

Title: The Fundamentality and Emergence of Time

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Abstract:

Recent work at the intersection of physics and philosophy of time suggests that time's absence from theories of quantum gravity (QG) entails that reality is fundamentally atemporal and that time is emergent. I consider two potential ways that time might be emergent: in a robust, dualist sense and in a systemic, physical sense. I examine what each of these possibilities would entail for substantialist and relationist views of time. I also examine what is meant by 'fundamental' when it is said that time's absence from QG makes reality 'fundamentally' atemporal. I argue that there are four senses of 'fundamental' at play and although time's absence from QG precludes it from being fundamental in all four senses, time may still be fundamental in two important ways. A consequence of this clarification of senses of 'emergence' and 'fundamentality' is that time may be both emergent and fundamental (in some sense). In particular, I propose that time is part of an emergent structure that is foundational for things with macro-level existence.

Key words: emergence, fundamentality, quantum gravity, relationism, substantialism, time

1. Introduction

Theories of quantum gravity (QG) seek to reconcile gravity—as it is in large-scale or macro-level theories, specifically the theory of general relativity (GR)—with what exists at a very small scale or a micro level of reality—more precisely: a high-energy, small-distance scale.¹ For present purposes, let us call the high-energy, short-distance scale or level of reality that is the focus of theories of QG ‘the quantum level.’ Let us assume that because time is absent from quantum structures in theories of QG, there is no time at the quantum level of reality.

In recent work at the intersection of philosophy of time and physics, the absence of time from theories of QG, such as String Theory, Loop Quantum Gravity, and Causal Set Theory, has prompted philosophers to argue that time is either emergent² or non-existent.³ These arguments can be formulated as two views of the nature of time in light of implications of QG. The first view, which says that although there is no time at the quantum level, time emerges at a macro-level of reality, I will call the emergentist view.⁴ The second view, which says that not only does time not exist at the quantum level, time does not exist at all, I will call the eliminativist view.⁵

Whether one endorses emergentism or eliminativism, one faces the challenging task of explaining the actual or apparent time of the macro levels, given the timelessness of the quantum level. Emergentists must explain from what at the quantum level time emerges, how time emerges, and in what this emergence consists. Philosophers of physics, such as Crowther, Vistarini, and Huggett and Wüthrich attempt to answer these questions.⁶ Eliminativists must explain the appearance of there being time, especially in numerous scientific theories whose predictions have been repeatedly empirically verified, if there is no time. Barbour attempts to do this.⁷ The endeavor of examining implications of theories of QG is a work in progress (as are theories of QG themselves!). For the remainder of this essay, I will set aside eliminativism and focus on emergentism.

In the work of those examining the emergence of time, ‘emergence’ is often used interchangeably with ‘derivation,’ and the most basic meaning of both terms seems to be: *to come from something else*. For instance, Huggett writes about time’s emergence as a relationship between a derivative structure (spacetime)⁸ and a more fundamental non-spatiotemporal structure (in QG) from which it is *derived*.⁹ Huggett also says that the derived structure will be qualitatively different from the more fundamental

¹ “The most useful definition of quantum gravity at this stage is *a theory that supersedes GR at (some) high energy scale*. In other words, it is a theory of the “small distance” physics that is responsible for the emergence of gravitational phenomena at large distances (or, equivalently, low energies, since energy is inversely proportional to length).” Karen Crowther, *Effective Spacetime: Understanding Emergence in Effective Field Theory and Quantum Gravity* (Switzerland: Springer, 2016), 7-8. doi: 10.1007/978-3-319-39508-1

² See, for instance: Crowther, *Effective Spacetime*; Nick Huggett and Christian Wüthrich, *Out of Nowhere: The Emergence of Spacetime in Quantum Theories of Gravity* (Oxford: Oxford University Press, forthcoming); Tiziana Vistarini, *The Emergence of Spacetime in String Theory* (New York: Routledge, 2019); Carlo Rovelli, *Reality is Not What it Seems: The Journey to Quantum Gravity* (New York: Riverhead Books, 2017).

³ Julian Barbour, *The End of Time: The Next Revolution in Physics* (New York: Oxford University Press, 1999); J. B. Barbour, “The Emergence of Time and Its Arrow from Timelessness,” in *The Physical Origins of Time Asymmetry*, ed. J. J. Halliwell, J. Perez-Mercader, and W. H. Zurek (New York: Cambridge University Press, 1994).

⁴ Proponents of what I am calling the emergentist view include Crowther, *Effective Spacetime*; Huggett and Wüthrich, *Out of Nowhere*; Rovelli, *Reality is Not What it Seems*; and Vistarini, *The Emergence of Spacetime in String Theory*. For a more extensive list, see section 7.

⁵ Barbour, *The End of Time*, and Barbour, “The Emergence of Time and Its Arrow from Timelessness,” is a proponent of what I am calling the eliminativist view.

⁶ Crowther, *Effective Spacetime*; Huggett and Wüthrich, *Out of Nowhere*; Vistarini, *The Emergence of Spacetime in String Theory*.

⁷ Barbour, *The End of Time*; Barbour, “The Emergence of Time and Its Arrow from Timelessness.”

⁸ I will use ‘time’ and ‘spacetime’ interchangeably. Spacetime is the emergent structure under examination, but for present purposes, I am more concerned with the time part of spacetime than the space part.

⁹ Huggett, “Spacetime ‘Emergence’,” in *Routledge Companion to Philosophy of Physics*, ed. Eleanor Knox and Alastair Wilson (New York: Routledge, 2023), 374-385.

one.¹⁰ Furthermore, being derived/emergent is typically presented in opposition to being fundamental—discussions in the literature proceed as though it is a given that if something is not fundamental, it is derived, and that if it is derived, it is not fundamental.¹¹

There are three overarching goals in this essay. One is to clarify what is meant by the terms ‘fundamental’ and ‘emergent’ in the literature on the emergence of time. Another is to show that, contrary to how it may seem, even if time is not fundamental to the fullest extent to which that word is used in the relevant literature, time is still fundamental in at least one important sense. The third is to present two types of emergence that may apply in the case of the emergence of time and to illustrate some of the implications of each type of emergence for relationist and substantivalist views of time.

2. *Taxonomy of senses of ‘fundamental’*

The word ‘fundamental’ appears frequently in the literature on the emergence of time. Theories of QG aim to describe the fundamental nature of reality—they are fundamental theories. There is the inference that if theories of QG are about the fundamental structure of reality and time is not part of this structure, then time is not fundamental. Insofar as we ascribe value to the idea of fundamentality and the quest to understand the fundamental nature of reality, it is important to be clear about what ‘fundamental’ means in ‘fundamental theories’ and ‘fundamental structure of reality’ and to be open to the possibility that there is more than one way that something can be fundamental. In this section, I will tease apart four different (though often overlapping) senses of the term ‘fundamental’ as the term is used in the literature on the emergence of time.

1st sense of ‘fundamental’ (F1) = Existing at the smallest level or scale of reality

When philosophers discuss whether time is fundamental, one thing they mean is whether time exists at the smallest level of reality. I will call that which is fundamental because it exists at the smallest level of reality F1. That which exists at the smallest level of reality—whatever that level ultimately is—has a claim to fundamentality on two grounds. The first is that by nature of its size, it can’t be reduced to something smaller. The second is that, at least spatially speaking, groups of small things compose bigger things and in virtue of this composition (or a similar relationship) the smaller things are building blocks of the bigger things. But if something is the smallest size possible, then it cannot be composed of anything else.

