" It would go well beyond the scope of the paper to offer jointly necessary and sufficient conditions for what it is for a world to have a spatial structure. But, it will suffice for my purposes just to offer a necessary condition for a world structure counting as spatial.

First, let's unpack the notion of *world structure*. Structures, I take it, are abstract entities that represent the bare-bones relational aspects that different parts of a world could enter into.[17] A structure is logically possible only if there are concrete inhabitants of some possible world that instantiate it.[18, 19] Possible structures are instantiated at worlds in virtue of the natural properties and relations those objects have at those worlds.[20] The *world structure* can be thought of as a network of external relations that unites a plurality of individual objects into a single possible world.[21, 22] Since a world structure is what unites individual objects into a world, every world will have a world structure.[23]

Some world structures are spatial. A prime example of a spatial world structure is Euclidean space. The individual objects in a Euclidean space are unified by virtue of standing in some spatial relations of distance to one another. Pseudo-Reimannian manifolds provide us with yet another example. The class of structures representing possible ways physical space might be is inclusive.

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[17] 'World structure' as I use the term here picks out the underlying structure of the world which differs from the world's *instantial structure* which is how the perfectly natural properties and relations are distributed over the world's underlying structure.

[18] Bricker (2020, p. 255).

[19] This characterization of *world structure* might sound like it begs the question against structuralism. While I do not think that some versions of structuralism are true (see my discussion in §§2.4.), I also think it would be inappropriate to settle the question as a matter of definition. Instead, the point here is to see world structures as representational entities that get instantiated in concrete worlds. Whether this requires being instantiated by some concrete particulars or the structure can be instantiated in some sense "prior" to the existence of concrete particulars is a matter for a later debate. So interpret my discussion here as being neutral between these two positions. Thanks to an anonymous referee for bringing up this point.

[20] *Ibid.*

[21] External relations are relations which don't supervene on the intrinsic natures of their relata but do supervene on the intrinsic natures of the fusions of their relata.

[22] Bricker (2020, pp. 273-4).

[23] If this weren't the case, it might seem that my goal is easy. All that would need to be shown is that it is possible to have a duplicate of a material object in a world without any world structure. Such a world wouldn't have any locations at all for the object to be located at, *a fortiori* spatial ones.

Presumably, it will include spaces of any arbitrary number of dimensions and with any varied kind of curvature. The question is whether we can point to some feature that all possible spatial structures must have in common to count as spatial.[24]

Recent discussions on *geometric* possibility provide us with a nice place to start. In this literature, the defining features of being a space are given in terms of what geometric features a structure has. For some possible structure to count as a possible structure of physical space the structure under consideration must have some distinctive set of geometric properties.[25] The two main proposals for what distinctive geometric features a spatial structure must have can be found in Belot (2011) and Brighouse (2014).

Belot thinks that we should take *distance* as central to our concept of space, where distance is understood in terms of having a natural metric function.[26] A distance function, d, is a *metric* when for any points, x and y, d meets the following three conditions:

D1 $d(x,y) = 0 \Leftrightarrow x = y$ (Positive Definiteness)

D2 $d(x,y) = d(y,x)$ (Symmetry)

D3 $d(x,y) + d(y,z) \geq d(x,z)$ (Triangle Inequality)

The class of structures that meet the conditions positive definiteness, symmetry, and triangle inequality is the class of *metric spaces*. So for Belot any possible spatial structure will be a metric space. [27] The class of metric spaces includes a vast amount of geometric structures. These include relatively familiar classes of spaces like the Euclidean spaces and all other Reimannian spaces to more unfamiliar and stranger classes of spaces such as metric graphs, discrete metric spaces such as integer lattices, and more.[28]

Brighouse, on the other hand, takes *having determinate dimension* to be essential to our concept of space.[29] Allow me to unpack what they mean by 'determinate dimension'. In classical topological dimension theory there are three different dimension functions: small inductive dimension, *ind*(X), large inductive dimension, *Ind*(X), and Lebesgue covering dimension, *dim*(X). Interestingly, these

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[24] I admit there is a sense in which the answer to this question seems to be a matter of convention. Belot says something to a similar effect. Namely, the question "What are the possible structures of space?" is "a little silly" however, he also says "our concept of spatial geometry is not a completely formless one." (2011, p. 8). But, this doesn't prevent us from producing interesting results. Some of the possible structures considered will be so far away from the norm of what we think of as spatial that there is a very intuitive sense in which we get material objects that are non-spatial.

[25] I don't take it that having these geometric properties is ever taken to be *sufficient* for a world structure to count as a physical space. In order for that to happen the structure would need to be instantiated by the right kinds of things. For example, a quality space might have the same geometric features as some possible spatial structure, but won't count as an instance of a possible spatial structure because it has the wrong kind of occupants. But this is fine, all we are looking for is a necessary condition for a possible structure to count as spatial.

[26] As opposed to some arbitrary metric defined on the space.

[27] Belot (2011, p. 13).

[28] See Belot (2011, ch. 1) for a survey of some of these spaces.

[29] Brighouse (2014, pp. 32 & 35).

dimension functions deliver different results in certain classes of topological spaces.[30] Moreover, each of these functions "breaks down" in some spaces. Either the functions don't return the same results for the number of dimensions that the spaces have or they exhibit pathological features such that they return the intuitively wrong results in certain classes of topological spaces. For example, in some classes of spaces a dimension function will return the result that a subspace has a greater number of dimensions than the space it is a subspace of. However, in the class of *separable metrizable spaces* all three functions yield the same results, *i.e.*, $ind(X) = Ind(X) = dim(X)$, and in the larger class of *metrizable spaces* $Ind(X) = dim(X)$. A space's having coinciding dimension functions, in the way just described, is what Brighouse takes to be constitutive of having a determinate dimension. In other words, for a space to have determinate dimension is for two or more of the topological dimension functions to yield the same results. Because of this, for Brighouse, the class of possible spatial structures is either the class of separable metrizable spaces or the full class of metrizable spaces. The metrizable spaces are those spaces where some metric globally determines the topology for the space. A metrizable space is separable, if it contains a countable, dense subset.

Without going into too much detail as to why, I believe that the class of possible spatial structures must be slightly larger than Belot and Brighouse say. A reason for thinking this is that there are classes of spaces where some points are indistinguishable from one another with respect to their distance features. In this class of spaces the left-to-right direction of positive definiteness doesn't hold. These are included in the full class of the *pseudo-metrizable spaces*. This class does have determinate dimension in the sense that $Ind(X) = dim(X)$. The only difference between pseudo-metrizable spaces and metrizable ones is that some pseudo-metrizable spaces have distinct points zero-distance from one another. They share in all the other richness of structure that metrizable spaces have. To me it seems arbitrary to leave them out.[31]

I don't want to lean too heavily on this assumption, though. There are plenty of topological structures that don't have many of the important features of the pseudo-metrizable spatial structures. I will consider my argument a success if we end up with the possibility of a material object located in a world structure that is captured by a structure significantly dissimilar from the pseudo-metrizable ones, for this just makes my task harder. Some examples of this could be structures that don't support distance functions that obey any of positive definiteness, symmetry, or triangle inequality. Or, those that fail to obey important separation axioms.[32]

With this all in mind let's unpack SVMO a little bit. SVMO tells us that, necessarily, anything that is material has a spatial location. Understood in light of the previous discussion we get:

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[30] A topological space is a pair $(X, \mathscr{T})$ where X is a set of points, and $\mathscr{T}$ is a collection of subsets of X (the open sets) satisfying the following: (i) $\emptyset$ and X are in $\mathscr{T}$; (ii) any arbitrary union of members of $\mathscr{T}$ is in $\mathscr{T}$; and (iii) the intersection of the elements in any finite members of $\mathscr{T}$ is in $\mathscr{T}$.

