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SPACE, TIME AND NATURAL LAW: A PEIRCEAN LOOK AT SMOLIN'S TEMPORAL NATURALISM

EL ESPACIO, EL TIEMPO Y LA LEY NATURAL: UN *LOOK* PEIRCEANO AL NATURALISMO TEMPORAL DE SMOLIN

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Resumen: En su libro *Time Reborn* y en otros escritos, el físico Lee Smolin identifica a Peirce como precursor de su idea de que las leyes naturales evolucionaron; una visión que va en contra de la opinión común dentro de la física de que el tiempo no es real. Después de discutir los argumentos de Smolin sobre la realidad del tiempo, se discuten también dos planteamientos defendidos por Smolin –la selección natural cosmológica y la *Quantum Energetic Causal Set Theory*– en el contexto de la cosmología de Peirce. Se muestra que el enfoque de Peirce proporciona una posible base para una teoría física como la *Quantum Energetic Causal Set Theory*, abriendo el camino para una cosmología completa que haga justicia a la física contemporánea.

Palabras clave: Smolin, cosmología, espacio, tiempo.

Abstract: In *Time Reborn* and elsewhere physicist Lee Smolin identifies Peirce as a precursor to his view that natural laws evolved, a view that runs counter the received opinion within physics that time isn't real. After discussing Smolin's arguments for the reality of time, two approaches advo-

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cated by Smolin –cosmological natural selection and Quantum Energetic Causal Set Theory– are discussed in the context of Peirce's cosmology. It is shown that Peirce's approach provides a possible ground for a physical theory like Quantum Energetic Causal Set Theory, opening the way for a full-fledged cosmology that does justice to contemporary physics.

Keywords: Smolin, cosmology, space, time.

§1. Introduction

Opinions on Peirce's cosmology are widely divergent[1]. W.B. Gallie famously termed it the white elephant of his philosophy (a description Murray Murphey later called charitable[2]), and to Christine Ladd Franklin it showed that her former logic teacher had gone off the deep end.[3] The contrary view is found as well. Situating Peirce's cosmology papers in "the radical fringe," Paul Forman observes that it would take physicists another quarter century to catch up and seriously consider the idea that all regularity in nature is statistical.[4] Vincent Potter goes even further, stating that Peirce's claim that there is real chance in the universe, "led him in fact to anticipate quantum theory."[5] My sympathy lays with the latter group, and in this paper I will examine the work of a contemporary physicist, Lee Smolin, whose cosmological views exhibit a close kinship to Peirce's, and see whether Peirce's work in cosmology has still something to offer to cosmologists today.

Like Peirce, Smolin is both physicist and philosopher, albeit that whereas Peirce was primarily a philosopher, Smolin is first and foremost a physicist. There is also much affinity between the two. Smolin's *The Trouble with Physics* (2006) is remarkably Peircean in spirit, even though there is no indication in the book that at the time Smolin had even heard of Peirce.[6] A few years later, however, in *Time*

[1] An earlier version of this paper was presented at the *Charles S. Peirce 2014 Centennial Congress.* Lowell, Mass., July 16-19, 2014. The author wants to thank Lee Smolin for his valuable criticism at that event.

[2] *Cfr*. Gallie (1952: 215), and Murphey (1965).

[3] *Cfr*. Ladd-Franklin (1916: 720f.).

[4] *Cfr*. Forman (2011: 152-53).

[5] *Cfr*. Potter (1996: 139).

[6] *Cfr*. Smolin (2006).

Reborn (2013), Smolin explicitly identifies Peirce as the first to argue that natural laws are not eternal, as is typically assumed, but evolve over time, a position Smolin also argues for[7] In what follows I take a closer look at Smolin's approach, especially his work in Quantum Energetic Causal Set Theory, by comparing and contrasting it with Peirce's and see whether there are elements in Peirce that could be helpful in developing this approach further.