Theories of QG are about what exists at a very small scale. It is currently the smallest scale discussed in scientific theories. Thus, one sense of ‘fundamental,’ as it is used in the relevant philosophy and physics literature, is ‘smallest.’ For instance, Crowther mentions “the existence of a fundamental (i.e., minimal) length scale, which is also taken as evidence for the scale at which quantum gravity is expected to be important.”¹² Similarly Vistarini says,

Physical facts that aren’t grounded are those defining the fundamental physical layer at the bottom of the hierarchic structure, that is, they are the physics occurring around the smallest length scale admitted by quantum gravity approaches like string theory and loop quantum gravity. Fundamental physical facts are physical properties and dynamics predicted by fundamental laws—laws applicable to the smallest length scale.¹³

Though he doesn’t explicitly call it what exists at the “smallest” scale, Oriti also discusses the size of the scale described by theories of quantum gravity: “we naively expect the quantum gravity description of spacetime to be relevant around the Planck scale, that is around seventeen orders of magnitude (in length)

¹⁰ *Ibid.*, 375.

¹¹ Examples are discussed in section 7e.

¹² Crowther, *Effective Spacetime*, 14.

¹³ Vistarini, *The Emergence of Spacetime in String Theory*, 4.

below the quark scale and even more below where we know the GR dynamics to be appropriate.”¹⁴ Since theories of QG are about what we believe to be the smallest level of reality and since time is absent from these theories and this level, time is not F1.

At this time, we don’t know of or if there’s anything smaller than that which is examined by theories of QG, so for now what exists at the quantum level or scale will be equated with ‘the smallest level,’ with the understanding that future advancements in science might reveal smaller levels. It is important to note, however, that the idea of ‘the smallest level’ is not a priori identical to the idea of ‘the quantum level.’ If there is no time at the quantum level, then time is not fundamental in this sense, the sense of existing at the smallest level of reality (F1). If the quantum level is not ultimately the smallest level—if there is a smaller level—then we would have to determine if time exists at that smaller level before making a claim about its fundamentality in this sense. Presumably its absence from the quantum level would suggest that it wouldn’t be at a smaller level either. However, perhaps it is possible that there’s something “smaller” (a sub-quantum level, if you will) and that time exists there, even if it disappears at the level of quantum theories and then reappears at larger scales.

2nd sense of ‘fundamental’ (F2) = Ontologically basic, irreducible

Another way that the term ‘fundamental’ is used in the relevant literature is to mean being a basic part of the universe, where ‘basic’ means ontologically irreducible into simpler or more basic things. I will call this sense of fundamental F2. Things that exist at the smallest scale of reality are basic and irreducible (so, what is F1 is also F2). However, basic-ness or irreducibility are not just about size. There may be basic, irreducible things that don’t have a size (see consciousness, below, as an example). There may also be macro-sized physical things or immaterial things that are irreducible.

Examples of things (other than time) that may be F2 even though they aren’t F1 include:

Consciousness. In some views of the mind, including dualism, panpsychism, and non-reductive physicalism, consciousness is a basic, irreducible part of what exists. For instance, on Chalmers’ panpsychism, consciousness is a fundamental immaterial part of reality, irreducible to something physical.¹⁵ Furthermore, consciousness, if fundamental, is fundamental in a way that does not pertain to size. It does not make sense to quantify consciousness as ‘big’ or ‘small’ though it may very well be a macro-level phenomenon—i.e., a function of medium- or large-scale entities.¹⁶

Persons. On Trenton Merricks’ view, all that exists are persons (human organisms) and microphysical particles. Although all other macro-level things are reducible to microphysical particles, persons are not.¹⁷

¹⁴ Daniele Oriti, “Disappearance and emergence of space and time in quantum gravity,” *Studies in History and Philosophy of Modern Physics* 46 (2014), 195. doi:10.1016/j.shpsb.2013.10.006

¹⁵ He defends this view in many places, including: David Chalmers, *The Conscious Mind: In Search of a Fundamental Theory* (New York: Oxford University Press, 1996) and David Chalmers, *The Character of Consciousness* (New York: Oxford University Press, 2010).

¹⁶ Emergentism about the mind is viewed as being incompatible with views like panpsychism, precisely because of the assumption that if something is emergent, it is not fundamental. I would argue, though this isn’t the place to develop the argument in any depth, that consciousness can be emergent and fundamental if what emerges is irreducible and basic. Interestingly, if consciousness is emergent and irreducible to the physical parts of reality from which it comes, this is a case of the emergent thing being fundamental in a way that what it emerges from is not (since neurons, although very small, are made of even smaller physical parts).

¹⁷ Trenton Merricks, *Objects and Persons* (New York: Oxford University Press, 2001).

Souls. In traditional dualist views, such as Swinburne's, wherein there is an immaterial soul that interacts with the physical body but is distinct from it, that soul is ontologically basic and irreducible.¹⁸

As discussed above, things that are F1 are also F2. However, it doesn't follow that everything that is F2 is also F1. So, time's not being F1 doesn't preclude time's being F2. Time would be F2 if it is basic and irreducible. It's possible that time is F2. Indeed, in many philosophies from around the world and throughout history, and throughout the history of science in general and physics in particular, time has been regarded as a basic, irreducible component of reality. However, it's also possible that time is not F2. If time is reducible to something more ontologically basic (for instance, if the spacetime of General Relativity is reducible to an atemporal quantum structure), if time's nature is complex, or if time doesn't exist, then time is not F2.

3rd sense of 'fundamental' (F3) = Ontologically foundational, part of the foundation of reality

Another way that 'fundamental' is used in the relevant literature is to mean being part of the foundation of reality. I will call this sense of fundamental F3. Indeed, one of the main goals of theoretical physics is to better understand the foundations of the universe. Let me elaborate on what it would mean to be part of the foundation of what exists.

Something, A, is part of the foundation of reality (F3) if, were we to quantify over everything that exists, most members of that set are either directly or indirectly dependent on A for their existence. This dependence can be a direct relation between other things that exist and A. Or it can be an indirect relation if something that exists, C, depends on something else, B, for its existence, and B depends directly on A for its existence. There can be multiple steps or levels of dependence in an indirect dependence relation, whereby something, Z, ultimately depends on A for its existence if there is a series of dependency relations between A and Z.

To some extent, deciding what is foundational to most of what exists is arbitrary (unless perhaps we go down to the smallest level). But something could be foundational to a great deal of what exists without being part of the smallest level. For instance, it may be that there is something that comes into existence at a macro level and is part of the foundation of all macro-level things. Or perhaps this thing brings into existence the macro levels by serving as (part of) the foundational structure of those levels. Such a thing would be F3 and it's possible that time is F3 in these ways.

4th sense of 'fundamental' (F4) = Having existence that is not derived from something else

Another way the term 'fundamental' is used in the literature on the emergence of time is to mean having existence that is not derived from something else. I will call this sense of fundamental F4. For instance, Vistarini says, "every physical fact is either fundamental or derived with respect to more fundamental physical facts...the physical world is hierarchically structured from physical fundamental facts to increasingly complex derived facts."¹⁹ If the base of the hierarchical physical structure is fundamental physical facts, and the other levels of the hierarchy are derived, then the fundamental level (or the *most* fundamental level) is the only level that is not derived from something else.

In their discussion of deriving spacetime from more fundamental structures in theories of QG, Huggett and Wüthrich similarly imply that there are degrees of fundamentality whereby the less derived something is, the more fundamental it is. For instance, they say of theories of QG,

We especially want to focus on a rather generic feature of them—that in various ways they do not contain familiar spacetime at a fundamental level, but rather it 'emerges'...in a higher, non-fundamental domain. That will lead us to a discussion...of the challenges to

¹⁸ Richard Swinburne, *Are We Bodies or Souls?* (Oxford: Oxford University Press, 2019).

