Weakly Timeless Emergence & the Siegel-Craver Model for Mechanistic Phenomenological Laws

Jasmine Elmrabti (Department of Physics and Astronomy, The University of North Carolina at Chapel Hill)

Abstract

A fundamentally timeless world implied by quantum gravity threatens a recent model offered for mechanistically justified phenomenological laws described by Gabriel Siegel and C. Craver. The criteria for these laws appear to collapse when met with thermal time, a physical theory compatible with weak timelessness. I argue that this collapse hinges on the theory of emergence used to define mechanistic explanation under thermal time. Two cases of emergence are examined—one reductionist, one pluralist—revealing that both erase the distinction between etiological and relevant constitutive explanation. However, only the reductionist perspective diminishes the explanatory power of phenomenological laws as determined by Siegel and Craver. The other preserves this power. I examine the intersection between interventionist mechanism, timelessness, and emergence within the authors' framework to support these conclusions by performing a thought experiment using propositional logic and set theory. This analysis discusses the implications of timelessness, principally its threat to mechanistically justified phenomenological laws and how its emergence shapes the sufficiency of mechanistic explanations.

Introduction

We tend to blur lines between explanation with observation, a conflation rather poetic:

> "[W]hatever is observed is changed by the observation. / How then will our true natures, let alone the light-clogged patterns of other galaxies, ever be known, / if God—as Sister Caritas proclaimed on the first day of school–is in fact watching us?"
>
> —– *Christopher Buckley, The Uncertainty Principle*

In the early aughts, new mechanists grappled with observation-as-explanation, underscoring the impermanence of what constitutes empirical observation since Descartes. A movement against nomic explanatory theories and neo-positivism, it questioned the domains of science mechanism could serve beyond the ones buttressed at the century's turn (e.g., the life sciences) and whether former incompatibilities could be overcome with new epistemological and ontological prescriptions. Heeding this tradition, recent work by Gabriel Siegel and C.F. Craver asks what makes an explanation *enough*. Their formulation defines a mechanistically justified phenomenological law as one explanatorily distinct from a phenomenal model. The former is "enough," the other is not. This discrepancy arises from the use of intervention as a rejection of explanations based on purely correlational observations. The sufficiency of so-called phenomenological laws, which credit a higher degree of explanatory power to a scientific explanation than the so-called phenomenal model would, depends on intervention methods as praxis to outline counterfactual information. The authors, however, leave undecided whether their explanatory model "bottoms out" at fundamental physical magnitudes (Siegel and Craver, 147).

Phenomen*al* versus Phenomeno*logical*: Mechanistic Explanation and Intervention

The caricature of Carl Craver, Stuart Glennan, and David Kaplan's interventionism hinges on the definition of phenomenological law. Wesley Salmon's causal-mechanical interpretation sees these laws as mere descriptions of observed regularities. Take the tide example: though a low tide may precede a high tide, the former's recession does not situate the latter into a causal structure. The low tide is not the *reason* the water eventually rises into the high tide, the relative position of the Earth and moon is. The low-to-high tide explanation is therefore merely descriptive, not explanatory, of correlational uniformities. They characterize epiphenomenal features. Thus, for interventionist mechanists, a sufficiently explanatory phenomenological law must cite either past light-cone (etiological) or relevant subpart (constitutive) factors, which exclude observed correlations. Siegel and Craver (henceforth "SiC") modify the argument of James Woodward and Michael Rescorla, which presume a causal-mechanical description of phenomenological laws, to align with interventionism:

> "Premise 1*: Mechanists hold that for a model to count as explanatory for a phenomenon P, that model must describe either a causally relevant antecedent [etiological factor] to the occurrence of P or a constitutively relevant feature [constitutive factor] of the mechanism underlying P" (Siegel and Craver, 135; brackets mine).

I herein modify Premise 2 and the conclusion (C) of the original Woodward-Rescorla argument precisely in the way SiC suggest, for explicit clarity:

> Premise 2*: Mechanists hold that phenomenal models describe regularities and do not describe the mechanisms by virtue of which those regularities hold.
>
> C*: Mechanists hold that phenomenal models are not explanatory.

Now, whether etiological or relevant constitutive factors are cited should determine whether mechanists choose to reject a phenomenological law's explanatory power, challenging the previous notion that mechanists should choose to reject these laws based on their failure to describe mechanisms.[1] The low-to-high tide explanation is thus phenomenal whereas the citation of gravitational laws would be phenomenological, since it involves constitutively relevant factors.