§2. The Nature of Cosmology

For the purpose of this paper, I take cosmology to mean the study of the origin, evolution, and eventual fate of the *entire* universe.[8] As such, cosmology is to be distinguished from theories that study particular phenomena *within* the universe, and the question naturally arises whether theories developed for the latter purpose can be applied equally to the universe as a whole. Smolin denies that they can, and he accuses those who do of committing what he calls a cosmological fallacy. Take Newtonian mechanics, which originated as the study of the motions of physical objects. Newtonian mechanics works by singling out a few salient aspects, while ignoring everything else. For instance, when studying the movement of cannon balls, the theory focuses on things like the angle of the barrel, weight of the projectile, and amount of gunpowder used, and then explores what happens when you vary these elements while assuming that nothing else in the universe affects it or is affected by it, including the clocks and the rulers we use in our measurements. In Smolin's words: "we isolate and study a few degrees of freedom [while] ignoring the rest of the universe" (Smolin, 2014: 108). The latter he calls the background. Though in all strictness the assumption that we can ignore all else is wrong, he continues, in practice it works amazingly well: It leads to approximate but effective theories that give us general laws that can be applied to a great variety of specific conditions. In fact, Newtonian mechanics

[7] *Cfr*. Smolin (2014: xxv) [Spin Networks, 2013]), p. xxv. The same observations return in Mangabeira Unger & Smolin, (2014: 367) and Mangabeira Unger & Smolin (2014: 417).

[8] Smolin and Cortês also call it fundamental cosmology to distinguish it from the study of large subsystems of the universe, which also goes by the name of cosmology. *Cfr*. Cortês & Smolin (2015: note 1).

was deemed so successful that it caused Laplace to conjecture that a sufficiently powerful intelligence knowledgeable of the current state of the universe could derive its entire past and future (Laplace, 1951: 4). Now even if this were true and such a Laplacean demon could retrace the past back to its point of origin, what we eventually would arrive at is a set of initial conditions and a set of laws. What such a demon would *not* be able to answer, Smolin correctly observes, are the following two questions: "Why did the universe start from these initial conditions, rather than different ones?" and "Why is it governed by these laws, rather than different ones?"[9] In Smolin's view these are two questions that any cosmology must be able to answer, especially since on both counts the possibilities are endless. It is here too that Peirce comes in. In the first of his *Monist* papers Peirce writes, "To suppose universal laws of nature capable of being apprehended by the mind and yet having no reason for their special forms, but standing inexplicable and irrational, is hardly a justifiable position."[10] Uniformities like the laws of physics, Peirce continues, "are precisely the sort of facts that need to be accounted for" (*W* 8.101). Without a cosmology, physics as a science is horribly incomplete, no matter how successful it is within its limited domain.

A historically popular answer –and one that long satisfied us– is that the laws of physics originated with God, the rational creator of the universe. Today this answer does not come as naturally as it once did, and both Peirce and Smolin reject it, opting instead for a naturalistic and evolutionary answer[11] (*W* 8.01) This brings in the notion of time.

§3. The Reality of Time

If laws do evolve, time must be real, because to evolve means to change over time. In line with this, Smolin spends considerable effort arguing for the reality

[9] In Newtonian physics laws are *justified*, either by being abstracted from experience or by being successfully applied, but they are not *explained*–no reason is given, or sought, why they are so and not otherwise.

[10] *Cfr*. Peirce Edition Project (1981-, vol. 8: 101) (the Wr*itings* are further referred to as *W* [vol#].[pg#]).

[11] A more extensive account for why Peirce holds that the explanation of laws has to be an evolutionary one is found in e.g. Cornelis de Waal, 2013.

of time. This raises a few questions: "Why do physicists deny that time is real?" "What does it mean for time to be real?" and, "What is time?" Let's start with the last question. To the scientifically inclined mind, time, like space, is an organizing principle of experience, and one that is reasonably captured by defining it as "irreversible sequence."[12] This definition captures in relatively simple terms the common sense notion that what has happened, happened –that one cannot go back or, so to speak, turn back the clock. Consequently, we can say that processes take place in time, or are "timed," when they cannot be reversed. Now it seems that many processes can be reversed. For instance, I can put a coffee cup on my desk and pick it up again. Physicists who deny that time is real will argue that all natural processes are in essence like this: they can be reversed, even if only in principle, and if this happens it is like playing a movie backwards.

In response to physicists who argue that everything that happens in nature is reversible, one can say that even something as simple as setting a coffee cup on a desk is not truly a reversible process. What enables us to say that it is that we are artificially isolating some aspects while assuming that the rest of the universe says put. Though typically this assumption is justified when we confine ourselves to such isolated domains –if only because at a practical level it gives us answers that we can work with– this does not warrant us to blindly apply it to the universe as a whole. In other words, whether time is reversible or not must be established at the cosmological level, not derived from some artificially delineated subdomain of it. To do otherwise is to commit what Smolin calls the cosmological fallacy.