¹⁹ Vistarini, *The Emergence of Spacetime in String Theory*, 4.

the very idea that something a[sic] seemingly fundamental as spacetime could be derivative, from even more fundamental, yet non-spatiotemporal, physics.²⁰

To have existence that is not derived from something else signifies fundamentality in ways that are fairly transparent yet would benefit from being elucidated. First, if something, X, is not derived from anything else, Y, then this means X does not come from anything else and also that the existence of X is autonomous—it doesn't depend on other existing things. If X does not come from anything else, then this automatically means that X is basic and irreducible (F2)—nothing, Y, composes or constitutes X such that X could be reduced to Y or such that Y is more basic than X.

X's being non-derived might also mean that X is foundational (F3), though it does not necessarily mean this—presumably there could be some non-derived things that aren't part of the foundation of everything else if nothing comes from them or is comprised of them. Furthermore, X could be part of the smallest level (F1), since presumably what is at the smallest level doesn't derive (at least size-wise) from anything else. However, X's being non-derived does not automatically mean that X is part of the smallest level of what exists, because it is conceivable that something without size or with a larger size is not derived from something else.

One may wonder what the difference is between F4 and F2, or whether there is a difference between them. The difference is subtle. As discussed above, something that is non-derived is automatically basic and irreducible. So, anything that is F4 is also F2. However, it doesn't follow that all things that are basic and irreducible (F2) are non-derived (F4). For example, consciousness may be both derived from neurophysiological processes and irreducible to these same processes. Medium-sized objects, on Elder's view, are both derived from their smaller physical parts (insofar as the smaller physical parts compose them) and irreducible to these physical parts.²¹ Persons are derived from various parts working together, yet on Merricks' view, they are ontologically basic and irreducible.²² Something can be derived from something else without being reducible to it. So, something can be F2 but not F4.

Time is F4 if it doesn't derive from anything else. If, however, time does derive from something else, such as something at the quantum level, then time is not F4.

3. Discussion of senses of 'fundamental' and a defense of the fundamentality of time

Currently, fundamental theories in physics investigate what exists at the smallest level of reality, what is ontologically basic and irreducible, what is ontologically foundational, and what is non-derivable. The quantum level is fundamental in all four senses: F1, F2, F3, and F4. Whatever exists at the quantum level is thus fundamental without qualification, or fundamental to the fullest extent. If time is absent from the quantum level, then time is not fundamental in all four senses.

However, it would be a mistake to assume that something must be fundamental in all four senses to be fundamental at all. Historically, the study of what is ontologically basic (F2) and foundational (F3) has not always been about what exists at the smallest level (F1) and certainly not about what exists at the quantum level. Before physicists came up with quantum mechanics and other quantum theories, 'fundamental theories' in physics were about the parts of reality that were the most ontologically basic and foundational. Rovelli has a useful discussion of the evolution of scientific beliefs about what fundamentally exists (in the sense of F2 and F3), from the space, time, and particles of Newton's physics, to the addition of fields from the theories of Faraday and Maxwell, to the shift to spacetime in the earlier work of Einstein, spacetime and quantum fields in quantum mechanics, and finally his (Rovelli's)

²⁰ Huggett and Wüthrich, *Out of Nowhere*, ch. 1, pp. 3-4.

²¹ Crawford L. Elder, *Familiar Objects and Their Shadows* (Cambridge: Cambridge University Press, 2011); Crawford L. Elder, *Real Natures and Familiar Objects* (Cambridge, Mass: M.I.T. Press/Bradford Books, 2004); Crawford L. Elder, "On the Reality of Medium-Sized Objects," *Philosophical Studies* 83, 2 (1996). doi:10.1007/bf00354288.

²² Merricks, *Objects and Persons*.

proposal of covariant quantum fields.²³ So, historically at any rate, it is not the case that the notion of a ‘fundamental theory’ in physics is (or must be) restricted to theories about the smallest level (or the quantum level).

Even if time is not F1 or F4, it may be fundamental if it is F2 or F3. For time to be F2 would be for it to be ontologically basic and irreducible. As argued above, something may be both derivable and irreducible/ontologically basic (consciousness being the prime example). It is possible that time’s existence derives from something at the quantum level but is not reducible to that from which it comes. At this time, I cannot do more than speculate about this. We first must learn if time derives from something at the quantum level and what that is, and determine whether time is reducible to that from which it comes. Such is the current research of physicists and philosophers of physics.

For time to be F3 would be for it to be foundational to most of what exists. If time is not present at the quantum level and the quantum level is foundational to everything else, then time is not foundational to everything that exists. However, as discussed earlier, it’s possible for something that is not present at the smallest level of reality to still be foundational to most of what exists. There are reasons to believe that time is F3. Distinct earlier and later states of reality provide structure for there to be change, causation, action, motion, and persistence which are, in turn, foundational for many other things, including scientific and philosophical endeavors. Furthermore, time (or, more precisely, spacetime) is a core part of the theory of general relativity, which is foundational for our scientific understanding of macro-level physical reality. Insofar as theories in the special sciences study changes of various sorts, and these changes occur at successive times, time is also foundational in the special sciences. When philosophers make the inference from no time at the quantum level to time’s not being fundamental, they are overlooking the possibility that time (atemporally) comes into existence at a larger scale of reality *and* is foundational to a vast array of things that also emerge at larger scales of reality. Time (spacetime) may be fundamental with qualifications, even if it is absent from the smallest level of reality (not F1) and even if it is derivable (not F4).

4. *Emergence in philosophy of mind*

Talk of emergence is predominantly found within philosophy of mind, where one view of mental states is that they are emergent. If mental states are emergent, there is also the further question of whether they are weakly or strongly emergent.²⁴ On both the strong and weak concepts of emergence, mental states are emergent if they arise from components of a physical system interacting in complex ways and they have properties that the individual components of the physical system lack. Sometimes the emergent mental states are said to have causal powers, but not necessarily (as in epiphenomenalism).

Let us call the mental states or phenomena ‘X’ and the individual physical (or neurophysiological) components ‘Y’. On Chalmers’ account, X is strongly emergent if truths about X are not deducible, even in principle, from truths about Y. We could know all of the truths about Y, without knowing any truths about X, because truths about X are not entailed by truths about Y, even though they are correlated with each other in the sense of being co-occurrent. On Chalmers’ view, strongly emergent things are immaterial. In contrast, X is weakly emergent if truths about X are unpredictable, given truths about Y, but truths about X are ultimately deducible from truths about Y. Chalmers’ notion of unpredictability, for weakly emergent things, presupposes that all physical things (other than the most fundamental ones) are reducible to something else physical that is more fundamental. This is because, on his view, if strongly emergent things exist, then physicalism is false, whereas weak emergence is compatible with physicalism. Another aspect of weak emergence is that the “core of this position is that a

²³ Rovelli, *Reality is Not What it Seems*.