[31] Just as metrizable spaces will be topologically rich, so will pseudo-metrizable spaces. For example, they obey the R_1 separation axiom, which is the counterpart of being Hausdorff but for *topologically distinguishable* points. In R_1 spaces topologically distinguishable points are separated by disjoint open sets.

[32] The separation axioms tell us how points can be distinguished topologically by their neighborhoods. Being Hausdorff or satisfying R_1 (or any of the T_i or R_i axioms) are examples of properties that spaces have which satisfy various separation axioms.

SVMO*

Necessarily, anything that is a material object has a location in a world structure that is in the class of pseudo-metrizable spaces.

So this means that if we can find a material object in logical space that is located in a structure that doesn't fall within this class of spaces, SVMO is false.

2. NON-SPATIAL MATERIAL OBJECTS: CONSIDERATIONS FROM MODAL PLENITUDE

Principles of plenitude are principles that tell us how logical space is filled out. To obtain the possibility of non-spatial material objects from principles of modal plenitude, we need two things. First, we need to ensure that there are worlds with structure that don't resemble the class of structures that represent the spatial ones. Second, we need some way to be able to "drag and drop" a material object from our world into one of these non-spatial structures. In other words, we need a way to ensure that there are duplicates of material objects occupying places within the non-spatial structure. In what follows, I make use of two principles of plenitude. One which tells us what possible world structures there are and one which tells us how we can recombine the parts of worlds into different world structures.

2.1. Plenitude of Possible Structures

Bricker (2020, Ch. 10) provides us with a method for figuring out which structures are possible.[33] First, we need to look to see what structure or structures have played an explanatory role in our theorizing about the actual world.[34] Playing an explanatory role, here, is not to be understood in sociological terms, but objective ones. The structure must have genuine explanatory power. Three dimensional Euclidean space is a classic example of one such structure. It has played an important explanatory and predictive role in our past physical theories and these theories still prove useful. These structures provide us with a base of logically possible structures that we can generalize to other classes of structures from.

Classes of structures can be divided into those classes that are natural and those classes that aren't. The members of natural classes of structures objectively resemble each other in ways that the members of classes of structures that aren't natural don't. We can then determine the natural classes of structures by looking to whether or not each of them serve as a principle object of study in some major area of study in mathematics. However, they aren't natural *because* they are the principle objects of study in some major area in mathematics. Instead, they are the principle objects of study in some major area in mathematics *because* they are natural.

[33] The next few paragraphs condense the discussion from (*ibid.*, 256-63).

[34] In particular Bricker tells us "[w]e have warranted belief that a structure is logically possible if that structure plays, or has played, an explanatory role in our theorizing about the actual world." (2020, p. 256). This just gives us a base set of structures from which we will determine the whole class or classes of possible structures from.

Once we've determined the natural classes of structures, this provides us with candidate classes of possible world structures. To determine whether or not they are logically possible, we begin by checking to see if they are generalizations of the aforementioned base class of logically possible structures. Now when generalizing we don't just generalize from our base of logically possible structures to any one natural class as we see fit. Instead, the generalization needs to be a *natural generalization*. It will always be the case that a natural generalization of a class of structures is a natural class. But it's not the case that any natural class is a natural generalization of its subclasses. Here, again, we defer to mathematicians to see what classes of structures are natural generalizations of others. This leads us to the principle of plenitude for possible structures:

> **Principle of Plenitude of Structures (PPS)**
> Suppose $\mathcal{S}$ is a class of logically possible structures. Any structure belonging to any natural generalization of $\mathcal{S}$ is logically possible.

Now this only tells us whether a structure is logically possible. But, in order for my argument to go through, I will need to show that some structures are *both* not spatial structures *and* are world structures. This requires a further assumption which determines which possible structures satisfy these conditions. Bricker (2020, pp. 271-77) suggests that any possible structure which is *externally connected* (*i.e.* the individuals related by that structure are connected *via* a series of external relations) is a possible world structure. In what follows, all of the examples of structures discussed are themselves externally connected structures. As such, I proceed under the assumption that the possible structures I investigate already meet the criterion for being world structures. So, for our purposes, to determine whether or not there are any logically possible non-spatial world structures we need to find a natural class of structures that includes non-spatial structures among its members that is a natural generalization of some class in the generalization base.[35]

2.2. Plenitude of Recombinations

This leads us to the principle governing the plenitude of recombinations. When formulating a principle of recombination we look to find a principle that allows us to "cut" any arbitrary individuals out from some worlds and "paste" them into another. In other words, principles of recombination guarantee that there is a world with a duplicate for each of any members of a class of individuals provided they are arranged in the right kind of way. Unlike the PPS the method that goes into the deployment of principles of recombination is straightforward. It just requires that we know when we can "cut and paste" or "drag and drop". However, formulating a plausible principle requires some definitions.[36]

[35] Moreover, the members of this class all need to unite their members into worlds. That is they need to connect each individual in the world *via* some external relations (*ibid.* p. 274).

[36] In what follows I closely follow Bricker (2020, pp. 224-6).

First, let's say that an *arrangement of* a class of possible world contents *within* a possible world structure is a category-preserving (possibly one-many) mapping from the contents in the class to (some or all) places in the world structure. Here 'world contents' should be understood as *occupants* of places in the world structure (henceforth 'occupants'). Now, what the occupants amount to can vary depending on one's view. If only individuals occupy the places in a world structure, then they are the occupants. If along with individuals we take points or regions to be occupants of the world structure, then the fusions of individuals and the regions at the places in a structure will be the occupants. (This will be important in giving the argument in §2.3.) 'Category-preserving' means that the possible world contents "fit" in the nodes of the world structure. This is what prevents us from putting a duplicate of a square in a circular region. Second, let's say that an arrangement is *consistent* just so long as whenever the arrangement maps distinct contents to distinct but overlapping places within a possible structure, the parts of those contents that are mapped to the place where the distinct places overlap are duplicates of one another.[37] This allows us to have possibilities for duplicates of things to overlap just so long as the place where they overlap contains consistent properties. It prevents us from taking an individual x and an individual y, such that x has intrinsic property P and y does not, and mapping them to the same place within a world structure. Finally, let's say a world *w recombines* a class $\mathcal{C}$ of world contents *according to* an arrangement $\mathcal{A}$ just in case $\mathcal{A}$ is an arrangement of the members of $\mathcal{C}$ within the structure of *w*, and whenever a content in $\mathcal{C}$ is mapped by $\mathcal{A}$ to a place in that structure, that place is occupied in *w* by a duplicate of the content. This is gives us the following:

> **Principle of Recombination (PR)**
> For any class $\mathcal{C}$ of world contents, and any consistent arrangement $\mathcal{A}$ of $\mathcal{C}$ there exists a world that recombines $\mathcal{C}$ according to $\mathcal{A}$.

