Composing the World Out of Nowhere

Abstract: *Space does not exist fundamentally: it emerges somehow from a more fundamental non-spatial structure. This intriguing claim appears in various approaches to quantum mechanics and quantum gravity. The goal of the talk is to show this apparent emergence does not commit to a stratified picture of the natural world with levels of reality. Trans-categorical mereology, may be used to interpret space and spacetime emergence in the background of a flat ontology. We can make sense of space emergence without subscribing to a picture of the natural world stratified in layers of reality, the non-spatial layer being more fundamental than the spatial one. The view will be described in relation to two particular researches programs: wave function realism and loop quantum gravity.*

Keywords: *levels of reality, spacetime, space, emergence, fundamentality, mereology, quantum gravity, loop quantum gravity, wave function realism*.

Space (or spacetime) does not exist fundamentally: it emerges somehow from a more fundamental non-spatio-temporal structure. This intriguing claim appears in various approaches to quantum mechanics and quantum gravity. In quantum mechanics, proponents of wave function realism argue that wave functions are entities of their own living in a physical counterpart of the configuration space, namely in a structure made of $3N$ dimensions, N corresponding to the apparent number of fundamental physical particles.[1] A problem is then to understand the metaphysical status of the *emerging ordinary space* we experiment on a daily basis. In quantum gravity, research programs such as loop quantum gravity state that the relativist spacetime is not fundamentally real and *emerges* somehow from a non-spatio-temporal ontology[2]. Here again, one problem is to understand the metaphysical status of the emerging structure (the relativistic spacetime). The proposal that space or spacetime is not fundamentally real is far more radical that the relationist claim, Leibnizian in spirit, that spatial or spatio-temporal relations depend on their relata, space or spacetime being identified with the collection of these relations. What comes under attack with the phenomenon of space emergence is not the *substantiality* of space (or spacetime), but the fundamental existence of its structure: if borne out, space emergence would entail that space (or spacetime), with its structural organization, does not exist fundamentally.

These views lead to many interesting metaphysical questions, but in this talk we will focus on only one matter: if one of these approaches turns out to be right, then it seems that we will have a novel reason to accept the existence of levels of reality. Indeed, one might argue that physics is (or could be) teaching us an important lesson regarding the fabric of the natural world, namely that it is made of at least two levels of reality: a more fundamental *non-spatial level* and a less fundamental *spatial level*. However, the goal of the talk is to argue that space emergence, as we find it in contemporary physics, is consistent with a flat ontology, namely an ontology in which there are no levels of reality. What I propose in the talk is to take a step back from philosophy of physics proper and enter a more metaphysical discussion over whether the situation in contemporary physics demands to

1 See Albert (1996), Monton (2002, 2006), Lewis (2004) and Ney (2012, 2015).

2 Similar claims appear in string theory (Huggett 2017), and in most research programs in quantum gravity. For a general review, see Huggett and Wüthrich (2013).

posit levels of reality. I shall argue that space emergence can be understood as a *compositional phenomenon*: in this philosophical interpretation, space is literally *made of* non-spatial building blocks, but there are no levels of reality, and so no level is more fundamental than other levels.

From now on, I will use the expression 'space emergence' as a hat which covers both the possible emergence of *three-dimensional ordinary space* in wave function realism and the emergence of *four-dimensional relativistic spacetime* in the context of discussions over the possibility to recover relativistic spacetime from loop quantum gravity. At first glance, the claim that ordinary space (or relativistic spacetime) is not fundamental invites two main readings: either space is *not real at all* or it is *non-fundamentally real*. In other words, the first interpretation amounts to the view that space is emergent (or does not exist fundamentally) because space does not exist *simpliciter*, suggesting that emergence should be explained away as a form of illusion.[3] This *no space view* leads to the disturbing consequence that almost everything we take to be true about space is literally false. According to the second approach, the *derivative space view*, space is emergent because *space does exist derivatively*. It suggests a layered picture of the natural world with at least two levels of reality, the space level being less fundamental than the non-spatial fundamental structure. Although the no space view has been voiced in the philosophy of physics literature,[4] most philosophers of physics are attracted by this second interpretation and take the disappearance of space or spacetime to engage the existence of at least two levels of reality: a *more fundamental non-spatio-temporal level* and a *less fundamental spatio-temporal level*. What is more, recent works in metaphysics explore the idea that there exists a generic *more-fundamental-than relation* or *grounding relation*, often identified with the notion of 'metaphysical causation' and obtaining in the world (see for instance Fine 2001, Schaffer 2003 and Wilson 2017), a fact which might encourage the layered interpretation. Indeed, philosophers of physics might find there a justification for adopting these conceptual tools. If it is natural to describe space emergence in contemporary physics in terms of more and less fundamental entities, why not use the tools crafted by metaphysicians?[5] Thus, we can already see why the derivative space view is more appealing than the no space view; but more will be said on this later.

