The physics of extended simples

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The idea that there could be spatially extended mereological simples has recently been defended by a number of metaphysicians (Markosian 1998, 2004; Simons 2004; Parsons (2000) also takes the idea seriously). Peter Simons (2004) goes further, arguing not only that spatially extended mereological simples (henceforth just extended simples) are possible, but that it is more plausible that our world is composed of such simples, than that it is composed of either point-sized simples, or of atomless gunk. The difficulty for these views lies in explaining why it is that the various sub-volumes of space occupied by such simples, are not occupied by proper parts of those simples. Intuitively at least, many of us find compelling the idea that spatially extended objects have proper parts at every sub-volume of the region they occupy. It seems that the defender of extended simples must reject a seemingly plausible claim, what Simons calls the geometric correspondence principle (GCP): that any (spatially) extended object has parts that correspond to the parts of the region that it occupies (Simons 2004: 371). We disagree. We think that GCP is a plausible principle. We also think it is plausible that our world is composed of extended simples.

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We reconcile these two notions by two means. On the one hand we pay closer attention to the physics of our world. On the other hand, we consider what happens when our concept of something – in this case space – contains elements not all of which are realized in anything, but instead key components are realized in different features of the world.

Not everyone thinks that the GCP is an independently plausible principle. Van Inwagen, (1981) for instance, rejects it.[1] We won't defend the principle here, except to say that it seems to us that the claim that only sub-volumes occupied by something 'natural' or 'non-arbitrary' are occupied by proper parts of an object, is to use 'part' in a different way from the way we use it. These may be natural parts, or functional parts, but we see no reason to suppose that they exhaust all of the parts. Or, to put it another way, we're not sure that there is a sufficiently strong grip on a pre-theoretic concept of 'part' to determine that we mean one thing or another, but we think there is one perfectly good deserver of 'part' according to which GCP is true. In this sense, not every part is a natural or non-arbitrary part.

Here, then, is the physical hypothesis about our world that we will consider. Our world contains objects – little two-dimensional squares – that are Planck length by Planck length (an area of 10^{-66} cms).[2] Are such objects in any sense extended? We think it is plausible that they are. At the very least, we think that they should count as extended given our pre-theoretic views about extension. When we talk about something having extension in space, we usually mean that it is not point-sized: we mean that given a metric that takes space to be continuous, that thing has length according to that metric. In this sense, our Planck square is extended, for according to this metric it has a length – the Planck length. Indeed, given such a metric we can talk about lengths that are shorter than the Planck length, and we can talk about squares that are of those lengths. We can divide Planck squares up into smaller and smaller squares that occupy the sub-regions of a Planck square. But then if the GCP is true, it looks as though we must conclude that our square is not simple: each of those smaller squares is a proper part of the Planck square.

We agree that you can so divide the square, in the sense of being able, conceptually, to so divide it using the relevant metric. But does this mean that there is any robust sense in which is has spatial parts? Now, there are disagreements as to exactly what it takes for something to count as a proper mereological spatial part of something else. But, plausibly, it is at

[1] He rejects the doctrine of arbitrary undetached parts, which entails a rejection of GCP.

[2] Though notice that everything we say holds true for a one-dimensionally extended object of Planck length, such as a string.

least *necessary* that a proper spatial part is an object that occupies a region of space that is a sub-region occupied by the whole. This minimal necessary condition presupposes very little. It does not, for instance, presuppose the GCP. But if proper parts occupy sub-regions of space occupied by the whole, then we have good reason to suppose that given the actual physics of space-time, our Planck square has no such parts. For physicists tell us that we cannot divide up space into any finer-grained regions than those constituted by Planck squares (Greene 2004: 480; Amati, Ciafaloni, and Veneziano 1989; Gross and Mende 1988; Rovelli and Smolin 1995). It tells us that talk of space breaks down altogether once we talk about regions smaller than the Planck square. Hence we know that talking about something occupying a sub-region of a Planck square makes no sense: there is no such sub-region. Exactly why is not relevant to this paper, but one way of understanding it is by thinking of Planck squares as being objects that carry a single unit of entropy. (If you put a grid of Planck squares over the surface area of a black hole, the entropy of the black hole is the number of Planck squares (Ashtekar, Baez, Corichi and Krasnov 1998)). Then there is nothing that could be taking place within these squares, because such activity would support disorder and the square would contain more than one unit of entropy. That is to say that *in principle*, there cannot be anything that occupies the sub-regions of such a square. For space-time is a macroscopic property at the scale of Planck squares and up. But if it makes no sense to talk about the sub-regions of the Planck square, then given our minimal necessary condition of proper parthood, it follows that Planck squares do not have proper mereological parts: they are spatial simples.[3]

We think, then, that there is a perfectly good sense in which there are *extended* simples, and that this sense is compatible with the geometric correspondence principle being true. The GCP only tells us that given that some object has proper sub-volumes, then it has parts at those sub-volumes. Planck squares, however, have no such sub-volumes (sub-regions, in this case) and hence have no proper parts. But Planck squares are, at least in our pre-theoretic sense of extension, extended. Of course, it is open to someone to claim that in fact Planck squares are not extended, because given what we now know, measuring spatial extension according to a metric that takes space to be continuous is just mistaken. We take the point; however, we think this usage captures what is usually meant when it is claimed that there exist extended simples, and that it is a perfectly coherent conception of extension – we can make *sense* of the idea of a point sized object and of Planck *length*. Indeed, we can consider

[3] They are 'spatial simples' in the sense that they do not have any proper spatial parts. We leave it open whether or not they might have temporal parts if they persist.

logically possible worlds where the smallest unit of space is smaller than the Planck square, and of worlds where it is larger.

What has happened is that our cluster of what seemed like conceptual truths about space turns out not to be uniquely realized. It seemed as though the idea of space as the fabric of the universe, the medium in which physical process take place, the subject of the best theories of space-time, and so forth, must be the very same thing as the geometric metric that we have a priori access to – the thing which allows us to consider different logical possibilities for the size of the minimum units of physical space. To coin a distinction, what me might call Kantian[4] space on the one hand, and physical space, on the other, are actually not the same thing: what this means is that in our world, having extension and having sub-regions of space, come apart. Pre-theoretically we might have supposed that that which has extension, has sub-regions. There are logically possible worlds like this, as well as ones where the spatial quanta are differently sized. Actually, however, our pre-theoretical intuition is not vindicated. But of course we do not think that this would mean that we should conclude that that which has no sub-regions thereby has no extension. And if that is right, then Planck squares have extension and have no spatial parts, but they do so without providing any counterexample to the GCP.

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[4] For the obvious reason that it is an a priori shaper of our concepts of extension etc.

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