This gives us a principle that allows us to take any class of world contents (potentially from different worlds) and recombine them into any world structure that is consistent with their being arranged that way. So if a possible world structure is two-dimensional, there would be no way to consistently put a duplicate of a three-dimensional object into that world structure. There aren't any "slots" in the structure for a three-dimensional object to go. Such a recombination would fail to be category preserving. One could, however, place a duplicate of a one-dimensional or two-dimensional object into it, provided that they are placed in a consistent and category preserving way.

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[37] The assumption here is that places within a structure can be complex. Now, I don't want to commit myself to the idea that all world structures must bottom out into an atomic relational place structure, but I think that invoking them here can be illuminating. We can think of places within a structure as being either the simple atomic nodes within a relational structure or unions of those nodes. Complex regions would then be unions of those nodes. Distinct places *P1* and *P2 overlap* when they have a non-empty intersection. Thanks to an anonymous reviewer for their comments here.

2.3. Possible Non-Spatial Material Objects

We are now in a place where we can run the argument for non-spatial material objects from the principles of plenitude. First, we need to get possible world structures that are non-spatial. We already take the class of metric spaces as possible world structures. So we can treat this class as our base for natural generalization. Is there a natural generalization of the class of the metric spaces to a class that includes structures that we aren't counting as spatial? I believe there is. The metric spaces are among the broader class of structures which are the topological spaces. The full class of topological spaces is the principle object of study in a major area of mathematical study, namely, topology. So it is a natural class. Moreover, the full class of topological spaces is obtainable through a process of natural generalizations from the full class of metric spaces. Let's assume the full class of topological spaces is obtainable directly through one step of natural generalization. Then through one application of PPS we know that any member of the full class of topological spaces represents a possible world structure. But suppose it is not. Between the full class of metric spaces and the full class of topological spaces there are intermediary natural classes of structures each of which is a natural generalization of another. In order words, there is a chain of natural generalizations from the full class of metric spaces to the full class of topological spaces. Because of this we know that the members of the full class of topological spaces represent possible world structures through multiple applications of PPS. Thus, I conclude that the members of the full class of topological spaces count as possible world structures.

There are members of the class of topological spaces whose structures don't qualify as spatial. This is because they don't have determinate dimension properties and aren't pseudo-metrizable. For example, spaces with a topology which fails to meet the most basic separation axiom R_0 are an example of topological spaces which fall far out of the class of pseudo-metrizable spaces. So, given this, it follows that there are possible world structures that don't qualify as spatial. Which gives us the possible world structures to recombine objects into to get non-spatial material objects.[38]

Let $\mathcal{S}$ be a possible non-spatial world structure. Before applying PR we need to make sure that the material objects we duplicate fit into $\mathcal{S}$. That is we can only recombine objects into $\mathcal{S}$ in a way that is category preserving. So we need to find some occupants in our spatial world structure that could be duplicated into the places in a non-spatial world structure. Note that not any occupant will do. Composite occupants will have intrinsic spatial structure. Their parts will stand in spatial

[38] To give this some teeth, let's consider a topological structure $(X, \mathcal{T})$ where X is the set of ten points $\{x_1, \dots, x_{10}\}$ and the set of open sets, $\mathcal{T}$, are $\{\emptyset, \{x_1, x_2\}, \{x_8\}, \{x_1, x_2, x_8\}, \{x_1, \dots, x_{10}\}\}$. This structure is significantly lacking in what we've taken to be the central features of being a space. It doesn't obey any of the standard T_i or R_i separation axioms which are required for a space to even be metric or pseudo-metric. It contains a mass of undifferentiated points (x_3 - x_7, x_9, x_{10}) which aren't in any open sets other than the space itself. This seems like it would be a good candidate for a topological structure that we shouldn't consider a space at all.

To see that this is a topological space note that both $\emptyset$ and X are in $\mathcal{T}$, so axiom (i) is satisfied, the union of each open set is in $\mathcal{T}$, since $\{x_1, x_2\} \cup \{x_8\} = \{x_1, x_2, x_8\}$ and the union of each of these with X just is X, so axiom (ii) is satisfied, and, finally, since there only intersections between open sets are between the subsets of X and X itself axiom (iii) is satisfied.

relations to one another. What is needed are occupants that won't carry spatial structure along with them. Otherwise, they couldn't be recombined into a non-spatial structure, because the arrangement would fail to be category preserving. Unextended objects and unextended regions (*i.e.* points) don't have any intrinsic spatial structure. Neither will fusions of co-located point-sized objects and regions. Call these *unextended occupants*.[39, 40] All topological structures have point places, so we can recombine unextended occupants across topological spaces in accordance with PR. To get the possibility of non-spatial material objects, the unextended occupants that we recombine need to be *material*. Since material points (unextended material objects) possibly exist, material unextended occupants will as well. We can now run PR on the unextended occupants to get non-spatial material objects.

Let $\mathcal{C}$ be a class of material unextended occupants we will recombine. And, let $\mathcal{A}$ be an arrangement of $\mathcal{C}$ within $\mathcal{S}$. Then, by PR, there exists a world, *w*, that recombines $\mathcal{C}$ according to $\mathcal{A}$. That is there exists a world that maps material unextended occupants onto duplicates of those unextended occupants occupying places in the non-spatial world structure $\mathcal{S}$. Thus, from PPS and PR, we get the possibility of non-spatial material unextended occupants – the duplicate material unextended occupants occupying the places in $\mathcal{S}$'s structure. Since the material unextended occupants will either be material points or fusions of material points and points of the structure, there being material unextended occupants duplicates occupying places within $\mathcal{S}$ at *w* will entail that there are duplicates of material points occupying places in $\mathcal{S}$ at *w* as well. Material points are material objects. So, at *w*, there is an intrinsic duplicate of a material object without a spatial location. By IM, this duplicate is material as well. I thus conclude that it's possible for there to be non-spatial material objects.

There are two important things to note about this argument. First, it gets us the possibility of non-spatial material objects while remaining neutral between three of the main positions concerning the nature of space and the location of material things: relationalism, supersubstantivalism, and dualistic substantivalism.[41] The relationist takes material objects to be the occupants in the spatial structure. So, the argument for non-spatial material objects for the relationist runs by identifying the unextended occupants we recombine with material points. Supersubstantivalists take material objects to be identical with the regions they occupy. So, regions are the occupants for the supersubstantivalist. In this case, the unextended occupants we recombine are to be identified with the point-sized regions that are identical with material objects. Finally, dualistic substantivalists take objects and regions to be non-identical, as such fusions of objects and the regions they occupy are

[39] One might worry that *being spatial* is a category and, thus, unextended occupants wouldn't be recombinable in a category preserving way. This would require a sense of a property counting as a category that is different from the sense that both Bricker and myself understand the term. A property enjoys the status of being a category insofar as it is intrinsic to the object which has it. Thus, the property *being spatial* has the status of being a categorial for extended occupants which are intrinsically spatial (due to the spatial relations between their parts) but it doesn't enjoy such a status for unextended occupants which are only extrinsically spatial. Thanks to an anonymous referee for bringing up this point.