²⁴ David Chalmers, “Strong and Weak Emergence,” in *The Re-emergence of Emergence*, ed. Philip Clayton and Paul Davies (Oxford: Oxford University Press, 2006). doi:10.1093/acprof:oso/9780199544318.003.0011

property is emergent if it is a systemic property of a system—a property of a system that none of its smaller parts share.”²⁵

5. *Emergence in science*

To some extent, the emergence of time discourse has appropriated the term ‘emergence’ from philosophy of mind. However, the term ‘emergence’ is also used in science to refer to any macro-level or complex entity, phenomenon, or structure that has properties and sometimes causal powers in virtue of the relations between its components, which work together as a system. The macro-level entity exists in virtue of its components interacting or being arranged in a certain way and has properties in virtue of the same. The individual components do not have these properties. This sense of emergence is similar to (if not the same as) the concept of weak emergence discussed above. It’s this sense of the term ‘emergence’ that philosophers working on the emergence of time predominantly use.²⁶

6. *Taxonomy of senses of ‘emergence’*

The following taxonomy of senses of the term ‘emergent’ has a similar framework to that from philosophy of mind discussed above. However, I prefer to not retain the ‘strong’ and ‘weak’ terminology because I don’t want the senses of emergence I discuss to be tied too closely to any particular philosopher’s view or for the topic to get diverted to a question of whether these senses are correctly capturing precisely what any particular philosopher means by ‘strong’ or ‘weak’ emergence. Furthermore, my goal is to offer a taxonomy of senses of ‘emergence’ that is most useful to the investigation into whether time is emergent and this does not precisely match the distinction between strong and weak emergence, though it does come close.

1st sense of emergent: Dualist emergence (E1)

The first sense of emergence is a more robust one, which I will call ‘dualist emergence’ or E1. Dualist emergence is a relation between smaller, more basic, more foundational, or less derived things, which I will call ‘lower-level things’ and a larger, less basic, less foundational, or more derived thing, which I will call a ‘higher-level thing’ such that the higher-level thing comes from the lower-level things yet is not physically reducible to them.

The higher-level thing has novel properties not possessed by the individual lower-level things from which it comes; however, the properties are not all that is novel—there is also a novel property-bearer of some sort. In coming from things from a lower level at which it doesn’t exist, this property-bearer’s existence at a higher level is novel and, as such, can be said to be distinct or partially independent from the lower-level things from which it derives. X is E1 if it is a novel higher-level thing that derives from lower-level things to which it *is not* reducible and it has novel properties and may have causal powers, qua higher-level, derived thing.

Furthermore, facts about something that is E1 are not (fully) deducible from facts about that from which it emerges. With respect to defining E1, Chalmers’ description of strong emergence is apt: “We can say that a high-level phenomenon is strongly emergent with respect to a low-level domain when the high-level phenomenon arises from the low-level domain, but truths concerning that phenomenon are not deducible even in principle from truths in the low-level domain.”²⁷ If time is E1, then truths about time and temporal properties are not deducible even in principle from truths about the quantum domain. If this is the case, then knowing all the facts about the quantum level of reality will not enable us to deduce facts such as whether one macro-level event is earlier or later than another or the duration of a macro-level

²⁵ *Internet Encyclopedia of Philosophy*, s.v. “Emergence,” accessed April 25, 2024, <https://iep.utm.edu/emergence/#SSH2ai>.

²⁶ See, for instance, Huggett and Wüthrich, *Out of Nowhere*, ch. 1, p. 6.

²⁷ Chalmers, “Strong and Weak Emergence,” 244.

event. Likewise, knowing all the facts about temporal properties and relations at the macro levels will not enable us to deduce facts about the quantum level.²⁸

Despite the legacy of the usage of the word ‘dualist,’ my account of dualist emergence is neutral on whether what emerges is immaterial or physical. This is a key way in which what I am calling ‘dualist emergence’ differs from Chalmers’ account of strong emergence.²⁹ As discussed earlier, on Chalmers’ description, what is strongly emergent is immaterial. He omits the possibility that there are emergent macro-level *physical* things that cannot be reduced to the micro-level physical things from which they come. But not all philosophers believe that every macro-level physical thing can be reduced to microphysical things. Elder, for instance, defends a view according to which there are macro-level or medium-sized physical objects that are not reducible to their microphysical parts arranged a certain way.³⁰ However, Elder does not use the word ‘emergence’ and it would likely be incorrect to say that his view is that macro-level things are emergent.³¹ On what I am calling ‘dualist emergence,’ something that is E1 may be either a novel immaterial thing or a novel physical thing. For instance, a mental state is E1 if it is a novel immaterial or physical state that arises from, yet is not reducible to, individual neurons and their systemic interactions and has properties and causal powers³² that the latter do not have.

None of the emergentists about time mentioned earlier have suggested that time is immaterial or that time is a physically irreducible thing. Crowther, however, explicitly refrains from ‘picking sides’ as to whether what is emergent is reducible or irreducible.³³

2nd sense of emergent: Physical emergence (E2)

Physical emergence (E2) is a relation between lower-level things and a higher-level thing, where the higher-level, derived thing is a *complex structure* or *system* that comes from and *is* physically reducible to the lower-level things, though it has properties and may have causal powers qua complex structure or system that the lower-level things that give rise to it do not have. It is different from dualist emergence in the following ways.

When something is E2, it is a complex structure or system that couldn’t exist independently of its components and their relations.³⁴ In contrast, something that is E1 may also be a complex structure or system, but its existence is to some extent independent of its components and their relations. Something that is E2 has novel properties qua complex structure or system and while these novel properties are unexpected, facts about them and about the structure itself are, in principle, deducible from facts about the components of the structure, their relations or arrangement, and laws governing these. In contrast, facts about something that is E1 and facts about its novel properties are not (fully) deducible from facts about the components of the structure, their relations or arrangement, and laws governing these. Something that is E2 is physically reducible to its components and their relations or arrangement; whereas something that

²⁸ Crowther (*Effective Spacetime*; “Emergent spacetime according to effective field theory: From top-down and bottom-up,” in *Studies in History and Philosophy of Modern Physics* 44 (2013): 321-328. doi: 10.1016/j.shpsb.2012.08.001) discusses how, with emergence, there are both top-down and bottom-up approaches to the levels of emergence and the direction of explanation.

²⁹ Chalmers, “Strong and Weak Emergence.”

³⁰ Elder, *Familiar Objects and Their Shadows*; Elder, *Real Natures and Familiar Objects*; Elder, “On the Reality of Medium-Sized Objects.” On Elder’s view, the macro-level thing has ontological precedence over its underlying micro-level components and their arrangement, because the essence or nature of the macro-level thing is what is responsible for the arrangement of its micro-level components.

³¹ I mention his view to provide an example of a view in which macro-level or medium-sized objects are entirely physical yet are not reducible to their underlying microphysical components, rather than as an example of a view in which macro-level things emerge from micro-level things but are irreducible to them.

³² If one holds that mental states are emergent but epiphenomenal, then one would deny this particular claim about mental states having causal powers.

³³ Crowther, *Effective Spacetime*, 56.

³⁴ Though the components can be interchanged with other components and it is vague how many of the components and their relations are necessary for the system or structure to emerge/exist.

is E1 is not physically reducible to its components and their relations or arrangement. Something that is E2 is physical; whereas something that is E1 can be either immaterial or physical.

E2 is the sense of emergence most similar to the emergence discussed in science, where complex, macro-level physical structures and systems exist because of an organization, arrangement, or the interactions of lower-level things. For example, a liquid, such as water, can be said to emerge in the sense of E2 from a group of water molecules. The emergent liquid, water, has properties and causal powers that its individual water molecules don't have. For instance, the water has temperature, which is the mean kinetic energy of its molecules. The individual molecules do not have temperature. Water can, in turn, be used to cook something, once the water is hot enough, but an individual water molecule, qua individual, does not have this causal power. However, water (by which I mean a quantity of the liquid) is fully physically reducible to its water molecules.³⁵

Note that although this sense of emergence is physicalist, it is not eliminativist. Whatever is said to emerge in the sense of E2 physically exists, even though its existence derives from the existence of its lower-level components. In contrast, according to eliminativism, there would be no derivative, higher-level thing, there would just be the lower-level things and laws that govern them.