Real challenge lies in the ambiguity of semantic markers like "sufficient," "relevant," and "satisfactory." The interventionist perspective requires etiological explanations to cite counterfactually relevant past light-cone parts. However, constitutive explanations, the only contenders for phenomenal models, confront some nontrivial difficulties in distinguishing causally *relevant* factors because they tend to restate explanandum as explanans. Intervention requires constitutively relevant explanations to cite counterfactually relevant part-whole relations. Yet the minutiae of what substantiates relevance remain subjective: in the view of W. Salmon and David Lewis, part-whole interactions themselves cannot be causal relations. In response, neomechanists including S. Glennan cite surgical intervention to distinguish between relevance and irrelevance in the case where the value of one part of a system (a variable) can be explained in terms of another variable's value. The ideal gas law (IGL), for instance, which SiC

---

[1]Held by Woodward, Rescorla, Shapiro, Weiskopf, & Ross.

find to cite relevant constitutive factors, works by indicating that "X is a cause of Y iff there is a possible intervention on X that changes Y" (Reutlinger 2013, 25). In other words, ideally intervening on temperature will indicate a cause of volume's change given the intervention. Though ideal, surgical intervention is taken to be an instantaneous process of fixing other variables and directly altering one to obtain a counterfactual, what we conceive as instantaneous in theory is not so in practice at certain spacetime scales. Even if we weren't concerned with these spacetime scales (we are), there are contentions in mechanism that ideal intervention does not indicate causal mechanism.[2] Some practical issues include what ideal intervention means to *represent* physically: if I change the value of temperature T to observe the corresponding change in the value volume V according to pV=nRT, I perhaps need to consider the time it takes to physically observe the change these values symbolize. Here is the interplay between subpart relations and past light-cone events whose consequences I intend to explore.

Working with intervention is nevertheless helpful in the special sciences.[3] The nature of the explanandum determines its relationship with its explanans, and therein lies the gradation of power and its markers (sufficient, relevant, satisfactory, etc.). Reliant on this gradation, SiC's phenomenological laws are either purely etiological or constitutively relevant explanations. The former defines a time-dependent sequence of *ipso facto* explanans and the latter specifies

---

[2] Recent work by Baumgartner (2020) is an example of this discussion. I do not assume here whether ideal intervention indicates legitimate causal mechanisms or not. I instead focus on demonstrating that regardless of its legitimacy, interventionist methods in mechanism lose explanatory power under certain conditions. I point out some issues with its conception to substantiate well-established problems with intervention beyond those I consider at fundamental physical magnitudes. These are more than likely more related than I address in this account, something to consider in the future.

[3] I haven't the space or explicit need here to discuss SiC's address of cognitive neuroscience and its relationship with their interventionist mechanism framework; however, it is a worthwhile read that may provide context for the model's macroscopic applicability. It is therein also made clear why phenomenal models are not useless entities, providing a good deal of referential knowledge that can guide the early stages of scientific theorizing and conceptualizing. IGL and other highly derivative laws are evidently very useful for the sciences and for constitutively answering particular explanandum, as is seen in the recursively examined "Anna's balloon" problem. See Siegel and Craver (2023) for more.

counterfactually dependent information between parts. There are then two distinctions to make, not just one, on the basis of (1) *time* to delineate between etiological versus constitutive and of (2) *parts* to delineate between counterfactually dependent versus independent variables. In the second case, these variables must be tied together in a frozen vacuum: what would happen to Y variable, instantaneously, if I changed the character or value of X variable?[4]

Timelessness and Emergence

At a certain level of spacetime, it becomes nontrivial and so curious to ask what is meant by "instantaneous" as it relates to the intervention of Woodward. In fact, every valid mechanistic explanation according to SiC must appeal to some concept of time: either its non-passage (instantaneity) for interventionist constitutive explanation or its passage for etiological explanation. General relativity (GR) says there can be no definite "now" which objects at disjoints of space can agree on. You check the clock then ask your friend to check theirs to see that both read 8:25:16 PM—to you both, this is now. However, this is demonstrative of a deficiency of the clocks you are using. More accurate atomic clocks, which tick differently at distinct locations due to redshifting, will tell you that there are slightly varying times associated with where you and your friend are in space, e.g. your relative heights on Earth. Your head is older than your toes and any object you gaze at is a past version of itself due to the time for light's travel.[5] This inability for observers to agree on a "now" presents a major problem to the fundamentality of time.