[40] For those who are worried about the possible existence of such entities, bear with me. A fuller defense of their possible existence is made in the following subsection.

[41] See Schaffer (2009) for an overview of these views and a defense of supersubstantivalism.

the occupants for them. So, for the dualistic substantivalist the unextended occupants we recombine are the fusions of material points and the spacetime points they occupy. So no matter which view one holds, we can run this argument to get non-spatial material objects.

Second, it's worth noting that, since PR allows us to recombine multiple material unextended occupants into non-spatial world structure, we can have composites of them in a non-spatial world. We weren't able to recombine composite material occupants into the non-spatial world structures due to it violating the constraint on recombination which requires that the categories of the occupants be preserved. Though, we are just a stone's throw away from getting the possibility of composite non-spatial material objects. All that we have gotten so far is the possibility of non-spatial material point objects. With the addition of MIP we can get the possibility of composite non-spatial material objects. To see this, use PR to recombine a class $\mathcal{C}^*$ of multiple material unextended occupants into distinct places in a non-spatial world structure $\mathcal{S}^*$. Then fuse members of $\mathcal{C}^*$ that are material points to get the composite object *o*. By MIP *o* will be a material object. This gives us the possibility of a complex non-spatial material object. I think this is a very interesting conclusion.

2.4. Objections

The possibility of non-spatial material objects seems to be a radical one. A possibility that, I'd imagine, many will treat as a reason to take this argument as a *reductio* on one of the premises. Perhaps we should reject one of the principles of plenitude that lead us to this conclusion, or argue that they are being misapplied in some way. Perhaps we should reject the possibility of material points. Or, so the objector will argue. I think that these responses are wrong. Each of these assumptions has independent grounds for its plausibility. So I will discuss each in turn.

First, consider the principles of plenitude. These principles play an important role in our modal epistemology. They provide a straightforward way of determining what's possible without brute appeals to intuition. Moreover, modal knowledge plays an important role in our scientific thinking. Knowing that something's possible allows us to develop new hypotheses positing new structures, individuals, and properties in the hopes that they enjoy more explanatory success than the previous ones. It would be a shame to have to give up on such principles.

Now, a friend of SVMO might want to argue that the principles of plenitude are being misapplied. For instance, they might note that defenders of SVMO often assume that there is some sort of generic dependence relation between material objects and regions of spacetime. However the dependence relation is spelled out, it would imply a necessary connection between the material object and some spatial region – in particular, the positing of a material object would necessitate the existence of some region or other. Assuming this were true, then PR couldn't be directly applied to material unextended occupants to "drag and drop" them into a non-spatial structure – any dragging and dropping would always carry a region along with it. Or, so the objection goes.

Such an objection would need to be developed in a way that is consistent with the Humean spirit of this first argument in order to claim that PR is being misapplied. What is at the heart of the Humean program which motivates the principles of plenitude is the dictum "no necessary connections between distinct existences". And this is something that such a proponent of SVMO can't maintain. As I noted in the previous section, unextended occupants lack intrinsic spatial structure. For the sake of illustration, let's assume that supersubstantivalism is true and the unextended occupants we are recombining are spacetime points. They are unextended and only have spatial properties insofar as they are spatially related to other entities (*i.e.* only insofar as they are occupants of a spatial world structure). As such, duplicating a point from a spatial structure *via* PR doesn't entail anything about whether or not the duplicate of that point has any spatial properties, and, thus, doesn't entail whether the point-duplicate has the status of being a *spatial region*. In order for the point duplicate to count as a spatial region, it *must* be *spatially related* to other point duplicates. Thus, the claim that we couldn't drag and drop the point *via* recombination without dragging and dropping a region is tantamount to saying that the point can't be duplicated without also duplicating other *distinct existences* and this is in conflict with Hume's dictum.

It might seem claiming that the points are distinct existences stands at odds with an increasingly popular view about the metaphysics of spacetime. Namely, ontic structural realism. Spacetime points, as understood by the proponents of ontic structural realism, are in some way or other specified by their place in spacetime's relational structure. The claim then would be because the existence of points is specified relative to their position within a spatial structure, points aren't distinct existences according to ontic structural realism. Now, a few clarifications are in order. First, it must be clarified what the precise claim ontic structural realism makes about the nature of points is. Second, it must be clarified whether points might have intrinsic character *even if* their geometric features fail to be intrinsic. Third, it must be clarified what ontic structural realism's modal status is.

Regarding the first issue, the central question is whether or not the picture of the world ontic structural realism offers is one of structure without content. A world without content would just be a series of external relations without there being any relata which instantiate those relations. This picture of the world is incoherent. Relations can't be instantiated without relata to instantiate them.[42] Moreover, relational structures require relata to tie together the relations in them so that we can properly distinguish between different varieties of structures.[43] Being at odds with such a view is no mark against my argument, for, given its incoherence, everything is at odds with it.

However, ontic structural realism needn't take the aforementioned form. Instead, the proponent of ontic structural realism may reify the nodes of the structure and claim that those nodes depend (existentially or essentially) on their position in the structure.[44] This leads us to the second issue of clarification. Say that this proponent of ontic structural realism takes points to be

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[42] See Chakravartty (2003) for this type of objection.

[43] For example, we won't be able to distinguish between structures with different cardinalities of "node" (see Jantzen (2011)). It should be noted that Jantzen makes the stronger argument that *any* version of ontic structural realism which is committed to the claim that the existence of points supervene on relational structure is incoherent. My sympathies lie with Jantzen on this issue. As such, I will skip over accounts of ontic structural realism which reduce or ground the existence and identities of the points in the nodes.

[44] See McKenzie (2014) for an example of ontic structural realism which makes use of essential dependence in the way suggested above. Similarly, Esfeld and Lam (2008) offer a picture where spacetime points and their relational structure are *interdependent*.

reified nodes in a spatial structure but allows that those nodes can contingently instantiate material properties intrinsically (*e.g.* they have whatever values of various matter fields they instantiate intrinsically).[45] On this clarification of ontic structural realism, the argument I provide above is perfectly consistent with ontic structural realism. It is important to note that duplication, and thus recombination, is *insensitive to* the essential properties of what is being duplicated through recombination. For example, while it may be essential to me that I have the parents that I do, there are duplicates of me which fail to be offspring of my parents or any duplicates of them. This is because my *being an offspring of my parents* is extrinsic to me. Because of this, while my existence and identity depends on my place in a particular biological ancestral structure, not all duplicates of me will need to stand in any such ancestral relations; in fact, they needn't exist with anything else at all. The same holds for points in this picture. Not all duplicates of points will be spatial, but, provided that they have some intrinsic material properties, all will be material. To reiterate the underlying point, this is because recombination operates off of intrinsic properties and is insensitive to the essential properties of the items recombined.

