Canadian Journal of Philosophy (2020), 50: 5, 622–635
doi:10.1017/can.2020.7

ARTICLE

Emergent Causal Laws and Physical Laws

Ranpal Dosanjh

Department of Philosophy and Religious Studies, Iowa State University, Ames, Iowa
Email: ranpal@iastate.edu

Abstract

Contrasting accounts of physicalism and strong emergentism face two problems. According to the neutrality problem, contrasting supervenience-based formulations of these positions cannot be neutral with respect to certain unrelated metaphysical commitments. According to the collapse problem, emergent properties can be accounted for using an appropriately expansive physical ontology, rendering strong emergentism metaphysically suspect. I argue that both these problems can be solved with a principled distinction between emergent causal laws and physical laws. I propose such a distinction based on a finite discontinuity in the behavior of fundamental physical constituents as a function of complexity.

Keywords: Emergentism; physicalism; neutrality problem; collapse problem; nomological and physical necessity; counterlegal conditionals; finite discontinuity

If physicalism is true, physical systems evolve exclusively according to the physical properties of the system and the physical laws governing them.[1] Any broadly scientific, higher-level property instantiated in these systems is physically acceptable, or nothing over and above the physical. All such properties strongly supervene on physical properties with at least physical necessity.

In contrast, if strong emergentism is true,[2] then there is a level of complexity at which physical systems no longer evolve exclusively according to the physical properties of the system and the physical laws governing them. At that level of complexity, the system instantiates a novel higher-level property, an *emergent property*, that is something over and above the physical. The emergent property affects the distribution of emergent properties and physical properties according to a novel and brute *emergent causal law*. Since the physical properties of such a system evolve in part according to the emergent causal law, the system demonstrates lawful downward causation. Because emergent properties depend on physical properties in this way, the former supervene on the latter, but more weakly than do physically acceptable properties.[3]

[1]For ease of exposition, I will assume that natural laws govern properties. Nothing hangs on this assumption.

[2]Here I follow the terminology in Wilson (2015). The position characterized below follows that of the British emergentists, including Broad (1925). See McLaughlin (1992). Other examples include Van Cleve (1990), O'Connor (1994), McLaughlin (1997), Shoemaker (2002), Wilson (2002), O'Connor and Wong (2005), Seager (2012), and Wilson (2015). For more on downward causation, see Kim (1998, 2005).

[3]Various attempts have been made to contrast these supervenience relations. Here are some examples. According to Van Cleve (1990), emergent properties strongly supervene on physical properties with nomological necessity, but not with logical necessity. According to O'Connor (1994), emergent properties strongly supervene on physical properties with causal necessity, but in a non-structural way, and while demonstrating a novel causal influence. According to McLaughlin (1997), emergent properties strongly supervene on physical properties with nomological necessity, but not with logical necessity, and the supervenience principles linking them are fundamental laws. According to Seager (2012), emergent properties weakly supervene, but do not strongly supervene, on physical properties with physical necessity, and physics fails to be a total (complete, resolvable, and closed) theory.

At least, that's the story. But two problems have been raised with this apparently clear contrast between physicalism and strong emergentism. The first is how to formulate the two positions so that they adequately contrast one another. Good accounts of physicalism and strong emergentism should be neutral with respect to unrelated metaphysical commitments, like necessitarianism (properties are metaphysically necessarily connected to laws) coupled with holism about laws (laws cannot be separated from one another) (Wilson, 2005), or whether properties are individuated in part by their causal powers (O'Connor, 1994). According to Wilson, physicalism and strong emergentism cannot be adequately contrasted by supervenience-based accounts while remaining neutral in this way. Call this the *neutrality problem.*

The second problem is that the contrast between emergent properties and physically acceptable properties appears to be metaphysically arbitrary. When there are candidate emergent properties, it merely reveals the existence of previously unconsidered physically acceptable properties. Something like this position has been in the literature since at least Pepper (1926). More recently, Taylor (2015) argues that for any supposedly macro-level emergent property, there are associated micro-level properties that completely account for them. Nothing prevents us from incorporating these micro-level properties into our physical ontology, collapsing emergent properties into the physical, and thus strong emergentism into physicalism. She calls this problem the *collapse problem.*

Fortunately, so I argue, both these problems have the same solution. What we need is a principled distinction between emergent causal laws and physical laws. Then we can secure a supervenience-based distinction between physicalism and strong emergentism that solves the neutrality problem while simultaneously solving the collapse problem.