There is another reason why physicists deny that time is real. Especially following Newton, physics has come to rely extensively on mathematics, and as Smolin also shows (and he is hardly the first to do so), the mathematics used is ill equipped to deal with time. Let's return to the example we looked at earlier. When we have readied our cannon, we can calculate how the projectile will travel and where it will land. In fact, we can draw a curve on a sheet of paper, the familiar parabola, where distance is a given as a function of time. However, in doing so something strange happens –something Smolin calls "the expulsion of time." The curve *presents the entire trajectory at once*, thus transforming what appears like a motion through time into a timeless object –a line on a sheet of

[12] For Peirce's notion of time, *cfr*. e.g. (*W* 8.130-134). Whereas for Causal Set Theory time is discrete at the Planck scale, Peirce insists that it is infinitely divisible (*W* 8.130).

paper. Its truth or falsity is timeless too. And, last but not least, the geometry of the curve beckons reversibility. To put it concisely, time is spatialized. Time thus becomes an added spatial dimension: rather than having three directions of freedom –right/left, back/forth, up/down– we now have four directions of freedom, and this fourth direction–past/future–is presumed to behave in exactly the same way as the first three. At this point physicists are tempted into another fallacy, that of confusing our mathematical representation of nature with nature itself and declaring the former "reality as it truly is." We could call this the representational fallacy –the confusion of ones object of study with a particular representation of it.[13] However, that geometry cannot represent time without spatializing it may say more about geometry as a medium of representation than about the object it seeks to represent.[14] This becomes especially clear when we compare the geometer with, say, the novelist. The novelist encounters the exact opposite problem. She cannot describe space, albeit a landscape or a bedroom, without temporalizing it –one sentence after another. We can also point at the painter whose medium forces him to depict depth by flattening it. In all these cases it is the medium that is being used that is a cause of distortion. In sum, the expulsion of time in physics is the combined effect of two fallacies that tend to reinforce one another: the cosmological fallacy and the representational fallacy.

This brings us to the third question: what meaning can be given to the claim that time is real? The distinction that is being drawn here is between what is real and what is an illusion and only has the appearance of being real. The prevalent view in physics today is that space is real and time is not. Smolin, reverses this, arguing that time is real and space is not (Smolin, 2014: 172)[15]. Smolin, following familiar usage in physics, argues that something is *not* real when it is a so-called emergent property. An example of an emergent property is temperature as it is conceived in thermodynamics, where it is a rough but useful way for describing

[13] This fallacy is nothing new. René Bergson and Alfred N. Whitehead already identified this it. *Cfr*. Bergson (1999: 34). Bergson called it the mistake of confusing partial notations for real parts. For Whitehead, *cfr*. Whitehead (1925: 51). Whitehead termed it the fallacy of misplaced concreteness– treating an ideal or abstract object, which is essentially a product of thought, as if it concretely exists.

[14] The spatialization of time is closely related to the measurement of time: We "measure" time by pairing a physical event with devices that capture some regular (often periodic) movement in space, whether it be a sundial, pendulum clock, clepsydra, or atomic clock.

[15] A more technical account is found in Cortês & Smolin (2015).

the state of a large number of particles, even though the description does not apply to any of the particles themselves. Now if particle physics were to provide us with a fundamental description of the universe in terms of particles in motion, temperature does not enter into such a description, and ipso facto is not real.[16] Reality is here conceived as the ontological commitment minimally required by our most basic theory of the universe. Smolin argues that an argument like that for temperature can be given for space, but not for time. Time, for Smolin, is not an emergent property, but a necessary part of any theory about the universe. Whereas one can, in principle, give an adequate account of the universe without making any reference to the concept of temperature, or to the concept of space, one cannot, so the argument goes, give an adequate account of the universe without introducing the notion of time –that is, without introducing irreversible sequence.

§4. Temporal Naturalism and Evolutionary Laws

When we draw together the various aspects discussed so far, what we get is a call for a temporal naturalism. Cosmological theories need to acknowledge the reality of time and they should be naturalistic. We are to study the world we encounter on its own terms, meaning that it is to provide us both with the phenomena to study and with the means for evaluating them.[17] And since it is cosmological theories we are discussing, such a temporal naturalism should be able to provide us with answers to the two questions Smolin asked: "Why did the universe start from these initial conditions, rather than different ones?" and "Why is it governed by these laws, rather than different ones?"

Smolin's naturalist requirement not only precludes the assumption of a supernatural being; it also precludes us from boldly positing an *n*-dimensional *multi*verse in which our four-dimensional universe is presumed to be but one of countless non-interacting multidimensional objects.[18] Both approaches have

[16] Note that this is a far more restrictive conception of what is real than Peirce's. On Peirce's conception of reality, *cfr* e.g. de Waal (1996).