Perhaps, however, the structuralist will want to deny that spacetime points have any robust intrinsic properties whatsoever. For example, they may hold that spacetime points only have "logical" properties such a self-identity, mereological simplicity, *etc.* intrinsically and *don't* have any intrinsic material properties. Is my argument inconsistent with this view? It is not. So long as there is some unextended occupants – say an unextended material property instance or material event distinct from the point – that has material properties intrinsically, my argument will go through. The structuralist would at least need to adopt a global claim that there aren't any intrinsic properties for unextended occupants to bear at all. But even this isn't enough to render my argument inconsistent with ontic structural realism. This leads to the issue of the third clarification (*i.e.* ontic structural realism's modal status). So long as there are some worlds with intrinsic material properties that are suitable for unextended occupants to instantiate, the argument for the possibility of non-spatial material objects can run from those worlds. Accordingly, it doesn't matter whether the actual world doesn't contain those properties.

Nonetheless, there is a variety of ontic structural realism that *is* inconsistent with the claims I make. This version of ontic structural realism holds both (i) a global denial of intrinsic material properties for unextended occupants, and (ii) holds this denial to be necessarily the case. On such an account, there wouldn't be any unextended occupants with material properties for me to duplicate into a non-spatial structure. I do not find this variety of ontic structural realism plausible. The most plausible arguments for ontic structural realism rest on contingent, empirical considerations.[46] As

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[45] Issues here get complicated quickly depending on how one's preferred metaphysics of quantities plays out. For example, Bricker (2017) takes the *determinable* quantities rather than the *determinate* values of a quantity to be what is fundamentally instantiated by an entity which makes room for the possibility of instantiating a fundamental determinable of a quantity rather than a determinate value of that quantity. My claim about intrinsicness above should be read as neutral to these kinds of options.

[46] Other, more *a priori*, motivations for ontic structural realism tend to overgeneralize to a point where they also end up being arguments against ontic structural realism as well. See Brading & Skiles (2011) and Davis (2021).

such, if we are to take ontic structural realism seriously, it won't be on the grounds that support this strong modal claim. Rather, ontic structural realism would be supported on grounds that fit better with it being a contingent, empirical hypothesis.

Second, consider the claim that there are material unextended occupants. There is initial plausibility to the claim that there are material points (*e.g.* they seem to play an important role in our physical theorizing). For example, when modeling matter fields in quantum field theory each point within spacetime receives an assignment of some physical quantity. Given the way that we are understanding the terms *material object* and *material thing* as stated in §§1.1, such entities would count as material objects. Now, there are a number of objections one might make to my assumption that there are material points. First, there's good reason to think that the use of unextended occupants in physical theory is a mere idealization (*e.g.* extended bodies are often treated as point objects merely for the purpose of making problem solving more tractable). So why not think that this is true in each case where physical theory makes use of unextended occupants? Second, it's contentious whether spatial regions in our world ultimately resolve into point-sized regions. Perhaps regions are gunky and each extended region decomposes without end into further extended parts. Or, perhaps, the mereological structure of regions is atomistic but regions ultimately decompose into extended atoms. Finally, some authors, such as Simons (2004), suggest that unextended occupants are *physically impossible*. Each of these arguments make important points and push on important questions. Unfortunately, adequately engaging with each of these arguments would require going into more detail than is appropriate for our discussion. Instead, I will side-step the issue by relaxing my commitment. All that I need to claim for my argument to go through is that there are *merely possible* material unextended occupants. If there are merely possible material unextended occupants, then I can recombine them from those non-actual worlds into worlds without spatial structure. I believe there is good reason to think there are merely possible unextended occupants. Consider the philosophical thesis of Humean Supervenience (HS). HS requires that the entire qualitative character of the world is entirely determined by *local matters of fact*. That is, the qualitative character of the world is entirely determined by the distribution of qualitative character of spacetime points and how those points are spatiotemporally arranged. Importantly, major defenders of HS like Lewis (1986b, 1994) argue that HS is a merely contingent hypothesis. HS may not be actual but it is *at least* possible, or so Lewis and his ilk will claim. But why think this? The reason for this is similar to my objection to the last version of ontic structural realism considered above. Specifically, HS finds its inspiration in a particular, intuitive, picture of classical physics. The reasons for rejecting that theory (such as non-locality) are contingent matters of fact. Thus, without further reason to think that HS is metaphysically impossible, I conclude that material unextended occupants are possible. And this is all that my argument needs.[47]

[47] One argument against the possibility of material points that is not discussed above can be found in Gibberman (2012). Roughly, Gibberman argues against the possibility of there being unextended occupants by arguing that it would be a violation of parsimony to posit unextended property instances as well extended ones and then goes on to argue that any unextended object must (understood in the sense of metaphysical necessity) lack properties. I must admit that I find this

Lastly, a worry one might have is that I've taken the class of spatial possibilities to be too exclusive. Instead, we should just take the whole class of topological spaces to count as genuinely possible structures of physical space. One might even think this broader classification gains traction given that material objects can occupy any members of this class.

Perhaps this is correct. But I think there are two things I can say about this. The first is more modest. Recall the fact that some of these spaces don't have determinate, or even well behaved, dimension properties. It seems to me that it's an incredibly interesting result that material objects could be located within structures that fail to have these properties. Maybe one might even think that when the dimension functions "break down" and return bad results this is an indicator that the topological space under consideration doesn't even have natural dimensions at all (no not zero-dimension, *no* dimensions). Dimensionless material objects would be a very interesting result. Other important features we closely associated with space aren't had by some of these topological spaces as well. In these cases there is an important sense in which we can call these material objects non-spatial – they fail to have important features we associate with space.

The second reply is less modest. Say we go more inclusive and we take all the members of the class of topological spaces as possible spatial structures. Question: should we think there are possible world structures that aren't included in the class of topological structures? I suspect we should. Some of these structures are even studied in topology to illustrate the boundaries of the class of topological spaces. But, if this is so, there are possible world structures that fail to even count as topological spaces. For example, why shouldn't we think that there are possible worlds where the underlying structure completely lacks any geometric structure and, instead, just has some algebraic structure like a group theoretic structure? Moreover, I see no reason why we can't recombine the class of material points into that non-topological structure according to some consistent arrangement. If so, then we would have an even clearer counterexample to SVMO.

Perhaps these considerations will still leave one unconvinced. There are other important considerations which point to this conclusion. Which leads us to my next argument.

3. NON-SPATIAL MATERIAL OBJECTS: CONSIDERATIONS FROM QUANTUM GRAVITY

So far I've argued that on grounds of principles of plenitude that we should reject the claim that, necessarily, anything that is a material object has a spatial location. Perhaps the reader will remain unconvinced by the argument just given. This does not mean that there aren't other paths to reach this conclusion. I believe there are.

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argument odd for a number of reasons. First of all, I find it deeply implausible that considerations of parsimony have any straightforward bearing on logical space as Gibberman's argument presupposes. But, secondly, and more importantly, I find Gibberman's application of parsimony entirely misguided. Parsimony doesn't work by applying it to any category we see fit. *Instead*, we need to have a rough idea of the categories of application by which considerations of parsimony count. To see why this is an issue, it's important to note that Gibberman's argument generalizes in unacceptable ways. In particular, it is as much an argument against point-sized objects as it is against lines, surfaces, and any *n*-dimensional entity besides those of one's preferred *n*.