---

[4] These are referred to as *w-questions* by Woodward (2003).

[5] It is worth clarifying here that the problem of simultaneity is (1) not the contribution of quantum gravity to scientific knowledge and (2) presents a challenging problem, I think, to ideal intervention. The problems afflicting the validity of surgical intervention are topics of discussion in philosophy, as mentioned above. I do not consider these in this account, and it may well be worth exploring simultaneity to understand how it pertains to constitutive explanation.

While the relativity of simultaneity has been widely accepted since the nascence of New Mechanism, the development of quantum gravity (QG)—the search for a description of gravity with QM—has corroborated the so-called problem of time. The problem of time arises from the reparameterization invariance of GR when we try to apply it to quantum entities. That is, when using Hamiltonian mechanics to describe the evolution of a quantum gravitational system, the time variable is rendered null because the quantity used in GR to describe a system's evolution[6]—it is definitively time independent. Many efforts have been made over the years to *deparameterize*, identify a physically meaningful time variable to demonstrate time dependence. Until then, however, the seeming lack of time dependence observed when encountering quantum gravitational fields has urged physicists and philosophers alike to consider a fundamentally timeless world. We needn't get into the mathematics; for sake of argument, I simply take the notion of time's non-fundamentality to be true to evidence the incompatibility of New Mechanism with modern physics as a function of certain assumptions about emergence.

This argument pivots on mechanistic organization: how explanans relate to one another and how these relations are understood. With organization comes the problem of emergence. SiC and the mechanists they endorse implicitly subscribe to a microphysicalist emergence view known as the quantum decoherence hypothesis (Glennan and Kuhlmann 2014). The hypothesis claims that at every physical domain, all phenomena can be explained with QM. Yet there is an obvious clash between quantum and classical effects. The ontological commitments of QM and QG reject both local causal interactions and determinacy—otherwise signatures of classical effects—as necessary features of a phenomenon. It is argued that this needn't undermine the use of New Mechanism in QM or vice versa because decoherence, the collapse of multiple possible

[6] This quantity is called *proper time*.

states into one under observation, approximates the quantum-to-classical transition[7]: All classical phenomena supervene or can reduce to quantum phenomena. This atomistic presumption in any physical context begs the following: How can one explain a process described by a phenomenological law (say, IGL) without citing the underlying causal mechanisms in its constituent atoms, without describing the gravitational fields around the atoms' electrons[8] or without explicating precisely what gives rise to the atomic behavior, what Heisenberg says we cannot know with certainty? Should there be nothing that says we stop at quantum physics, need we prove mathematical Platonism every time a prime is used in the Schrödinger equation? If we must answer the fundamental problems of physics and mathematics to sufficiently explain macroscopic phenomena, then arguably we cannot sufficiently explain much at all.

Additionally, these interpretations fail when we try to assign organizational levels where supervenience can even happen. There is no spatial scale at which the ontological properties of quantum phenomena differ from those classical because there are both microscopic *and* macroscopic quantum phenomena (Cordovil 2024). That is, there can be no equivalence between quantum-to-classical emergence and micro-to-macro emergence. The former is an ontological matter, the latter is a phenomenological one (*ibid.*). This idea completely degrades the Universality Thesis (UT) wherein upper-level phenomena, such as those we can observe with our eyes directly, can be derived from some set of fundamental properties of physical reality. In fact, it suggests that UT pantomimes the ouroboros, never ambitioning to really address QM's non-localizability or indeterminacy by relegating these to "approximation" yet simultaneously

---

[7] Alternative non-classical explanations may solve this clash such as the de Broglie-Bohm theory or the Many-Worlds Interpretation, in opposition to Copenhagen. I assume the Copenhagen Interpretation here, considering its wide acceptability and compatibility with the emergence models and thought experiment in this account. It would be useful to explore alternate interpretations in the future.

[8] This is precisely what QG seeks to do.

questioning why the incompatibilities between QM and classical physics exist to begin with. The search for unification between QG and GR can, I think, be seen as a symptom of this pretense.