[17] For Smolin's definition of naturalism, *cfr*. Smolin (2013).

[18] More broadly, it precludes the Platonism popular among physicists as a way of explaining the success and timelessness of mathematics. *Cfr*. e.g. Smolin (2015).

been used, and are still being used, to answer Smolin's two questions. The former seeks to answer them in terms of a Divine Creator; the latter by means of probability theory.

In the 1870s Peirce argued against the application of probability theory to the universe as a whole, remarking not without sarcasm: "Universes are not as plentiful as blackberries" (Peirce, 2014:141; *W* 3.266. The multiverse theory found a way around this. By making universes even more plentiful than blackberries, it allows for a statistical argument to account for the initial conditions and natural laws of *our* universe. As Smolin correctly observes, however, such an explanation of our universe is non-falsifiable and falls beyond the scope of science. To put it in Peirce's terms, it fails the pragmatic maxim. For Peirce, the epistemic content of any conception (including hypotheses) is strictly limited to "[the] effects, that might conceivably have practical bearings, we conceive the object of our conception to have" (Peirce, 2014: 90; *W* 3.300). For the multiverse hypothesis there are no such effects (in fact, they are excluded a priori), making the hypothesis not just unfalsifiable, but literally meaningless. It is also a form of cheating, one very much like the invocation of God, as our universe is here again subsumed under some grander scheme, the entirely entire universe, one that has its own laws and initial conditions that still need to be explained.[19]

As far as Smolin's account of evolutionary laws goes, he seems to move in two, possibly complementary directions: cosmological natural selection and quantum energetic causal set theory. "The basic hypothesis of cosmological natural selection," Smolin explains, "is that universes reproduce by the creation of new universes inside black holes" (Smolin, 2014: 124)[20] This makes the formation of universes a natural process that, at least conceivably, can be empirically verified, or falsified, by studying our universe, something that is not possible with the multiverse theory described earlier.[21] I see, though, a different problem with this theory, as it puts *multiple* universes within the same causal chain. If our universe

[19] Though it may be perhaps true that a divine being created the universe, claiming that it is so utterly fails as an explanation, and it does so for very much the same reasons as why the multiverse theory fails. The latter is not to deny that a Peircean view precludes the possibility of multiple universes.

[20] *Cfr*. also Smolin (1992).

[21] In contrast to the multiverse hypothesis, the black hole theory passes the pragmatic maxim, as it has conceivable practical effects that could be brought to light by future research.

sprouts forth from another universe, our universe is again no longer the *entire* universe, but is merely a sub-region within a larger whole. Should this hypothesis be true, the universe is once again proven to be a lot larger than we thought it to be. This larger whole comes with *its own* laws, such as a cosmic law of natural selection, as well as something to which those laws are being applied. So here too there seems to be an element of cheating. We are no longer giving a theory of the *entire* universe, but we only seek to explain that subsection that we happen to live in.[22] In short, it seems that cosmological natural selection too cannot account of the cosmos as a whole but is in the end a local theory, not unlike Newtonian mechanics, and to imagine otherwise is to once again fall victim to the cosmological fallacy.

I think that the prospects are far better for Smolin's second approach: quantum energetic causal set theory; a view he developed with Marina Cortês[23]. It is to this that we turn next.

§5. Quantum Energetic Causal Set Theory

The quantum energetic causal set theory (QECST) developed by Smolin and Cortês is part of a group of theories that fall under the umbrella of Causal Set Theory (CST). Partially motivated by the goal of unifying quantum theory and general relativity theory, CST seeks to describe the structure of space-time at the smallest, or quantum, scale. It proposes that the universe at its most basic level can be defined as a causal set –a finite set of identifiable "events" that stand in a partial order relation– and then aims to show how a smooth homologous 4-dimensional space-time manifold can be explained in terms of it. Very briefly, space-time emerges as a uniform sprinkling with Planck density of discrete elements. This allows us to say that at the macro level we could maintain that

[22] This is not to imply that the theory is false, only that if it were true it would only show that that the universe as we know it is not the entire universe, just as in the past we discovered that our galaxy is not the entire universe. Hence, cosmological natural selection, though it would provide an explanation for the origin of our universe would not provide an explanation for the origin of *the* universe (it is cosmology, but not *fundamental* cosmology; see note 8 above.