In this section, I would like to point to some considerations from current issues in fundamental physics that point in the direction of non-spatial material objects. In particular, my interest is in theories of fundamental physics where spacetime is not a fundamental phenomenon, but an emergent one.[48] These considerations come from theories that have emerged over the last several decades in theorizing about quantum gravity. A growing number of theories in this literature seem to suggest that spacetime does not exist at the fundamental level. Theories like causal set theory and loop quantum gravity lack any straightforward spatiotemporal interpretations. Some string theories also seem to evade interpretation in straightforwardly spatiotemporal terms. In fact, it's not just that spacetime fails to fundamentally exist on these theories, the structures they posit appear to lack anything at all that resembles a spatial or temporal metric. Space, time, and spacetime then would be emergent features of the world on these theories.[49]

What I would like to do here is give the bare bones for an argument for the possibility of non-spatial material objects that makes use of the insights from these theories. Now, it has become a recent project in philosophy of physics to provide an explanation for how the spatial and temporal, or spatiotemporal structure can emerge from the objects and structures in these theories.[50, 51] Many of the details are left to be ironed out, and, so far as I can tell, the focus has remained entirely on providing an account of the emergence of spacetime. Thus, not much has been discussed about the relation of the non-spatial fundamental structure of the world and matter, at least, not in the philosophical literature.[52] As such, whatever will be said about the *relata* or *qualitative content* that fills out these non-spatiotemporal world structures (beyond what gives rise to spacetime) must be *inferred from other commitments*. In this case, MDP will do most of the work. Accordingly, the argument I give here is provisional.

For the sake of space, in what follows, I'll limit my discussion to the non-fundamentality of space in causal set theory and loop quantum gravity. I'll then say why this might lead one to think that we have reason to think there are possible instances of non-spatial objects.

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[48] In this section I will often slide between talk of 'spatial' and 'spatiotemporal' for ease of discussion. I don't think that this makes any significant difference to the point that I make because the theories which I discuss will fail to have both spatial and spatiotemporal structure at the fundamental level.

[49] For discussion see Butterfield & Isham (1999), Huggett & Wüthrich (2013), Oriti (2014), Wüthrich (2019), Huggett & Wüthrich (2012), and Yates (2021).

[50] See Baron (2020), Lam & Wüthrich (2018), and Wüthrich (2019) for discussions of how one might go about providing such explanations.

[51] This has mainly been due to an objection from Maudlin (2007) that such views are empirically incoherent. That is that any empirical justification provided for the views would be undermined by their claim that spacetime doesn't exist and the world lacks spatial and temporal structure. The idea behind the project is that if it can be explained how spacetime can emerge from the fundamental non-spatiotemporal reality, then the empirical coherence of the theories can be saved. See Ney (2015) for a discussion of this objection and how it relates to wave function realism.

[52] However, see Bilson-Thomson (2005) and Bilson-Thomson *et al* (2009, 2012) for recent discussions in physics combining the braid model of particles with loop quantum gravity. In these models, particles are modeled without making use of a spatiotemporal ontology.

3.1. Non-Spatial Fundamental Structures

Causal set theory and loop quantum gravity are two projects in the attempt to provide a theory of quantum gravity. A feature that they both share which already distinguishes them from the picture of spacetime provided by the general theory of relativity is that the underlying structures that appear in both causal set theory and loop quantum gravity are discrete and, thus, aren't continuous like relativistic spacetime is. Both also offer a picture of the world's underlying structure that is non-spatiotemporal. That is, at the fundamental level they lack sufficient structure to count as either spatial or spatiotemporal. Instead, the spatiotemporal features of the world emerge from the fundamental non-spatiotemporal underlying structure. Put differently, the ungrounded or perfectly natural properties and relations that give the underlying structure aren't spatial or spatiotemporal ones. The spatiotemporal relations then arise by supervening on, being realized by, or grounded in these perfectly natural properties and relations and their pattern of instantiation. They do differ in how far they depart from the structural features of spacetime. Causal set theory is seen as a less radical departure from spatiotemporal structure than loop quantum gravity.[53] Since our interest is in the possibility of material objects that lack spatiality I will limit my discussion here to the features of these theories that display their lack of spatial structure. Most of what I have to say in my exposition of causal set theory and loop quantum gravity draws from Huggett and Wüthrich (2013).[54] However, what I draw from them is relatively minimal and seems to be widely held amongst philosophers of quantum gravity.

3.1.1. Causal Set Theory

The initial idea behind causal set theory comes from an important result in the general theory of relativity that tells us that the causal structure determines, up to a 'conformal factor', the geometry of a relativistic spacetime.[55] This result motivates the postulation of a fundamental causal relation that imposes a partial ordering on the basic events, called 'the causal set'.[56, 57] The features of this fundamental causal relation depart from typical spatiotemporal relations in a number of ways. First, nothing in the fundamental level of basic events connected by the causal relation corresponds to lengths, durations, and spacetime intervals. Moreover, the ordering of events by the causal relation isn't structurally rich enough to identify space-like connected events, in the sense of a space-like hypersurface. This is because, when one finds sets of events which aren't connected by the causal relation, these sets exhibit no more structure than their cardinality. As Wüthrich (2019) puts it "As only the relation of causal connectability is fundamental, a 'spacelike' cross section of a causal set

[53] Huggett & Wüthrich (2013), Wüthrich (2019).
[54] Though also see Huggett & Wüthrich (2021) for a more detailed discussion.
[55] Malament (1977). See Wüthrich (2019) for discussion.
[56] Hugget & Wüthrich (2013, p. 278).
[57] An anonymous referee has suggested to me that it is important that we needn't see the fundamental relation in causal set theory as causal in any familiar or intuitive sense, but, instead, that the relativistic relation of causal connectedness emerges from it in certain causal sets. For our purposes, all that matters is that the relation doesn't necessarily bring anything seemingly spatial or spatiotemporal along with it. I thank the referee for this comment.

encompassed no relations among the basal elements whatsoever. Hence, what would be the best candidate to correspond to space is completely unstructured, and so *a fortiori* does not have topological or metrical structure as we would expect a space to have." This is significant. Not only is it the case that the would-be candidate space-like cross sections fail to have any spatial structure, they fail to have any fundamental structure *period*.

3.1.2. Loop Quantum Gravity

Loop quantum gravity is obtained through applying a standard quantization procedure to the Hamiltonian formulation of the general theory of relativity. The fundamental structures in loop quantum gravity are spin-networks which are discrete structures that consist in nodes and connecting edges, both of which have additional properties beyond their connection in the network. These are expressed by half-integer spin representations. There is a sense in which it is tempting to think that the spin-networks exhibit spatial features. For example, the spin states are eigenstates of operators that admit of interpretation as area and volume operators. The spin representations on the nodes, according to this interpretation, depict volume of an atomic region of space. The spin representations on the edges provide the size of the area of the shared surface between two atoms. This leads to a natural interpretation of the edges as providing a relation of adjacency between two parts of the discrete structure.