Instead of the UT approach of Kuhlmann, Glennan, and similar mechanists, one may move towards the pluralistic relational ontology for emergence J.L. Cordovil submits. Under this assumption, a physical object is composed of its internal relata and their relations. These relations and relata bring about qualitative transformations in the object such that new levels of organization emerge. Therefore, all properties which exist at upper levels are not necessarily found in the relata themselves. Note the stark difference between this notion of emergence versus the UT assumed by SiC. Assuming the latter, a classical, time-dependent phenomenon must be explained by reduction to timeless quantum properties. This renders both time-dependent and parts-dependent explanations irrelevant, impossible, or both. Assuming the former, however, the same non-quantic phenomenon *can* emerge from a timeless, quantic domain. I aim to evidence this with a particular timeless physical theory of emergence known as thermal time.

First, I must draw a distinction between the two forms of timeless theory, distinguished primarily by the emergence/reduction models they subscribe to. *Weakly* timeless theories describe a fundamentally timeless world where time emerges at certain levels of spacetime. *Strongly* timeless theories describe a fundamentally timeless world where time does not emerge. While some scholars have focused on strongly timeless theories, there remains a great deal of inquiry that lies in its counterpart.[9] Weakly timeless theory pertains especially to the SiC phenomenological law model because it claims time, the central presumption for mechanistic

[9] K. Miller suggests we should assume that weakly timeless theories, as opposed to strongly timeless ones, create "no philosophical problems." However, simply because these problems are consigned to emergentists does not mean there are no problems. (One can argue this entire account was inspired by her position.) Miller appropriately addresses, though, that there has been debate whether emergence can be consistent with non-fundamentality. I do not intend to explore this issue here, so it is assumed that emergence *can* be consistent with non-fundamentality for simplicity.

explanation, exists at some level of spacetime more or less in the way we observe it—as a linear progression. I speculate that what makes a mechanistic explanation *enough* when applied to such a theory poses severe consequences to SiC's model.

Thermal time describes the Tolman-Ehrenfest law without dynamical assumption, which provides a basis for entirely general-relativistic thermodynamics. This relation can be understood as the proportionality of larger gravitational potentials with larger thermal-to-proper time flow ratios, indicating higher temperatures in thermodynamic systems (Rovelli 2011). Thus, while the second law of thermodynamics states that entropy must increase with the flow of time, thermal time states that the flow of time is determined by statistical mechanics. It is important to not confuse the latter as a rejection of the former; it is, instead, a reframing of the problem of time. It reverses the emergence of *entropy from time* to instead an emergence of *time from entropy*. That is, the directional passage of time we experience macroscopically is a result of a Boltzmann distribution of statistical probability of a thermal system: "it is the thermal state *itself* that defines the variable which plays the role of preferred internal time" (Rovelli 1993, 1563). The objects we see macroscopically are derived from these thermal states. Thus, in theory, we live in a world of events, not things, that flow from distributions of microstates (Rovelli 2018).

A *Gedankenexperiment* with Thermal Time

I have thus far introduced the parameters of the ensuing thought experiment. I will clarify these here to lay out the independent variables, dependent variables, and constants in this experiment. The first assumption I consider is the interventionist mechanism assumed by SiC, which posits three categories of mechanistic explanation: etiological explanation, constitutively relevant explanation, and constitutively irrelevant explanation. Either of the former two, *a priori*, justify phenomenological laws as explanatorily powerful. The latter renders a law or description as a phenomenal model. The weakly timeless theory we consider, thermal time, suggests two additional assumptions: (a) time emerges and (b) the macroscopic flow of time results from statistical mechanics in thermal systems (i.e., objects can be described strictly as events). These are our constants.

Time can only flow once it has emerged. I do not assume anything about where or when this emergence happens; emergence theory is thus our independent variable. The first level of this manipulation variable that I shall investigate is the microphysicalist perspective. This atomistic approach derivative from UT sees objects strictly as sums of their parts, and all observable phenomena must be accounted for solely by the ontological properties of its constituents or relata. The second level of the independent variable is the antireductionist case J.L. Cordovil and Gil Santos endorse, advocating a pluralistic relational ontology that allows distinct properties in the non-quantic domain to emerge from the quantic domain. The dependent variable, what I will observe change in, is the *survival of power* in constitutive explanation. That is, whether the gradation between etiological or constitutively relevant and constitutively irrelevant explanation ceases to exist or not. The cessation of power would indicate a blending between the phenomenological laws previously understood to be explanatorily superior to phenomenal models. Naturally, this would weaken their power and render many phenomenological laws which had previously satisfied Premise 1* and Premise 2* now explanatorily insufficient. I hypothesize that the pluralist formulation will allow constitutive explanation to retain its explanatory power as deemed in the SiC model. Or, at least, that the reductionist one will not.