The majority of philosophers who argue that time is emergent—such as Baron and Le Bihan,³⁶ Huggett,³⁷ Huggett and Wüthrich,³⁸ Lam and Esfeld,³⁹ Lam and Wüthrich,⁴⁰ Oriti,^{41, 42} Vistarini,⁴³ and Wüthrich⁴⁴—use the term 'emergent' in the second sense (E2). Sometimes they explicitly say that the type of emergence they have in mind resembles 'weak emergence,' which, as discussed in section 4, is similar to E2. For instance, Huggett and Wüthrich say, with respect to the word 'emergent,'

we do not use this term in its strongest philosophical sense to indicate the *inexplicability* of X from Y: as some have claimed life or mind emerges from matter. On the contrary, we argue that classical spacetime structures *can* be explained in more fundamental terms...Some might then say that spacetime 'reduces' to non-spatiotemporal QG, but we prefer to stick with the notions of 'explanation' or 'derivation', because there are many notions of 'reduction', some of which are too strict. But we are also happy to speak of (weak) 'emergence' even when spacetime is derived.⁴⁵

And Oriti says, when discussing the definition of emergence he uses, "It goes without saying, then, that we are speaking here only of what is usually referred to as *weak emergence*, as opposed to *strong emergent behavior*."⁴⁶

³⁵ Oriti has a much more in-depth discussion of this example in Daniele Oriti, "The Complex Timeless Emergence of Time in Quantum Gravity," in *Time and Science- Volume 3: Physical Sciences and Cosmology*, ed. Rémy Lestienne and Paul A. Harris (New Jersey: World Scientific, 2023), 141-144. doi:10.1142/9781800613775_0006

³⁶ Sam Baron and Baptiste Le Bihan, "Composing Spacetime," *Journal of Philosophy* 119, 1 (Jan., 2022): 33-54. doi:10.5840/jphil202211912

³⁷ Huggett, "Spacetime 'Emergence'."

³⁸ Huggett and Wüthrich, *Out of Nowhere*.

³⁹ Vincent Lam and Michael Esfeld, "A dilemma for the emergence of spacetime in canonical quantum gravity," *Studies in History and Philosophy of Modern Physics* 44 (2013). doi:10.1016/j.shpsb.2012.03.003

⁴⁰ Vincent Lam and Christian Wüthrich, "Space-time is as space-time does," *Studies in History and Philosophy of Modern Physics* 64 (2018). doi:10.1016/j.shpsb.2018.04.003

⁴¹ Oriti, "Disappearance and emergence of space and time in quantum gravity."

⁴² Oriti, "The complex timeless emergence of time in quantum gravity."

⁴³ Vistarini, *The Emergence of Space and Time*.

⁴⁴ Christian Wüthrich, "The Emergence of Space and Time," in *Routledge Handbook of Emergence*, ed. Sophie Gibb, Robin Finlay Hendry, and Tom Lancaster (London: Routledge, 2019). doi:10.48550/arXiv.1804.02184

⁴⁵ Huggett and Wüthrich, *Out of Nowhere*, ch. 1, p. 6.

⁴⁶ Oriti, "The Complex Timeless Emergence of Time in Quantum Gravity," 3.

Another reason I interpret time as being E2 on their views is that they hold that emergence is compatible with reduction. Although Huggett and Wüthrich say in the above quote that they prefer to use the terms ‘explanation’ or ‘derivation’ rather than reduction, because some notions of reduction aren’t applicable in the current context, they explicitly say, later in the same chapter, that their approach is a functional one where they examine what fills the functional roles of spacetime in theories of QG and that spacetime reduces (in some sense anyway) to whatever fills its functional roles in QG:

it should be made clear that we take emergence and reduction to be compatible with one another, and hence functional *reduction* may serve as a template to explain the *emergence* of a higher-level feature, i.e., the fact that higher-level entities exhibit novel and robust behavior not encountered or anticipated at the more fundamental level.⁴⁷

Oriti’s view also involves reduction. He treats reduction as being the same thing as deduction, because the type of reduction in question involves mathematical models of time in physical theories. He also seems to regard reduction as being ‘bottom-up,’⁴⁸ where the more fundamental thing reduces to the less fundamental thing—theories of QG reduce to GR.⁴⁹ As a point of clarification, if reduction is being used in the ‘bottom-up’ sense, then it may seem as though fundamental things are reducible and so would not be F2. However, since Oriti says he is using ‘reduction’ to mean deduction—as opposed to say, being constituted by smaller or more fundamental things—his description of what counts as fundamental doesn’t really differ from mine, and because he is really saying that from descriptions of quantum structures we can deduce descriptions of macro-level structures, this just further shows how emergence is E2 on his view.

An additional reason I interpret time as being E2 on their views is the very task in which they are engaged: using deduction to try to figure out how time comes out of timeless theories. For instance, Le Bihan says, “we must actually derive General Relativity from Quantum Gravity—using mathematical tools and bridge principles between the primitive notions of the two theories.”⁵⁰ The timelessness of quantum theories makes time’s emergence unexpected, but if we can use deductive reasoning to show how this happens, then time would be E2 rather than E1.

7. *The emergence of time*

In this section, we will examine what it would be for time to be emergent in each of the two senses previously discussed—E1 (dualist emergence) and E2 (physical emergence). In order to do this, we must first stipulate (at least to some extent) what time is and what temporal properties are, since time and temporal properties are what would be E1 or E2. To this end, I consider substantivalism and relationism about time and then discuss what it would be for time to be emergent on each of these views, including what it would be for temporal properties to be emergent. We will also examine whether time is the sort of thing that can have causal powers, since emergent things are often said to have causal powers not possessed by that from which they emerge. Finally, I will discuss how time can be both emergent and fundamental.

a. Substantivalism and relationism

In philosophy of time, prior to recent investigations into whether time is emergent, discussions of time’s existence centered on a couple of different issues: the A-theory/B-theory debate and the substantivalism/relationism debate. Discussion of the emergence of time as it relates to the A-theory/B-

⁴⁷ Huggett and Wüthrich, *Out of Nowhere*, ch. 1, p. 17.

⁴⁸ As Crowther calls this type of reduction in “Emergent spacetime according to effective field theory: From top-down and bottom-up.”

⁴⁹ Oriti, “The Complex Timeless Emergence of Time in Quantum Gravity,” 12-13.

⁵⁰ Baptiste Le Bihan, “Spacetime emergence in quantum gravity: functionalism and the hard problem,” *Synthese* 199 (Suppl 2) (2021): S378. doi: 10.1007/s11229-019-02449-6

theory debate will be saved for another time. The present discussion will focus on the substantivalist and relationist views.