In section 1, I describe the neutrality problem. In section 2, I show that, given a principled distinction between emergent causal laws and physical laws, modal reasoning can be constructed that is neutral with respect to unrelated metaphysical commitments. I use this result to propose neutral supervenience-based accounts of physicalism and strong emergentism that transparently depend upon the distinction between emergent causal laws and physical laws. In section 3, I describe the collapse problem, and show that a principled distinction between emergent causal laws and physical laws is sufficient (and perhaps necessary) to solve it. In section 4, I discuss how the threat of collapse constrains a principled distinction between emergent causal laws and physical laws. I propose that such laws are distinguished not by their content, but rather by a finite discontinuity in the way a system evolves as the system becomes more complex. I conclude in section 5.

1. The neutrality problem

Here are two simple, contrasting, supervenience-based accounts of physicalism and strong emergentism.

Physicalism (naïve): All broadly scientific properties are *physically acceptable*, that is, they strongly supervene on physical properties with physical necessity.

Strong emergentism (naïve): Some broadly scientific properties *strongly emerge from the physical*, that is, they strongly supervene on physical properties with nomological necessity, but not with physical necessity. (Furthermore, these strongly emerging properties: (a) lawfully, downwardly cause changes to the distribution of physical properties; and (b) are properties of wholes whose parts have the physical properties from which they strongly emerge.)

We can unpack these accounts as follows. There is a set of laws—the physical laws—according to which physically acceptable properties evolve. These are the properties that supervene with physical necessity on physical properties. But if strong emergentism is true, then when systems of physically

https://doi.org/10.1017/can.2020.7 Published online by Cambridge University Press

acceptable properties reach a certain level of complexity, new, emergent properties are instantiated according to brute emergent laws of nature (which are not themselves physical laws). These are the properties that supervene with nomological (but not physical) necessity on physical properties. The parenthetical conditions on strong emergentism (downward causation and whole-part supervenience) differentiate it from related non-interactionist and anomalously interactionist positions.

These accounts make sense only if it is possible for nomological necessity and physical necessity to come apart. Consider the naïve account of physicalism. If strong emergentism is true, then emergent properties supervene with nomological necessity on physical properties. If nomological necessity just is physical necessity, then, according to the naïve account of physicalism, these emergent properties would incorrectly count as physically acceptable. Now consider the naïve account of strong emergence. It is even more obviously dependent on distinguishing nomological necessity and physical necessity, for otherwise the account becomes impossible to satisfy. Given this critical dependence, these accounts are vulnerable to arguments that erode the distinction between nomological necessity and physical necessity.

I haven't seen any arguments against that distinction per se; indeed, to my knowledge, the distinction itself isn't made explicitly in the literature. In contrast, at least since Van Cleve (1990), philosophers writing about strong emergence have been sensitive to the importance of the distinction between nomological necessity and *metaphysical* necessity, and arguments have been presented that erode this latter distinction. Since physical necessity is intermediate in strength between nomological necessity and metaphysical necessity, these arguments a fortiori erode the distinction between nomological necessity and physical necessity.

Wilson (2005) presents one such argument. According to necessitarianism, properties are individuated in part by their relationship to the particular laws that govern them. So any world where those (or very similar) laws fail to hold is a world that fails to instantiate those properties. According to holism about laws, the laws of nature come together as a package: any world in which one (actual) law holds is a world where all the (actual) laws hold. Together, necessitarianism and holism about laws erodes the distinction between nomological necessity and metaphysical necessity, and thus between nomological necessity and physical necessity. It follows from holism about laws that any world where one actual law fails to hold is a world where all the actual laws fail to hold. Therefore, by necessitarianism about laws, no nomologically impossible world instantiates any property of the actual world.

For example, suppose we live in a Newtonian world with only two forces: the (Newtonian) gravitational force and the Coulomb force. According to necessitarianism, mass is instantiated only in worlds where Newton's law of gravitation (or something very much like it) holds, and charge is instantiated only in worlds where Coulomb's law (or something very much like it) holds. According to holism about laws, Newton's law of gravitation holds in all and only those worlds where Coulomb's law holds and vice versa. Therefore, any world where either of these laws fails to hold is a world where both these laws fail to hold. (By parallel reasoning, they also fail to hold in any world where any other law holds.) Therefore, there is no mass and no charge in any nomologically impossible world.

The lack of actual properties in nomologically impossible worlds implies that nomological supervenience, physical supervenience, and metaphysical supervenience converge. Consider one set of properties (the supervening properties) that nomologically supervene on another set of properties (the subvening properties) with nomological necessity. Any nomologically impossible world is a world instantiating neither the supervening nor the subvening properties. Therefore, the former also supervene on the latter with both physical necessity and metaphysical necessity.