So space emergence seems, *prima facie*, to entail the existence of some levels of reality. The idea that there are several levels of reality is not new under the sun. In particular, it appears in discussions about special sciences and the ontology they involve. One possible interpretation of the non-reductionist claim that special sciences such as biology or cognitive psychology do not reduce to fundamental physics is that the entities engaged by these special sciences do not reduce to the entities posited by fundamental physics. If this is true, then the natural world is layered in several levels of reality, one corresponding to each of the special sciences.[6] A proponent of levels might argue that contemporary physics *is* providing us with new empirical evidences that the natural world is layered. The idea is intriguing since reductionists about special sciences usually believe that special sciences should be reduced to physics. Could it be that even within physics we find evidences of levels? Could general relativity became a special science? Do we find evidences *within physics* that anti-reductionism is the proper approach to special sciences?

3 Emergence would be then epistemic with no counterpart obtaining in the world. Of course, understanding exactly how this is possible is part of the challenge the no space theorist has to meet.

4 For example, see Albert (1996).

5 However, the notion of grounding is heavily criticized: see for instance Wilson (2014) and Miller and Norton (forthcoming).

6 The layered approach is famously criticized by John Heil (2003a, 2003b).

I will suggest otherwise and shall argue that we have good reasons not to posit levels. The aim of the talk is to advance a flat approach to space emergence that respects the spirit of the derivative view, but refuses any commitment to levels of reality. Indeed, I believe that the demand for ontological parsimony is a healthy one: if we want to welcome non-fundamental entities and relations of fundamentality obtaining between the fundamental and the non-fundamental entities within the ontological realm, we should ascertain whether it is the only way to go. But, as I will show, space emergence is consistent with a flat ontology. It shows that we should not interpret space emergence as a new evidence in favor of the claim that the natural world is stratified in layers.

So how are we going to describe space emergence without committing to levels? According to the *mereological view of space emergence* that I will defend, what we call a 'derivative' or a 'non-fundamental' space is in fact a mereological sum of proper parts of the 'maximal structure', namely the whole cosmos, whatever its exact nature turns out to be. I use the expression 'maximal structure' instead of 'fundamental structure' to avoid any reference to fundamentality. Or, to put it differently, space is a *proper part* of the maximal structure,[7] and, as such, it is not a genuine derivative structure. In a nutshell, the idea is that space might be conceived as a collection of entities scattered in the maximal structure. Rather than being an underlying structure in which things occur, ordinary space or relativistic spacetime should be conceived as a *corner of reality*,[8] a structure which is itself distributed across another 'broader' structure, namely the cosmos. In this model, any particular spatial relation, or spatio-temporal relation, is itself made of entities belonging to a different metaphysical category or, to put it differently, the *building blocks* of space (the spatio-temporal relations) are themselves *made of non-spatio-temporal building blocks* (the primitive entities described by wave function realism and loop quantum gravity). I will use *logical mereology*, a view elaborated by L.A. Paul (2002, 2012) and will show that this view does not need to commit further to a relation of fundamentality obtaining between the non-spatio-temporal building blocks and the spatio-temporal building blocks. Logical mereological composition offers us tools to interpret space emergence without committing to levels of reality. In the proposed picture, space results from a trans-categorical relation of composition that takes as inputs entities belonging to one metaphysical category and gives as an output an entity belonging to a distinct metaphysical category. In brief, it turns the non-spatio-temporal into space.

7 I operate under the assumption that describing our ontology in terms of relations of *composition* or relations of *decomposition* is equivalent. Wherever there is composition there is decomposition and *vice versa*.

8 This metaphor should not confuse us, though: a *corner* is local in a way space is not (in the framework of space emergence). I use this image of corner only to emphasize that space is not an underlying maximal structure. According to the mereological view, space is only a scattered part of the maximal structure.

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