Traditional substantivalism, such as was defended by Isaac Newton, is the view that space and time exist independently of objects, events, entities, and other existing things and are fundamental substances. Post-Einstein's theory of general relativity, substantivalism is the view that *spacetime* exists independently of things and events and is a fundamental substance. Furthermore, independently-existing spacetime is a container of sorts for things and events—things and events exist within this container, but spacetime itself is separate from them. Imagine, for example, a cylindrical take-out food container with food in it.⁵¹ Spacetime is the container and things that exist within spacetime (objects, entities, events) are the food. The container would exist even if it was empty; its existence is independent of the existence of its contents. Spacetime is also a fundamental part of reality. "Substantivalists maintain that a complete catalogue of the fundamental objects in the universe lists, in addition to the elementary constituents of material entities, the basic parts of spacetime."⁵²

In contrast, relationism says that space and time (or just spacetime) are relations between existing things. As relations between existing things, spacetime's existence is interwoven with the existence of objects, entities, and events. Thus, on relationism, spacetime does not exist by itself, independently of objects, entities, and events. Relationism says that the existence of spacetime depends on the existence of material things. On Pooley's description of relationism:

Relationists maintain that spacetime does not enjoy a basic, non-derivative existence. According to the relationist, claims apparently about spacetime itself are ultimately to be understood as claims about material entities and the possible patterns of spatiotemporal relations they can instantiate.⁵³

A brief examination of what Pooley means by spacetime 'not enjoying a basic, non-derivative existence' is in order. First, I think by 'basic' he means 'independent'—something that exists in its own right. Further, I think he means that something must be non-derivative in order to have independent existence. (This was something I disputed in my discussion of the senses of fundamental in sections 2 and 3, in which I argued that there may be some things that are both derived/emergent and basic/irreducible.) However, when Pooley says that, on relationism, spacetime's existence is not basic or non-derivative, but rather claims about spacetime are really 'claims about material entities and the possible patterns of spatiotemporal relations they can instantiate,' he seems to be speaking to a mutual dependence between material things and temporal relations. On relationism, temporal relations only exist where there are material things and events, and material things and events can only exist because of temporal relations. The relations and their relata can't exist without each other.

So, we have from the substantivalism/relationism debate two possibilities for what spacetime could be: a 'fundamental,' independently existing 'container' of sorts in which things exist and events occur, or relations between and within things and events where the relations and their relata are mutually dependent. We will next examine what the emergence of the spacetime container or spacetime relations would involve.

b. Substantivalism and the emergence of time

⁵¹ The choice of a cylinder for this metaphor is arbitrary—the metaphorical container could potentially be any 3-dimensional shape. Also, the use of a concrete object to represent spacetime in the metaphor is not perfect, because although on substantivalism, spacetime is a substance, it's not the same type of material substance as its contents (whereas the food and the container are both concrete, material substances).

⁵² Oliver Pooley, "Substantivalist and Relationist Approaches to Spacetime," in *The Oxford Handbook of Philosophy of Physics*, ed. Robert W. Batterman, 523. (New York: Oxford University Press, 2013). doi: 10.1093/oxfordhb/9780195392043.001.0001

⁵³ *Ibid.*

First, it seems as though the emergence of time is incompatible with substantivalism, because on substantivalism, spacetime is fundamental and its existence is independent of things and events. But in what sense would spacetime be fundamental, if substantivalism is the correct view of spacetime? Substantivalism suggests that the existence of spacetime is independent of the levels of reality that can be more-or-less ordered by their size, since it is material things that belong at these levels and, on substantivalism, spacetime is independent of material things. However, since substantivalism holds that spacetime is supposed to be the container of all existing material things, it would most likely be correct to say that spacetime exists at the smallest level of reality or, at the very least, that it structures the material things that exist at the smallest level of reality. Spacetime would thus either be F1 or structure the material things that are F1.

Spacetime would also be F2, for it is part of the substantivalist view that spacetime is a basic, irreducible substance. On substantivalism, spacetime would be foundational (F3) as well, because the view holds that spacetime is a container of sorts that structures the things and events that exist within it. Finally, spacetime would be F4, because it would not be derivative of anything else (if its existence was derivative, then it would depend on that from which it derives because it comes from it). So, it seems upon first examination that if spacetime is substantival, then rather than being emergent, it is fundamental in every sense—it is fundamental without qualification.

What of substantivalism and quantum gravity then? It would seem to be the case that if a theory of quantum gravity is correct, this would preclude substantivalism. In order for a theory of quantum gravity and substantivalism to both be correct, the theory of QG would need to be revised to include some type of fundamental spacetime structure or perhaps substantivalism would have to be weakened, such that spacetime is seen as only being fundamental at the macro levels.

At this point, I think the latter option is more promising than the former. My proposal will be that spacetime is fundamental at the macro levels in that it is (at least part of) the foundational structure of everything that has macro-level existence. On this view, spacetime would emerge from a quantum structure and it would be an emergent structure that is a container of sorts for all macro-level things and events. Now, would this emergent foundational structure be E1 or E2?

It might seem, *prima facie*, that it would have to be E1, because in order for this view of spacetime to be substantival (especially since it's already a revised version of substantivalism in which spacetime is not fundamental in every sense), it would have to retain the independence of the macro-level spacetime container from the macro-level things and events that exist within the container. The spacetime container gives structure to these macro-level things and events but it does so extrinsically, not intrinsically. However, E1 also says that facts about the emergent structure are not deducible from facts about the structure from which it comes. This is where the relationship between E1 and substantivalism collapses, at least for anyone who wishes to retain the in-principle deducibility of spacetime from a quantum structure. As mentioned in section 6, none of the emergentists mentioned defend E1; they seem committed to the idea that, given that this is a scientific enterprise, we must be able to deduce facts about emergent spacetime from facts about quantum structures.⁵⁴

One further part of E1 to consider is that something that is E1 can be either material or immaterial. Given spacetime's role in scientific theories, taking an immaterialist view of spacetime would not be helpful and such a position would run into a lot of the same challenges faced by dualist views of the mind. Taking a materialist view of spacetime and also holding that spacetime is E1 would be more productive and is worth looking into, despite knee-jerk reactions philosophers often seem to have against macro-level, physically-irreducible material things. In summary, a combination of E1 and post-QG

⁵⁴ It's possible that Crowther's view, in *Effective Spacetime*, is compatible with E1, but her view may also be compatible with E2. She refrains from taking a stance on whether what is emergent reduces or fails to reduce, due to difficulties that exist in defining reduction. She advocates separating the concept of reduction from the concept of emergence. On her view, emergence involves dependence, autonomy, and novelty, all of which time could be said to have if it is E1. However, the 'not-deducible-in-principle' part of E1 would likely preclude Crowther from fully embracing a view of spacetime that is E1.

revised substantivalism is possible, but would likely not appeal to many of the philosophers working in this area, due to such a view's commitment to non-deducibility.

Is the post-QG revised version of substantivalism compatible with E2? Would such a view preserve deducibility? On this view, spacetime is a macro-level structure/container whose existence is independent from the macro-level things and events it structures/contains, but whose existence is not independent from the quantum-level things from which it emerges. On E2, that which emerges does so as a complex structure or system, facts about which are, in principle, deducible from facts about that from which it emerges. Post-QG revised substantivalism would be compatible with E2 in the following ways: spacetime is independent from the macro-level things it structures/contains and facts about spacetime are deducible in principle from facts about the quantum-level structure from which it emerges. On E2, that which emerges is also reducible to that from which it comes. So, on this view, the spacetime structure would reduce to a quantum one, though more would have to be said about the type of reduction involved.⁵⁵ There is no obvious reason why post-QG revised substantivalism wouldn't be compatible with E2, since spacetime's independence from macro-level things and events does not preclude its dependence on and reducibility to things at the quantum level.

We end with the suggestion that given a commitment to quantum theories (whichever one ends up being best), we can have a revised (post-QG) version of substantivalism in which spacetime is an emergent foundational structure of everything with macro-level existence (but we cannot retain the pre-QG substantivalism according to which spacetime is independent of *everything* with material existence). As just discussed, this emergent foundational structure is a container of sorts of macro-level things and events and its existence is independent from these macro-level things and events. However, this emergent foundational structure is E2 because facts about it are deducible (in principle) from facts about the quantum level from which it derives and it is reducible to the quantum level from which it derives.