O'Connor (1994) presents another argument that erodes the distinction between nomological necessity and metaphysical necessity. If property types are individuated at least in part by (all) their causal powers, then it is metaphysically impossible for one instance of a property type to lack even a single one of the causal powers of another instance of the type. Since different laws imply different causal powers, neither emergent properties nor physical properties are instantiated in any nomologically impossible world. By the same argument as above, any nomologically necessary supervenience relation among such properties is therefore both physically and metaphysical necessary.

Whatever the merits of these metaphysical positions, good formulations of physicalism and strong emergentism ought to be neutral with respect to them. Call this the *neutrality condition.* As we have seen above, our naïve supervenience-based accounts of physicalism and strong emergentism are unable to satisfy the neutrality condition while adequately contrasting the positions. Moreover, supervenience-based formulations of physicalism and strong emergentism in general appear to be unable to satisfy the neutrality condition, because they ultimately rely on a distinction between nomological necessity and metaphysical necessity (or between nomological necessity and some kind of necessity stronger than it).[4] This is the *neutrality problem.*

2. Neutral supervenience-based formulations

In this section, I propose supervenience-based accounts of physicalism and strong emergentism that satisfy the neutrality condition, thereby solving the neutrality problem. As with the naïve accounts, they embrace the need for a principled distinction between emergent causal laws and physical laws. I use the distinction, together with the downward causation and part-whole relations characteristic of strong emergentism, to ground the required difference between two kinds of necessity.

2.a Biased and unbiased modal reasoning

Let us diagnose how the naïve accounts fail to satisfy the neutrality condition. A world is nomologically possible if and only if all the actual natural laws hold in that world. A world is physically possible if and only if all the actual physical laws hold in that world. Since the physical laws are a (perhaps improper) subset of all the laws, the nomologically possible worlds are a (perhaps improper) subset of the physically possible worlds.

Here is where the modal reasoning needed by the naïve accounts becomes controversial. If there are emergent causal laws (or indeed any fundamental laws that are not physical laws), then nomologically possible worlds are a proper subset of the physically possible worlds: that subset of worlds where the emergent causal law also holds. The emergent properties are thus instantiated (under the appropriate conditions) in all nomologically possible worlds, but not in all physically possible worlds. This is how emergent properties supervene on physical properties with nomological necessity but not with physical necessity.

But if the conjunction of necessitarianism and holism about laws is true, or if properties have all their causal powers necessarily, then the set of nomologically possible worlds is identical to the set of physically possible worlds. The modal reasoning at the heart of the naïve accounts cannot accommodate these metaphysical positions. We can say that the naïve accounts are based on *biased* modal reasoning, since they cannot satisfy the neutrality condition. What we need is a way of talking about a distinction between emergent causal laws and physical laws without running afoul of the neutrality condition, to ground a difference between nomological necessity and physical necessity in an *unbiased* way.

There are good reasons to expect that such an unbiased way of talking about the distinction can be constructed. Distinguishing between emergent causal laws and physical laws is a species of counterlegal reasoning: reasoning with counterfactual conditionals whose antecedents are nomologically impossible. Counterlegal reasoning is widespread and accepted in both science and

[4] See Wilson (2005).

philosophy.[5] In fact, the central motivation behind strong emergentism can be interpreted as counterlegal reasoning: had there been no emergent causal law, the physical system that instantiates the emergent property would have evolved in a different manner. This sort of reasoning is no different, in principle, than reasoning about whether orbits would be stable had masses obeyed an inverse-cubed law of gravitation. A metaphysics that conjoins necessitarianism and holism about laws, or one that requires properties to have all their causal powers metaphysically necessarily, must be able to handle such reasoning. However counterlegal reasoning is handled in the general case, that solution can be applied to distinguishing emergent causal laws and physical laws.

How such reasoning is to be accommodated needs to be worked out.[6] For example, it may be metaphysically impossible for a property to be instantiated in a world with very different laws, or to have different causal powers. Nevertheless, there may still be metaphysically possible worlds with properties or laws that correspond to those of the actual world, without being identical to them.[7] Unbiased counterlegal reasoning could then be performed by considering such worlds.

2.b Unbiased counterlegal reasoning

For my purposes, there is no need to work out the details of unbiased counterlegal reasoning in the general case. Formulating physicalism and strong emergentism just needs to ground a difference between nomological necessity and physical necessity in case there are emergent causal laws that govern only relatively complex systems. At least in this special case, counterlegal reasoning that captures this distinction can be straightforwardly constructed.