Consider two propositional functions of x, an explanation in the domain of possible explanations A for a phenomenon P. The functions are subject to a two-valued, Boolean logic system.

e(x) = "x describes the past light-cone."

r(x) = "x is a relation between relevant subparts."

By the Law of the Excluded Middle, there can only be two possible truth values to these functions, true or false. Under the standard convention of time, i.e., not assuming timelessness, we know either $e(x) \oplus r(x)$ constitute phenomenological laws. A phenomenological law is explicitly distinct from a phenomenal model—an explanation cannot be both a true phenomenological law and a false phenomenological law. Under thermal time supposing weak timelessness, objects including subparts and variable relations are now fundamentally events. Thus, the notion of subparts in relevant constitutive explanation reduces to descriptions of the past light-cone of a phenomenon and vice versa. Relevant constitutive explanation therefore reverts to etiological explanation. With these considerations, the logical quantifier for the truth value of a phenomenological law transforms from standard to thermal time. It may be expressed as:

$$(1) \quad \exists x \in A(e(x) \oplus r(x)) \Rightarrow \exists x \in A(e(x) \leftrightarrow r(x)).$$

$e(x)$	$r(x)$	$e(x) \oplus r(x)$	$e(x) \leftrightarrow r(x)$
T	T	F	T
T	F	T	F
F	T	T	F
F	F	F	T

Table 1. Truth table depicting the allowed truth statements under the standard to thermal time convention.

Note that, though we have not yet considered irrelevant constitutive explanations, the transition from the standard $e(x) \oplus r(x)$ to thermal $e(x) \leftrightarrow r(x)$ represent diametrically opposing possibilities: states that the standard convention forbids (e(x) and r(x) being simultaneously true or simultaneously false) are precisely those the thermal convention allows. Cases where the output truth value equals T represent true phenomenological laws. The table demonstrates that, in thermal time, both e(x) and r(x) must be true to satisfy a true phenomenological law, and that this is not allowed in the standard convention.

Consider now the domain set of all possible explanations A for a phenomenon P. Take the set of phenomenological law explanations L and the set of phenomenal model explanations M of P as subsets of A, i.e., $A \supseteq L \cup M$. Note $\overline{L \cup M} = \emptyset$; there are no possible explanations outside the sets L and M. First, assume the standard convention of time. Suppose, then, that $L \supseteq E \cup R$ where E and R are the sets of etiological explanations and relevant constitutive explanations, respectively. We are now considering phenomenal models, so presume that the set of irrelevant constitutive explanations I are such that $M \supseteq I$, $\bar{I} = L = E \cup R$. Again, $\overline{E \cup R \cup I} = \emptyset$ ($x \notin A$ if x $\notin$ $(E \oplus R \oplus I)$ unless $x \equiv \emptyset$). These sets are, in the standard worldview, defined as follows: E = $\{x \in A \mid e(x) \equiv T\}$, R = $\{x \in A \mid r(x) \equiv T\}$, I = $\{x \in A \mid e(x) \oplus r(x) \equiv F\}$. Under standard time, the elements of I represent forbidden cases of e(x) $\oplus\, r(x)$, which definitively are the cases of false phenomenological laws—phenomenal models. These "black box" relations are insufficiently explanatory.

We have already established that relevant constitutive explanation implies etiological explanation and vice versa given the objects-as-events equivocation, and further demonstrated the allowable phenomenological law truth values given the quantifier transform (1). Thus, transitioning to thermal time, an element that makes e(x) true should also make r(x) true by $e(x) \leftrightarrow r(x)$. More simply, E = $\{x \in A \mid e(x) \equiv T\}$ = $\{x \in A \mid r(x) \equiv T\}$. Thus $E \subseteq R$ *and* $R \subseteq E$. Because E and R bijectively consist of the same elements and sets are equivalent when one set is a subset of the other and vice versa, E and R are the same set.