[23] See esp. Cortês & Smolin (2015: 4), and Cortês & Smolin (2015).

space-time is continuous, even though at the micro level (at a scale of about 10^{-20} times the size of a proton) it is discrete. To present an analogy: space-time relates to causal sets in very much the same way as the temperature of a gas relates to the kinetic energy of its particles. Space, time, and temperature are all emergent properties.

There are various arguments within physics for favoring CST's discrete approach to the prevailing continuity-grounded approach with its heavy reliance on differentiable space-time[24]. For the purpose of this paper, I will take such arguments for granted and take an optimistic attitude toward CST's future as a theory in physics. Instead, I will sketch the main elements of both CST and QECST with the aim of drawing a connection with Peirce's evolutionary cosmology to explore the possibility of a Peircean contribution in this area that goes beyond a quick reference to a few sentences of his "The Architecture of Theories," as is done by Smolin.

The core of CST consists of a causal set (or causet): a (finite) set of elements combined with a partial order relation (or porelation). To minimize conceptual contamination, a minimal interpretation is given to these elements and to this partial order relation.[25] CST is not entirely successful at this, as it refers to the elements as events and to the partial order relation as causal. Moreover, already by applying set theory and combinatorics, these events are presumed to be discrete, hence identifiable, or labelable, meaning that they can be paired with, say, (a subset of) the natural numbers. As far as CST goes, this seems permissible, as CST explicitly seeks to inquire whether a discrete basis can be given to space-time, but, as we will see, it is unlikely to be a permissible presupposition when our aim is, as it was Peirce's, to provide a cosmology that seeks to give an account of how the universe could have emerged.

A partially ordered set, P, is a set with an order relation $\prec$ that is:

(1) reflexive: $\forall p \,\varepsilon\, P, p \prec p$

(2) anti-symmetric: $\forall p, q \,\varepsilon\, P$, if $p \prec q$, then $q \prec p$ iff $p = q$;

(3) transitive: $\forall p, q, r \,\varepsilon\, P$, if $p \prec q \prec r$, then $p \prec r$.

[24] A helpful overview is found in Bombelli (1983: c. 1).

[25] Bombelli (1983: 26) speaks of "a *new* substance, which does not have any precise correspondence with any large-scale concept". However, what may be really called for is a rethinking of the notion of *substance,* rather than calling the substance "new."

CST adds to this a fourth condition, namely that the number of events lying between any two fixed events is always finite; put differently, any two related are connected through a chain with a finite number of links. These links can be defined in terms of nearest neighbor: *p* and *q* are nearest neighbors iff $p \prec q$ and there is no r (distinct from *p* and *q*) such that $p \prec q \prec r$. The model thus developed can be used to construe so called Hasse diagrams where events are represented by points, and relations between them by lines. The chains that are formed in this manner must not be interpreted as "in" space, or as "in" time, but space and time must be interpreted as emergent properties over the causal set as here defined. For instance, considering time, we can say that in $p \prec q \prec r$, *p* belongs to the past of *r*, and *q* belongs to its future, without this commiting us to hold that somehow the chain as a whole takes place in time. By making the past inacccessible, the anti-symmetry requirement of the porelation occasions the directionality of time. As the above account suggests, the mathematics of choice for CST is combinatorics, including graph theory, rather than (differential) geometry.

QECST differs from CST in that certain intrinsic qualities are assigned to the events, namely energy and momentum, which are propagated along causal links and are conserved at each event (i.e., conservation laws apply to them). In "The Universe as a Process of Unique Events," Cortês and Smolin (2015:3f.) present their model in terms of four principles:

- "Time is a fundamental quality [through] which new events are created out of present events. Causality results directly from the irreversible agency of time."
- "The future develops out of the present constantly; there are no causal loops and no regions or phenomena where time 'evolves backwards.'"
- "The space-time properties of an object or event arise from its relationship with other objects or events." Assuming Leibniz's principle of indisernables, this implies that "each [object or] event in cosmological evolution [is] unique and distinguishable from all others" by its causal past.
- "Energy is fundamental. Energy and momentum are not emergent from space-time [but] space-time is emergent from a more fundamental causal and dynamical regime in which energy and momentum are primitives."

Though QECST declares time to be more fundamental than causality, whereas CST takes causality to be more fundamental than time, this seems mostly a squabble over very vague and tentatively conceived concepts that were frankly admitted to lack any precise correspondence with how they are defined and used in macroscopic physics (Bombelli, 1983: 26). The main difference between QECST and CST is the fourth principle where QECST introduces energy and momentum as primitives (i.e., non-emergent properties).