This spatialized interpretation of loop quantum gravity shouldn't be taken literally, however. There are two considerations that lead to this conclusion. First, parts of the spin-network, which were taken to be spatially adjacent in the spatialized interpretation, can give rise to regions of space which are quite far apart in the emergent spacetime. So they cannot be seen as discrete building blocks pieced together side by side to build the emergent spacetime in the way one can put blocks of Lego's together to build a cube. Thus, spin-network adjacency doesn't seem to correspond to *spatial* adjacency at all. Second, it must be noted that the fundamental structure is supposed to be in a superposition of spin-network states. The terms of the superpositions have different structures. As such, it will turn out that what is local in one superposition needn't be local in another. These considerations are taken to block spatialized interpretations of loop quantum gravity where the nodes and edges are taken to be spatial volume and area, and adjacency is taken to be spatial contact.

This provides just a brief overview of why a couple of theories in quantum gravity have been interpreted as being committed to the fundamental structure lacking any spatial structure. Out of the two views loop quantum gravity is taken to exhibit a more radical departure from the spatiotemporal structure of the general theory of relativity than causal set theory does. Before moving on, I think it is important to note that there are other developing theories in research on quantum gravity that involve even more radical breaks from spatiotemporal structure than either causal set theory or loop quantum gravity. For example, group field theory, which arises from another quantization of loop quantum gravity, takes the basic structures between the basic constituents of the world to be fundamentally algebraic, instead of geometric, in nature.[58, 59]

3.2. Actual non-spatial Material Objects?

So we've seen two theories of quantum gravity that are completely devoid of spatial structure at the fundamental level. Instead of fundamental spatial structures, the aforementioned theories picture the world as fundamentally structured by either a causal relation or in terms of spin-networks. The spatiotemporal features of the world are then taken to emerge from these structures. So spacetime regions don't count as fundamental aspects of the world according to these theories, but, so far, I haven't said anything about the material aspect of the world. How should we understand materiality on these views? In other words, what status with regards to materiality should we think the content of the structures given by causal set theory and loop quantum gravity would have?

The possible range of answers to the questions just asked divides neatly into two groups. The first group takes some material objects to be fundamental.[60] Of course the material objects of everyday experience and most of the material objects of most of our scientific theories will be derivative. Only a select few kinds of material objects will be fundamental which should come as no surprise. On this view, the fundamental material objects could be identified with part of whatever directly instantiates the non-spatial fundamental structures discussed in these theories, or material things could be taken to be fundamental posits distinct from whatever directly instantiates the non-spatial fundamental structures.

The second group denies that they are fundamental. This could be because either material objects are taken to be derivative or material objects are taken to not exist. There are a number of ways material objects could be taken to be derivative. We might take them to be identical to other derivative things like spacetime regions, or they might be independently derived from what instantiates the non-spatial fundamental structure, or what instantiates the non-spatial fundamental structure plus some other fundamental aspects of the physical world.

I think there is good reason to prefer the view that some material objects are fundamental. The argument takes two steps. First, we have ruled out eliminativism from the outset and taken material objects to exist. There is another reason for denying eliminativism, however. The major philosophical project involved in discussing theories of quantum gravity without fundamental spatiotemporal structures is to explain how spacetime can emerge on these theories so as to save these theories from the charge of *empirical incoherence*.[61] A theory is taken to be empirically incoherent if the theory undermines the observational evidence in favor of it. Views like causal set theory and

[58] Oriti (2014). Also, note how this reinforces the possibility of non-geometric world structures suggested in §2.4. For further discussion along these lines see Huggett, N., Lizzi, F., & Menon, T. (2021).

[59] For more detailed discussions of Loop Quantum Gravity see Huggett& Wüthrich (2013), Wüthrich (2019), and Yates (2021).

[60] We can take an object to be fundamental just in case either it is the bearer of fundamental properties or is involved in an ungrounded fact.

[61] Maudlin (2007), Huggett & Wüthrich (2013), Ney (2015).

loop quantum gravity have been charged with empirical incoherence because they seem to imply the non-existence of the realm of observables – spatiotemporally related material objects. The thought is that if the emergence of spacetime is saved, then the observables are saved, and if the observables are saved, then material objects are saved. This project rules out eliminativism from the beginning.

Second, I don't think that we should take all material objects as derivative, or, at least, so derivative as to be spatial. The reason for this stems from MDP. Recall MDP tells us that each of the things that compose a material object are themselves material.[62] Due to the reasons noted above, we should accept that there are objects which are material.[63] These objects will then be made up of those things at the fundamental non-spatiotemporal level. Since the non-spatiotemporal things will compose the emergent spatiotemporal material objects, MDP entails that each of those non-spatiotemporal things themselves are material. So, it seems that, if these theories are correct, the world must *also* be fundamentally populated with non-spatial material objects. (Whether these are thick particulars of some sort, parts of fields, or other events, my argument remains neutral on.) Thus, not only would non-spatial material objects be merely possible, they would *actually* exist. In other words, not only does SVMO come out to be false, given the above reasoning, but it isn't actually the case that all material things have spatial locations either.

One objection that might be raised by a friend of SVMO is that even if the fundamental material objects aren't *fundamentally* spatial, this doesn't mean that they aren't spatial in a derivative way. (As I'm using the term, something would fail to be *fundamentally spatial* if it occupies a place in an underlying world structure that itself fails to be spatial. It would then be *derivatively spatial* if it occupies some place in the emergent structure of the world where that emergent structure is itself spatial.) That is, they are spatial because they collectively along with the non-spatial fundamental structure give rise to the emergent spatiotemporal structure. In this way, they would take SVMO to be saved. However, this isn't enough to save SVMO. For even if the fundamental material objects did end up being derivatively spatial it is still a physical possibility that they could have not given rise to spacetime and failed to even be derivatively spatial in the proposed way. Wüthrich says:

> [I]n general, there will be some model of the quantum theory of gravity, i.e., some physically possible fundamental structures, which will not give rise to anything like spacetime. Just as elementary particles may fail to combine to give rise to a carbon molecule, or a liquid, or a life, fundamental structures in quantum gravity may inauspiciously assemble such that no effective spacetime results. (Wüthrich (2019))

So whether the material objects at the fundamental level end up being derivatively spatial, they need not be involved in structures which give rise to spacetime. In other words, there are models of causal

[62] One complication that arises with regards to my use of MDP here is whether or not it is appropriate to apply mereological notions in describing the generative relations between the entities which appear in theories of quantum gravity and the emergent spatial objects (see Baron (2021)). I will address this issue in the next section.
[63] Or material in the very least. See the end of § 1.1. as well as n.'s 17 & 18.

set theory and loop quantum gravity where spacetime doesn't emerge. As such, it is a real physical possibility that they won't even be spatial in any derivative sense. Given the argument using MDP above and IM, we should think that the things at the fundamental level in these possibilities are material. Therefore, we should think that if it is possible that the things in causal set theory and loop quantum gravity could fail to be spatial in any derivative sense, then non-spatial material objects are possible.