Recall that UT defines a whole as the sum of its parts: phenomena are ideally reducible. Also recall that phenomenal models are explanations that relate "black boxes," the "parts" in the sum of parts. Since every phenomenological law explanation reduces to a series of temporal relations (etiological explanans) according to thermal time, UT says these explanations then reduce to black boxes. The black box exists at the scale where time emerges. Within these boxes, there cannot be etiological explanation, which we have demonstrated equates to constitutive explanation, because time ceases to exist.[10] Therefore, UT emergence defines an emergence of time and therefore of phenomenological explanation that exists only past the timeless quantum domain, supposedly the Planck scale. IGL, for instance, then explanatorily reduces perfectly to interactions among Planck-scale relata. Where set *I* formerly contained elements that satisfied the negation of either etiological and relevant constitutive explanations, it now consists of those where either e(x) or r(x) is true according to what would in standard time be considered separate etiological or relevant constitutive. (Note that our perception injects a false distinction between the two, which we have demonstrated with the transition to thermal time. The continued reference to e(x) as distinct from r(x) is for folk comprehension; there is no actual difference between these two considering a thermal time worldview.)

Given I = $\{x \in A \mid e(x) \vee r(x) \equiv T\}$ and E = R, we find $E \subseteq I$ and $I \subseteq E, \therefore I = R$. There is no longer distinction between any of the explanan modes. If I = E = R, M ⊆ I, and I ⊆ M, then M ⊆ E, M ⊆ R, E ⊆ M, R ⊆ M or M = E = R = I. From the standard convention, we know L ⊆ $E \cup R$. We now see $L \subseteq M \text{ and } M \subseteq L$. The set of phenomenological laws are the set of phenomenal models. Explanatory power, as defined by SiC, no longer remains.

---

[10] There are arguments against the assumption that timeless causation does not exist (see Tallant 2019). There certainly is opportunity to comment on the implications of timeless causation on the "black box" relations I purport happen under UT. However, this depends on an analysis on the nature of timeless causation and how it may relate, in the pre-emergence sense of UT, to relata relations.

Alternatively, consider a relational ontology (RO) theory of emergence. The pluralist perspective allows us to consider emergent properties from relations at the Planck scale, so upper-level or macroscopic phenomena are explainable by such relations. If it is possible to explain electron position, an indeterminate quantum property, as an ontological emergent property even at the Planck scale, etiological explanation (still synonymous to relevant constitutive explanation) does not reduce perfectly to phenomenal models. RO therefore posits an anti-scale frontier approach to explanation. Indeterminate statistical probabilities underlying the arrow of time may indeed themselves be "black box" relata, but we are concerned with events, the relations *between* said relata. These relations are no longer parts of a sum. Instead, objects-as-events can be emergent properties from relations that may interact with measurement or the act of observation. Under RO, phenomenological laws can be relations of distinct properties like position, spin, mass, force, dead, alive, time. This is to say all phenomenological law explanations consist of relata between emergent properties, whereas phenomenal models consist of relata without such properties. There remains the distinction between irrelevant and relevant explanation, as SiC outline, so explanatory power is retained. In set terms, E = R ≠ I because I ≠ $\{x \in A \mid e(x) \vee r(x) \equiv T\}$. The sets are no longer bijectively equivalent in that there are different, emergent property elements in E and R relative to I, which only hosts "black boxes."

Conclusion

The above experiment has evidenced constitutive relevant explanations reverting to etiological explanations under the theory of thermal time, regardless of whether UT or RO emergence is assumed. The SiC model, reflective of interventionist mechanism, rejects the abject conflation between explanation and observation seen in Old Mechanist perspectives such as of

Salmon. They instead discriminate “good” and “bad” observation, one satisfying sufficient explanation and one not, respectively. I proposed a transition from a standard convention of time to thermal time, a weakly timeless physical theory, to probe whether these kinds of observations yield changes in explanatory sufficiency. On thermal time under UT emergence, the sets of phenomenological laws and the set of phenomenal models assume the same elements. Elementary set theory demonstrates that set equivalence must be bijective, and this is satisfied given the parameters of the experiment. Notably, observation takes on new parameters in RO emergence. We no longer consider part-whole interactions as simply sums of parts but instead as *parts themselves*. This removes the set equivalence between phenomenological laws and phenomenal models in the domain of possible explanations, ultimately restoring explanatory power to relevant observation. Explanatory power finds its limits in UT. However, in RO the black boxes of quantum phenomena are fringed by emergent properties which permit macroscopic, phenomenological explanations. Here, we can explain phenomena without having all the microphysical answers. Explanatory power survives.