Because each event is unique (principle C), there can be no exact repetition –all repetition is approximate and the result of seeing only part of the story– and this affects how we can conceptualize the laws of physics. For QECST the causal structure and the momenta provide a complete description of the world, and the dynamics of the system is a product of the agency of time operating under three sets of constraints (the conservation laws being one of them). Space is an emergent property that functions "as an arena for a statistical description of the fundamental processes" (Cortês & Smolin, 2015: 5). The concept of space makes it possible "to conceive of a law or a rule for generating unique events when that rule had to be simple, [while] what distinguishes the events in a big universe are the intricacies of their histories" (Cortês & Smolin, 2015: 8) This explains Smolin's view that space isn't real but merely conceptual shorthand that enables us to apply simple, general laws to a vast complex of unique events. These discrete events must not be confused with elementary particles. Only when the system is "dominated by persistent repeated patterns" do we encounter what Smolin and Cortês call quasi-particles, and it is only with quasi-particles that we can have reversible processes –i.e., time symmetric dynamics. Moreover, the emergence of regularity is associated with "the loss of novelty in the system [which] at some stage stops being sufficient to destabilize regularity" (Cortês & Smolin, 2015: 19). In general, what computer simulations based on this model have shown is that "irreversible dynamics seems to have the tendency to evolve towards predictable, reversible evolution" (Cortês & Smolin, 2015: 19).

Though QECST may fare better than CST in deriving a space-time congruent with current physical theories about macroscopic physical processes –which, incidentally, includes the behavior of things as small as protons– it comes at a significant cost from a fundamental cosmology perspective as it involves a significant increase in terms of ontological commitments.

Now, neither CST nor QECST provides a full-fledged cosmological theory. Its purpose is rather to show that space-time is an emergent quality and that there is a more fundamental level at which physical processes can be described without having to invoke space. For QECST, apart from what must be called a rather mysterious "agency of time," there is a preset ontology of events (with each event intrinsically endowed with energy/momentum), and there are three very specific constraints set on the formation of new events. For a cosmological theory that leaves quite a bit unexplained. One could try to make QECST into a cosmological theory by combining it with Smolin's theory of cosmological natural selection. In that case one could just say that when our universe burst fourth from a black hole, it propelled itself through this "agency of time" as a shower of discrete events that became more and more regular over time. But as I indicated before, this would not count as a proper cosmology. Just as a Newtonian cosmology is an uncritical extension of Newtonian mechanics to the entire universe, so the theory of cosmological natural selection appears an uncritical extension of the (biological) law of natural selection, this time not merely to the entire universe, but even squarely beyond it.

Earlier we asked whether Peirce's evolutionary cosmology has anything of value to offer to contemporary physics, something that extends beyond the obligatory historical footnote. This question can now be recast as follows: Has Peirce anything of value to offer to CST or QECST? I think he does, so let's have a brief look at his evolutionary cosmology.

§6. Peirce's Evolutionary Cosmology

For Peirce, the universe did not develop within a multiverse, from a black hole, or out of a pre-existing causal set, but it developed literally out of nothing. To make sense of this, we need to take a brief look at Peirce's theory of the categories. According to Peirce, all we can possibly think of, whether it is a toothache, a mathematical theorem, or the universe, exhibits three indecomposable characteristics, which he calls firstness, secondness, and thirdness. Though he gives various formulations for them, in essence they come down to the following: Firstness is "that which is such as it is, positively and without reference to anything else”[26]; secondness “that which is such as it is, with respect to a second but regardless of any third” (*CP* 8.328); and thirdness “that which is such as it is, in bringing a second and third into relation to each other” (*CP* 8.328) Peirce uses a mathematical argument to show that these three categories are irreducible, to establish their hierarchy, and to show that they are exhaustive (there is no fourthness etc.). Finally, he gives convincing *empirical* evidence that these three categories are present in all that we can experience or think of.[27]

To say that the universe emerged out of nothing means that it originated out of a state entirely free of constraints –a state of pure possibility. What happens in a state like this? With nothing to stop it, something is likely going to happen, and this something is what it is, positively and without reference to anything else, if only because there is nothing else that it can be in reference to. In brief, nothing is bound to give rise to something. Taking this route requires us to be more explicit about what we mean by the term “nothing.” One could conceive of “nothing” as what is left behind after everything is removed. This doesn’t seem to be a particularly good way of going about it, though, as this gives us rather an empty something.[28] It is the kind of argument that has led us to the notion of empty space, of which Newton’s notion of absolute space in the Scholium to the *Principia* is perhaps the clearest example. The “removal method” also results in a conception of nothing that is entirely passive.