Further, as an emergent structure, it bestows on the macro-level things and events it contains novel properties not possessed by its underlying quantum structure. These novel, emergent properties may include things like having duration, having persistence, having a direction or orientation, being successive, being static, being robustly dynamic, or being dynamic in a less robust or deflationary sense. An event's duration, for example, would be an emergent property of that event because it is a property that macro-level events have but that nothing at the atemporal quantum level has. A macro-level entity's persistence is another emergent property because it can only be ascribed to macro-level things that exist at multiple successive times (or have temporal parts at multiple successive times). In contrast, quantum-level physical things do not persist because they are atemporal.

How the emergent spacetime container bestows upon or transfers to its contents these temporal properties is not clear. Perhaps the container would be something like a boundary condition or constraint for its contents. However, on this combination of E2 and post-QG revised substantivalism (which I will call E2 substantivalism), the emergence of the spacetime container seems to be distinct from the emergence of the contents of the container. Even if the contents depend on the container, the container does not depend on its contents and so presumably could emerge without them.

I will end this section by commenting that I do think, given time's absence from theories of QG, that E2 substantivalism is the most plausible substantivalist view of time. In future research, more work will need to be done to defend this position, as well as to work out how the emergent spacetime container bestows temporal properties upon its macro-level material contents.

c. Relationism and the emergence of time

If one is a relationist about time and wishes to take seriously the implications of theories of QG and thus also be an emergentist about time, one will find that relationism and emergentism are complementary views. As discussed in 7a, the core aspect of relationism is that the existence of spacetime depends on the existence of the things and events within and between which it exists. On relationism, spacetime does not exist in its own right, independently of material things and events—it does not have

⁵⁵ Saying more about the type of reduction involved would go beyond the scope of this paper.

the same kind of claim to independence that it does in substantivalist views. Instead, temporal relations and material things and events are mutually-dependent or laterally-dependent.⁵⁶

A set of relations within and between material things and events is, in itself, a system or structure of sorts. Because of this, relationism seems to fit easily with E2. When relationism and E2 are combined, temporal relations and their relata (things and events) form a complex structure or system that derives from something at the quantum level. The material things and events and the spatiotemporal relations within and between them would emerge from the atemporal quantum level. The emergent structure/system (spacetime) may have novel properties as a whole, such as a universal direction or orientation. Parts of the structure also have novel properties in virtue of having temporal extension that the spacetime system/structure gives them. Events, for example, have durations. Entities persist. These properties are emergent because they are only possessed by the macro-level structure/system or parts of it; they are not possessed by the underlying quantum-level things from which the macro-level system/structure emerges.

On the view that combines E2 and relationism (E2 relationism), although the macro-level structure/system and its parts have novel properties and these properties are not possessed by quantum-level things, the structure/system is physically reducible to a quantum structure or arrangement. Note that this doesn't mean that the macro-level structure isn't real. It's just as real as the quantum structure from which it comes, but facts about the macro-level physical structure are deducible, in principle, from facts about the quantum structure. Facts about the macro-level physical structure can be explained by facts about quantum-level structures. There is nothing extra, mysterious, or independent about macro-level temporal relations. They are a structural part of an emergent system.

It's clear how relationism and E2 are compatible, but is relationism also compatible with E1? For something to be E1, it comes from but is not reducible to something else; it not only has emergent properties but is an emergent property-bearer of sorts, with its own existence that is in some sense distinct from the existence of that from which it comes; it could be either material or immaterial; and facts about it are not (fully) deducible from facts about that from which it comes. For temporal relations to be E1, they'd have to be capable of having properties and to some extent being distinct property-bearers. It's not clear that temporal relations are the right sort of things to have properties or be property-bearers. The only qualities they have that would distinguish them from each other would be the events they exist between. It would be similar to saying that the relation of 'to the left of' could have its own properties or be a distinct property-bearer. It might not be impossible to hold a view that combines E1 and relationism, but given that the emergentists in question do not defend E1 and already have a choice between E2 relationism and E2 substantivalism, and given that substantivalism would be a much better match for someone who wanted to hold that time is E1, there's little reason to further pursue E1 relationism.

E2 relationism, like E2 substantivalism, is a promising view of the nature of spacetime, given QG. The difference between E2 substantivalism and E2 relationism is in the emergent spacetime structure's dependence on or independence from other macro-level things and events. The view one endorses will also depend on whether one is willing to accept my post-QG revised substantivalism as genuinely counting as substantivalism. If one rejects this, then E2 relationism is the only view left standing (at least if one wishes to take seriously the implications of current theories of QG and be an emergentist about time).

d. Causal powers of time?

It is useful to examine a trait commonly attributed to emergent things: that they tend to have causal powers not possessed by that from which they emerge.⁵⁷ However, time appears to be different. Time is not a thing with causal powers; rather, time is some type of acausal emergent structure or foundation that enables there to be causation between things that have causal powers, by making it

⁵⁶ Again, what I mean by this is that relations don't seem to come from their relata, nor do the relata come from the relations. Rather, the relations and relata 'come into existence' (in a nontemporal sense) together.

⁵⁷ Unless one takes an epiphenomenalist emergentist stance.

possible for them to have existence—though not specifically *causing* them to come into existence. On substantivalism, time is a container *in which* causation takes place. On relationism, time is relations within and between events, *without which* causation couldn't take place. The container or the relations are not themselves causal but enable or allow there to be causation, via a succession of states of the world. That time itself does not seem to be something that could have causal powers makes time's emergence different from typical cases of emergence.

Someone could retort that time *does have* causal powers, such as causing feelings to subside or a plant to grow or a species to evolve. However, it's not really time itself that causes these things. Rather, time allows other things (such as the restorative effects of sleep, the division of cells, and genetic mutations) to occur, which are what actually cause the things in question.

Unlike other emergent properties, which are said to be properties of the emergent thing or system, many emergent temporal properties are properties of the things that exist because time structures those things (as opposed to being properties of spacetime itself). These temporal properties include things like having duration, occurring in a single direction, and occurring successively. Emergent temporal properties belong to macro-level things and events in virtue of time structuring those things and events. This is the case whether time is an independent container or whether time is relations within and between existing things.

e. Time as emergent and fundamental

In the literature on the emergence of time, it is implicit that being emergent and fundamental are mutually exclusive, such that if something is fundamental, it's not emergent, and if something is emergent, it's not fundamental. For example, Crowther says, "If spacetime does not appear fundamentally in quantum gravity, but is to be recovered at some large distance/low energy scale (compared to that at which the theory has been formulated), then general relativity is an *effective* theory, and spacetime is *emergent*."⁵⁸ In this passage from Crowther, spacetime's fundamentality is determined by whether it appears in theories of QG; spacetime's not appearing in QG means it is not fundamental and its not being fundamental means it is emergent. Another example is from Oriti, who says, "The purpose of this contribution is to outline a few key lessons about the nature of time from current physical theories as well as from promising theories under development, and the many ways in which it should be considered an emergent, non-fundamental notion."⁵⁹ Huggett and Wüthrich also say,

Many proposed theories of quantum gravity (QG) suggest that their fundamental quantities and structures do not include all the familiar ones of theories involving classical spacetimes (especially the relativistic spacetimes of general relativity [GR] and quantum field theory). If so, relativistic spacetime must to some extent be a derived, effective entity.⁶⁰

As we saw earlier with F4, one sense of fundamental is 'non-derived.' In the above quote, we have Huggett and Wüthrich saying that if something is not fundamental, it is derived, by which they mean emergent.