It goes without saying that what makes an explanation *enough* must appeal to some level of cognitive success, an epistemological concern. It would seem that we return to a Machian phenomenology in acknowledging an emergence which permits ontic properties that mingle with human perceptual and cognitive faculties. Less apparently, the ontological considerations here provide some latitude in the modern definition of physicality. I sustain on behalf of Cordovil that the decoherence ‘approximation’ is not only a point rested on oblivion, but that not finding a way to overcome this insufficiency hinders important scientific explanations and novel means of questioning. The UT frame restricts us from considering possible notions of the physical world, perhaps those more imaginative. In these imminent imaginations, we must contend with the emergent properties of relata as products of our observation. The perception of time itself is subject to this contention. As such, the folk concept of time and temporal error theory have together justifiably been explored by K. Miller and colleagues in strongly timeless pretenses. Yet weakly timeless cases ought to be examined for the folk concept as well, given that non-localizability and indeterminacy are not compatible with the reductionist emergence theory that this experiment emphasizes. The restoration of explanatory power by RO emergence indicates that, despite the ostensible interaction between observation and reality, what is observed retains pragmatic explanatory utility for the special sciences. RO does this by redefining precisely what observation means, transitioning from a Democritean atomistic worldview to one that considers relations between "black box" a-toms. If we are to sit soundly with uncomfortable quantic truths, that is, we must first sit with what makes these truths so uncomfortable.

References

Baumgartner, M., Casini, L., & Krickel, B. (2020). Horizontal Surgicality and Mechanistic Constitution. Erkenntnis, 85, 417-430, https://doi.org/10.1007/s10670-018-0033-5.

Cordovil, J.L. (2024). "Fundamental Physics and (New-) Mechanistic Ontologies." In J.L. Cordovil, G. Santos, D. Vecchi (Ed.), New Mechanism: Explanation, Emergence and Reduction (pp. 179-188). Springer.

Glennan, S. (2002). "Rethinking Mechanistic Explanation." Philosophy of Science, 69(S3), S342-S353. http://www.jstor.org/stable/10.1086/341857

Glennan, S. & Kuhlmann, M. (2014). "On the relation between quantum mechanical and neo-mechanistic ontologies and explanatory strategies." European Journal for Philosophy of Science, 4, 337–359. DOI: 10.1007/s13194-014-0088-3.

Kaiser, M. & Krickel, W. (2016). "The Metaphysics of Constitutive Mechanistic Phenomena." The British Journal for the Philosophy of Science, 68(3), 745-779. DOI: 10.1093/bjps/axv058.

Reutlinger, A. (2013). The Interventionist Theory of Causation. In: A Theory of Causation in the Social and Biological Sciences (pp. 25-70). Palgrave Macmillan, London. https://doi.org/10.1057/9781137281043_2.

Rosen, M. (2008). "Quantum Gravity and Phenomenological Philosophy." Foundations of Physics, 38, 556-582. DOI: 10.1007/s10701-008-9221-5.

Rovelli, C. (1991). "Time in quantum gravity: an hypothesis." Physical Review D, 43(2), 442-456. https://doi.org/10.1103/PhysRevD.43.442.

Rovelli, C. (1993). "Statistical mechanics of gravity and the thermodynamical origin of time." Classical and Quantum Gravity, 10(8), 1549. DOI: 10.1088/0264-9381/10/8/015.

Rovelli, C. (2006). "The Disappearance of Space and Time." In D. Dieks & M. Redei (Ed.), The Ontology of Spacetime (pp. 25-36). Elsevier B.V.

Rovelli, C. & Smerlak, M. (2011). "Thermal time and Tolman-Ehrenfest effect: 'temperature as the speed of time.'" Classical and Quantum Gravity, 28(7), DOI: 10.1088/0264-9381/28/7/075007.

Rovelli, C., & Carnell, S. (2018). "The Order of Time." New York, New York, Riverhead Books.

Santos, G.C. (2015). "Ontological Emergence: How is That Possible? Towards a New Relational Ontology." Foundations of Science, 20(4), 429-446. DOI: 10.1007/s10699-015-9419-x.

Siegel, G. & Craver, C.F. (2023). "Phenomenological Laws and Mechanistic Explanation." Philosophy of Science, 91(1), 132–150. https://doi.org/10.1017/psa.2023.65.

Tallant, J. (2019). “Causation in a timeless world?” Inquiry, 62(3), 300-316, DOI: 10.1080/0020174X.2018.1446051.