Furthermore, from a cosmological standpoint, such a post-universe conception of nothing is acceptable only if we assume that the creation and subsequent annihilation of the universe leaves not a single trace behind (i.e., space is invariant with respect to the creation and annihilation of a universe), which is a very strong assumption with which to begin ones cosmology.

Alternatively, one could conceive “nothing” in terms of oppositions that cancel each other out. For example, when your assets equal your debts, you find

[26] Hartshorne, Weiss, & Burks (1931-1958, vol. 8: paragraph 328). Subsequently referred as *CP* [vol.#].[paragraph#].

[27] For a more developed account, see de Waal (1996: sect. 3.2).

[28] This way of conceiving nothing takes its cues from operations such as emptying a dishwasher or cleaning out a closet. However, when the closet is emptied what is left isn’t nothing, but an empty closet–and removing the closet is a very different kind of operation compared to merely emptying it. Similarly, the “removal of empty space” is a very different kind of operation than removing things from space.

yourself in a situation where you have nothing. Though this way one might avoid a commitment to the notion of empty space, it is hard to deny that what we effectively end up with is a conception that is the product of a juxtaposition of opposites–namely, that juxtaposition where they cancel each other out–which is still something. To truly have nothing, is to have neither assets nor debts (nor anything else for that matter). Hence, as with the former situation, we have not properly succeeded in conceptualizing "nothing."

A far leaner approach is to simply maintain that if there is truly nothing –meaning there are no constraints whatsoever– there is nothing to prevent anything from happening, so that eventually something will happen, which, as there are no constraints, will be a purely random event. In other words, all we are doing is to remove the restriction that came with the concept of nothing as it was conceptualized through the removal of everything, which is that it has to be purely passive –something like an inert, empty space at t_0– unable to generate anything. Such active, or energetic, interpretation of nothing dovetails nicely with the remarks by Peirce that drew Smolin's attention, namely that a purely random event is not the kind of thing that needs further explanation to justify belief in its possibility, as any explanation to that effect will give us a narrative that de facto negates the event's randomness. It also dovetails with the idea of Smolin and Cortês, discussed earlier, that the events CST speaks of are intrinsically endowed with energy and momentum.

To the above account it could be objected that in all strictness it cannot be put that way because such a "first" would already stand in some kind of relation (namely, that of emergence) to the nothing that it emerged from, and to which it would be second. Put briefly, already in the emergence of a first, all three categories are present, so that it would not truly be a first as defined by Peirce. This agrees with Peirce's notion, already referred to, that one cannot think of anything at all without *all three categories* being invoked. What this objection reveals, is that in contemplating the origin of the universe we are truly roaming at the border of what is conceivable, a problem that we also encountered in the attempts by CST to conceptualize its main ingredients: events, and the relations that are taken to hold between them. Two options quickly present themselves. We could conceive of this nothing as pre-first –as whatever can give rise to a first. Or we could identify this nothing itself as first, to which whatever that is to emerge from it would be a second that stands to it in a relation of random emergence (which brings in a third). Since nothing can be conceptualized as what it is, positively and without reference to anything else (Peirce's definition of a first, see above) the second option seems the cleanest. This means that, from a cosmologist's perspective we have to say: first there was nothing. This first sets some limits, because whatever is to come next can no longer be first, but has to be second to it, and in virtue of that some relation between the two is introduced as well –that is, a third. Any such relation is at once a limitation. Building on this, Peirce argues that the original state of pure possibility is continuously reined in, allowing some things to emerge, while precluding others.

At this point we are at great risk of ascribing all sorts of thing-like properties to what is said to emerge out of nothing. It is, for instance, tempting to say that at this point things "come into existence." To say so, however, would not only be premature but also wrong as existence entails standing out and interacting with other things like it in a persistent manner, and that requires a relatively high level of regularity that is clearly absent at this level. In fact, because of this regularity requirement, in its early stage not even the universe itself can be said to exist. For the same reason, there are no laws in the early universe. It is only in virtue of a high-level restriction of possibility that laws can emerge by enabling certain paths while precluding others. The laws of physics thus develop not unlike the manner in which a stream wears its own bed (*CP* 5.492); they have the character of deeply engrained habits, leaving the possibility, as with any other habit, that they could be broken assuming the circumstances allow it. As Peirce puts it in "The Architecture of Theories" (the text cited by Smolin): "The one intelligible theory of the universe is that of objective idealism, that matter is effete mind, inveterate habits becoming physical laws." (*W* 8:106). Hence, our task becomes "to search out a natural history of laws of nature."[29] (*W* 8:101).