3.3. Possible non-spatial Material Objects

A reason one might worry about the approach given above stems from a standard attitude taken by scientific realists. Roughly, we should only believe in the reality of the objects and structures of our *successful* theories.[64] Given the infancy of causal set theory and loop quantum gravity, the fact that they haven't offered any novel predictions yet, and that they haven't reached a point where they have been able to recapture all of the observational evidence for the general theory of relativity, seems to point to the fact that these theories haven't yet gained the right kind of success. Moreover, the fact that each of these theories are live contenders for providing a theory of quantum gravity should induce agnosticism about which theory, if any, is correct. And rightly so. It follows from this that we should be agnostic about the actual or physical possibility of non-spatial material objects as well. But does this mean that we should remain agnostic about the logical possibility of non-spatial material objects? I think not.

While it might seem right to take an agnostic stance towards the actual (approximate) truth of these theories, this hardly prevents it from being the case that there is some world where these theories are true.[65] One principle that I have been supposing throughout the whole paper is that the things and structures which figure into genuinely explanatory theories provide us with good reason to take those things and structures as logically possible. This principle is made use of when we apply PPS to get the base of logically possible structures that we make natural generalizations from. Because theories like causal set theory and loop quantum gravity are live options in theorizing about quantum gravity, we should take them to be genuinely explanatory. Accordingly, we should take them to represent logical possibilities. Further, note that it will be a physical possibility for these worlds that the fundamental entities and structures will not give rise to any spatiotemporal structure at all. I suggest that it's at these worlds where we will find possible non-spatial material objects.

3.4. Emergent Gravity and Non-Mereological Basing

There has been one suppressed assumption made throughout this discussion. In particular, my use of MDP presupposes that non-fundamental material objects are always related to more fundamental parts *via* a single mereological relation. There are two ways in which one might resist this assumption. First, one might deny that the relationship bridging the more fundamental goings on at

[64] Indeed, the main argument for being realists about scientific theories is due to their success. See Boyd (1984) for an important defense of scientific realism.

[65] Or, more realistically, much more fleshed out versions of those theories could be true at some world. For the ease of style, I will continue to speak as if the theories under consideration are appropriately fleshed out.

causal set theory's and loop quantum gravity's level and the entities at the emergent, spatiotemporal levels is a mereological relationship. Instead, other building relations such as constitution, functional realization, grounding, *etc.* might better account for the relationship between quantum gravity and emergent spatiotemportal levels.[66] The second way to resist is a little more complicated. It requires *both* the denial of there being a single decomposition relation that relates non-fundamental material objects to lower level things *and* the claim that not all of these decomposition relations carry the status of *materiality* down the decompositional chain (as MDP requires). Thus, according to this objection, we wouldn't be licensed to conclude that the things at the level of quantum gravity are material.

Both of these points deserve serious attention. While I favor a monistic mereological approach to the issue, I agree that this commitment is contentious. Thankfully, the commitment is inessential to my argument. To see this, consider how MDP could be modified by generalizing it so that whatever things *build* some material object (at least, for some appropriate set of building relations $\mathcal{B}_{1}, \ldots, \mathcal{B}_{N}$), would themselves be material. This would yield something in the vicinity of the following principle:

MATERIAL DECONSTRUCTION PRINCIPLE (MDP*)

Each of the things that $\mathcal{B}_{1}, \ldots, \mathcal{B}_{N}$-build a material object are themselves material.

So for any objects, $o_1, \ldots, o_n$, that build an an object o^* *via* building relations $\mathcal{B}_{1}, \ldots, \mathcal{B}_{N}$, such that $o_1, \ldots, o_n$ are *things*, if o^* is material, then each of $o_1, \ldots, o_n$ are material objects as well.

Now, one might worry that this generalization of MDP to MDP* is arbitrary. But I don't think that it is. Whether or not the preferred building relation of materialism and material objects is mereological is up for grabs. That is, whether we adopt anything like mereological relations as the preferred building relations seems dependent on theoretical progress. As such, we shouldn't want to wed our understanding of materialism to a particular building relation. Indeed, this precise point was made by Crook and Gillett (2001). They argue that materialists leave open which the preferred building relation (or *relations*) for material objects are permissible for the materialist to adopt. The sharing of materiality (upwards and downwards) would then be mitigated by whatever those relations are.

What I *am* committed to is that the plurality of building relations involved in making up material things does involve the sharing of materiality amongst relata (that is so long as the relata are things). However, I don't think that this commitment counts against my argument. It is quite plausible to assume that the sharing of materiality amongst things goes downward along these building chains. To see this, consider the role that various building relations are taken to play in different philosophical projects. Take the role that the sharing of materiality plays in positing constitution and realization amongst various mid-level things. Regarding constitution, lumps of matter are posited to constitute various artifacts, bodies to constitute persons, and so on. Regarding realization, various neurophysiological states are taken to realize mental states, various interpersonal states are taken to realize socio-economic states, *etc.* It is important that we take a moment to consider why such relationships are posited. A central reason for positing these relationships amongst mid-level things is to secure the material status of the constituted and realized things from the things that constitute and realize them. Surely this practice would be strange and unfounded, if

[66] See Baron (2021) for such an objection and Baron & Le Bihan (2022) for a response.

those mid-level constituters and realizers didn't "bottom out" in further material things as well.[67] What this highlights is that a principle in the vicinity of MDP* is built into the theoretical background underlying many of our philosophical and scientific practices.

I think this gives us a plausible reason for adopting a principle in the vicinity of MDP*. Further, that is all that is needed to get to the conclusion that SVMO is false. That said, I must admit that this is where this strand of the argument reveals its provisionality. As I noted at the beginning of this section, my goal was to provide the bare bones for a plausible argument from physical theorizing that results in the possibility of non-spatial material objects. I believe I have done that much. As such, the onus is on the defender of SVMO to tell us why we should reject one or more of the assumptions of my argument.

4. CONCLUSION

I've offered two arguments in this paper for the possibility of non-spatial material objects. One from largely *a priori* considerations involving principles of modal plenitude, another from largely *a posteriori* considerations involving developing theories in the field of quantum gravity. We have two very different routes to the same conclusion. There is a way in which I think these arguments can be seen to bolster each other. The argument from plenitude assumes a picture of the world that I take to be relatively intuitive to the modern mind. The world we live in, according to this picture, is filled with material objects that are ultimately composed of material points. It then proceeds from this picture, with the help of principles stemming from systematic metaphysics, to the possibility of non-spatial material objects (and composite ones at that!). So it provides us with a route from a more intuitive world picture to possible non-spatial material objects. One may remain skeptical though of arriving at such unintuitive conclusions regarding the natures of material objects merely through metaphysical principles. This unintuitive conclusion might be thought of as being 'too far off' from actuality to be taken as genuinely possible. The accusation here is that the principles of modal plenitude prove to be too liberal. The argument from fundamental physics sharpens the teeth of the first argument by providing us with pictures of the fundamental nature of the physical world fundamentally lacking in spatial structure. Thus, the possibilities arrived at through considerations of modal plenitude aren't so far off after all. Important developments in physical theories aimed at explaining how the actual world fundamentally is tell us that the actual physical world might, at rock bottom, lack the structure we thought necessary to support material objects. So, whether, at the end of the day, one thinks that non-spatial material objects are genuinely possible, their possibility is something that we should take seriously.

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[67] Or continually regress into further material objects, if the world doesn't have a fundamental level.

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