It should be noted that the philosophers of physics who discuss the emergence of time do not *argue* that being fundamental and being emergent are mutually exclusive; however, it seems to be assumed. They often speak of emergence as the alternative to being fundamental. This is probably because, if something is emergent, then by nature it comes from—or derives from—something else and can't be fundamental in the sense of F4.

My position is that it is an error to assume that being emergent and fundamental are mutually exclusive, but if emergence and fundamentality are presented as mutually incompatible as is done in the

⁵⁸ Crowther, *Effective Spacetime*, 1.

⁵⁹ Oriti, "The Complex Timeless Emergence of Time in Quantum Gravity," 137.

⁶⁰ Huggett and Wüthrich, "The (A)temporal Emergence of Spacetime," 1190-1191.

cases above, then what is meant by ‘fundamental’ must be clarified, for there are other ways in which time may be fundamental that are compatible with its being emergent. First, it is useful to say something about how time is different from other things commonly said to be emergent, insofar as it seems to be an emergent structure (whether independent container or temporal relations). It is also useful to discuss what it means for time to exist as a structure.

Ordinary uses of the term ‘structure’ often refer to concrete entities or objects. For example: ‘That old fort is a sound structure.’ and ‘That’s an imposing structure up on the hill.’ Time is not a structure in this sense. It is not a concrete object like a building.⁶¹ Even if substantivalism is the correct view of time and spacetime is a substance of some sort, it would not be a concrete object, because it is part of what gives concrete objects the structure they need to have physical existence.

It is also the case that ordinary uses of the term ‘structure’ refer to the physical parts of something that compose it. For example: ‘Cells are part of the structure of an organism.’ and ‘One part of the structure of a cell is its nucleus.’ Time is closer to a structure in this sense, especially if relationism about time is the correct view. Similar to how cells in an organism are organized to support functions that enable that organism to live, temporal relations within and between macro-level things enable them to exist, to cause and be caused by other things, and to change and persist.

I proposed in sections 7b and 7c that spacetime is an emergent foundational structure of the macro levels. I will now consider some objections and respond to them. Again, to be foundational is one sense of being fundamental (F3) and, as defined in section 2, for X to be foundational is for most of what exists to depend on X. For spacetime to be an emergent foundational structure is for it to be both emergent and fundamental (in the sense of F3). Someone might challenge spacetime’s being F3 by arguing that, even if everything at the macro-levels depends on spacetime, that isn’t most of what exists because it doesn’t include what exists at the quantum level.

My response to this challenge is that ultimately this is an empirical question; however, it is reasonable to assume that everything at the macro levels would be a majority of what exists. Quantum theories, which are about what exists at the quantum level, describe what reality is like at that smallest level. There are many other levels above that, so if spacetime emerges from the quantum level and structures what exists at all of the other levels, then it would be safe to say that most of what exists depends on spacetime, even if not everything that exists does. What something needs to be foundational is just for most of what exists to depend on it. So, spacetime would likely qualify as foundational, on these terms.

Someone might, however, object to my considering that which exists at the macro levels as existent at all. This would be an eliminativist who believes that only that which exists at the smallest level truly exists. An eliminativist would say that insofar as everything that we describe as existing at higher levels can be reduced to what exists at the lowest levels, what exists at the lowest levels is the ‘true’ ontology of the world (what really exists). If someone holds this view, then they will by default disagree with my claim that spacetime, as an emergent structure, is foundational to most of what exists. However, as an eliminativist, they would also have to disavow the existence of spacetime altogether, if it is emergent (and absent from the smallest level of reality, as is suggested by theories of QG). It is not one of the goals of this paper to address eliminativism, so that will be reserved for future work.

Someone might also challenge emergent spacetime’s being F3 by arguing that on E1 or E2 substantivalism, spacetime’s independence from macro-level objects, entities, and events prevents spacetime from being foundational for them. One might say that although the spacetime container gives structure to its macro-level contents, it seems ad hoc to say that spacetime is foundational for its contents when the structure it imposes is extrinsic to them. This would seem comparable to saying that the take-out

⁶¹ Substantivalists might be inclined to say that time, as a container that’s independent of its contents, *is* a concrete entity or object like a building. However, I would challenge this by saying that buildings and other concrete entities and objects of this sort take up space or have spatial extension. The substantivalist’s spacetime container doesn’t take up space like a building does. It is what lets there be space for things like buildings to occupy. The container doesn’t exist in spacetime; it is spacetime.

container with food inside of it is foundational to the food. Usually when something is foundational to something else, the former is part of the latter in some way (by composing it, constituting it, or transitioning into it, for some examples). But if time is a container whose existence is independent of the macro-level things and events it contains, then the container is not part of the things and events, nor does it transition into them. (This objection wouldn't apply to E2 relationism because on that view, temporal relations give material objects and entities structure intrinsically by giving them temporal extension—like the parts of a cell that give it structure. Furthermore, since temporal relations are mutually dependent on material things and events, the pattern in which events exist is intrinsically structured by the temporal relations between them.)

On behalf of the emergentist substantialist, I would respond that even though the spacetime container gives structure to its contents extrinsically, spacetime is unlike the take-out container because the take-out container does not enable the food it contains to exist, whereas time enables macro-level physical things to exist. There can be food outside of a take-out container, but there can't be macro-level things, entities, or events outside of spacetime. The spacetime container enables its contents to have temporal extension and thus enables macro-level physical reality to contain change, causation, action, motion, and persistence.

The other view that combines the fundamentality and emergence of time would be E1 substantialism. On E1 substantialism, spacetime would be a container whose existence is to some extent independent from and irreducible to the quantum-level structure from which it derives, making the emergent spacetime container fundamental in the sense of F2. Furthermore, facts about spacetime would not be (fully) deducible from facts about the quantum structure from which it comes. I've already addressed some of the challenges to E1 substantialism so I will not repeat those here. I largely embrace those challenges and believe that E2 substantialism is the better view.

Finally, someone might raise a 'meta' objection to my argument for the fundamentality and emergence of time by saying that there aren't philosophers arguing for the incompatibility or mutual exclusivity of emergence and fundamentality, so I'm responding to a non-existent problem. In response to this potential objection, let me remind the reader that *it's true* that there aren't arguments against time's being both fundamental and emergent. In every place the topic is discussed in the relevant literature, it is just *assumed* that if a structure is emergent (i.e., derived), then it's not fundamental. My task here has not been to challenge a pre-existing view that's been defended, but rather to challenge a widespread, unclarified, undefended assumption that if time is derived/emergent, it cannot be fundamental. I have done this by exploring different senses in which the terms 'fundamental' and 'emergent' are used in the relevant literature and by explaining how an emergent spacetime container or emergent temporal relations are also fundamental by being foundational (F3). (And if the container is E1, how it may also be F2.)

8. Conclusion

The primary goal of this paper has been to investigate implications of theories of quantum gravity for the nature of time. Specifically, I have examined how the absence of time from the quantum level suggests that time is emergent, and I have examined two senses in which time might be emergent. I have also argued that, contrary to a widespread assumption in the literature, time's being emergent does not preclude it from being fundamental. I have examined four senses of fundamental and argued that if time is emergent, it is also fundamental by being foundational. Specifically, time is an emergent structure that is foundational to the macro levels. This is the case whether spacetime is a container whose existence is independent of material things and events (substantialism) or whether spacetime is relations whose existence is mutually dependent on the material things and events that are its relata (relationism).⁶²

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