On Peirce's approach, irreversible processes are thus far more basic than reversible ones, as the latter require a much more regimented environment for a *reversal* to be even possible. We can see that in Peirce's approach, too, time lies at the very origin of the universe –already the appearance of a first cannot be undone– while space can only originate at a much later stage, as our notion of space encapsulates a high degree of regularity. The latter is true also for matter.

[29] CST makes a comparable move when it shifts its mathematics from geometry to combinatorics. *Cfr*. e.g. Sorkin, (2010).

Hence, we see the same line of progression in Peirce as the one we encountered in the QECST of Smolin and Cortês. Moreover in both approaches, the emergence of regularity is associated with a loss of novelty, or spontaneity, in the system. To both this loss of novelty is not complete (there remains room for what Peirce called "absolute chance"),[30] rather "at some stage [it] stops being sufficient to destabilize regularity" (Cortês & Smolin, 2015: 19). There are also important differences between Peirce and CST. Most significantly, whereas CST seeks to show that the universe is ultimately discrete, one finds in Peirce a strong and pervasive commitment to continuity.

§7. Conclusion

Though the main project of CST and QECST is to show how space-time can be generated from a more basic set of partially related discrete events, Smolin also uses it to formulate a cosmology, including an explanation of the origin and nature of natural laws. We saw further that both faced significant challenges interpreting these events and the relations they take to hold between them. It is in essence the (a priori) structure of the underlying mathematical model, combined with loosely used vague analogies with concepts from macroscopic physics, which provides such an interpretation. As a cosmology, especially if we assume that QECST fares better than CST in reaching its goals, the theory seems to be further hampered by the fact that it has to assume too much to truly answer Smolin's two questions: "Why did the universe start from these initial conditions, rather than different ones?" and "Why is it governed by these laws, rather than different ones?" We saw moreover that, at least in its general outline, Peirce's cosmology is close to CST. In fact, I think that the above account sufficiently shows that Peirce's approach to cosmology, with the conceptual framework he developed, could be helpful in developing the CST approach further, especially if we conceive of it as a cosmological theory. The challenge would be to show how something akin to CST can be conceived as a natural product of the pri-

[30] The idea that there is absolute chance in the world is Peirce's doctrine of Tychism (*W* 8.135). The doctrine is argued for in the second *Monist* article, "The Doctrine of Necessity Examined" (*W* 8.111-25).

mordial state that is still all-too-vaguely described by Peirce –a *natural* product, that is, not a *necessary* product. We would be looking for an argument that is not deductive, and since there is only one universe, not inductive or probabilistic either. So we would be looking for an *abductive* argument, one not unlike how Sherlock Holmes solved his puzzles, albeit with the important difference that here we must *also* figure out what the puzzle is and what the pieces look like.

Such an argument, which would reside within Peirce's scientific metaphysics, would have to take seriously his doctrine of the categories, with all its triadic implications (including those for logic), and utilize whatever can be learned from both mathematics and physics. The categories, together with a categories-based semiotics, could be used to give a conceptually richer account of both the "events" that CST speaks of and the relations it conceives between them. Moreover, it carries with it the potential of doing so in a manner that prevents all sorts of conceptual pollution, including preloading our cosmology with various ontological commitments. To give one example, Peirce's mathematical derivation of the categories,[31] and his graphical logic of relatives (de Waal, 1996: 41f.), dovetail nicely with the Hasse diagrams used by CST, allowing for a leaner interpretation of the nodes and relations encountered in those diagrams and how they can be taken as representative of events and relations between them.

This may all sound pretty aprioristic, and in a way it is. Doing so, however, and taking a minimalist attitude toward our conceptions and presuppositions, has the best chance for avoiding that unawares we are smuggling in things we take for granted because of our familiarity with how the universe is now, or that carry over from long defunct metaphysical or religious views. Moreover, it is quite clear that a solidly empirical account can only lead to a very provincial cosmology. The result of a Peirce-inspired abductive cosmology would be a plausible, naturalistic account of the universe, one where time is fundamental and space an emergent property.

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[31] *Cfr*. e.g. de Waal (1996: 41f.)

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