What follows below is a way of adapting the biased counterlegal reasoning above to accommodate the neutrality condition while preserving some kind of distinction between nomological necessity and physical necessity. I use the fact that emergent properties are never instantiated at the lowest levels of complexity to isolate the physical properties, and functionally characterize them. The union of, on the one hand, worlds instantiating only properties that satisfy those functional characteristics, and, on the other hand, nomologically possible worlds, can play the role of physically possible worlds in unbiased counterlegal reasoning.

Suppose strong emergentism is true. For any given emergent causal law, there is a physical configuration to whose evolution the law contributes not at all. Specifically, the emergent law does not contribute to the evolution of any system at a lower level of complexity than a system that instantiates the emergent property, given that the system is (more or less) causally isolated from any emergent system. In fact, there must be physical systems, like pairwise particle interactions in deep space, or any system of the universe prior to the instantiation of the first emergent property, that are at a low enough level of complexity that *no* emergent property is instantiated, and so to whose evolution no emergent causal law contributes. Call the set of all such systems the *non-emergent domain*. A theory of the causal interactions of the entire non-emergent domain can be constructed, and this theory can be deductively extended outside the non-emergent domain.[8] We can then Ramsify the theory to get an extended functional characterization of each property.[9] In the actual world, the functional characterizations described in that extended theory will be satisfied by physically acceptable properties in the non-emergent domain. But, plausibly, they will also be

[5]It is significant that most counterfactual reasoning about the actual world proceeds from an epistemic context of ignorance of the true laws of nature.

[6]For a discussion on counterlegal reasoning under the supposition that properties have causal powers necessarily, see Handfield (2004).

[7]For example, perhaps mass, necessarily connected to the laws of the actual world, corresponds to *schmass* in worlds with an inverse-cubed law of gravitation. See Fine (2002). Or perhaps mass is world-bound (not instantiated in any non-actual possible world), but has counterparts in other possible worlds. See Heller (1998) and Black (2000).

[8]In other words, we can construct a theory that correctly describes the non-emergent domain but (if strong emergentism is true) incorrectly describes systems outside this domain. Indeed, that theory would be the physics theory of the actual world.

[9]Ideally, in topic-neutral terms.

https://doi.org/10.1017/can.2020.7 Published online by Cambridge University Press

satisfied by (possibly distinct) properties in metaphysically possible worlds that are nomologically impossible. Call the worlds all of whose properties satisfy the functional descriptions of the extended theory *superficially-physically possible worlds.*[10] The laws of those worlds are the *superficially-physical laws*, and they govern the *superficially-physical properties.*

We can establish a correspondence between actual properties and superficially-physical properties using the following counterlegal conditional:

> *Correspondence to the superficially physical*: Nomologically possible property *P* corresponds to superficially-physical property *Q* if and only if: if there had been no emergent causal laws, then *P* would have been *Q*.[11]

By construction, emergent properties correspond to no superficially-physical properties. Moreover, if physicalism is true, then (also by construction) the physical properties correspond to themselves, i.e., the superficially-physical properties just are physical properties, the superficially-physical laws just are physical laws, and the superficially-physically possible worlds just are physically possible worlds. Even if strong emergentism is true, the superficially-physical properties might just be physical properties, the superficially-physical laws might just be physical laws, and the superficially-physically possible worlds might just be the physically possible worlds. But under strong emergentism, if either the conjunction of necessitarianism and holism about laws is true, or properties have their casual powers necessarily, then the physical and the superficially-physical come apart.

Suppose the conjunction of necessitarianism and holism about laws is true. Under strong emergentism, none of the actual laws are laws that hold in the superficially-physically possible worlds, so no property instantiated in the actual world will be a superficially-physical property. Nevertheless, the physical properties of the actual world will correspond to the superficially-physical properties of nomologically impossible worlds, and those actual laws that govern systems in the non-emergent domain will resemble the superficially-physical laws.

Suppose instead that properties have all their causal powers necessarily. Again, under strong emergentism, no property instantiated in the actual world will be a superficially-physical property. But again, the physical properties of the actual world will correspond to the superficially-physical properties of nomologically impossible worlds. Indeed, if causal powers are given in topic-neutral

[10] If properties have quiddities, superficially-physically possible worlds can be collected into sets of qualitatively identical worlds. For each such set, an arbitrary world whose distribution of quiddities best (or else adequately) matches that of the nomologically possible worlds can be selected as a representative.

[11] Alternative consequent: *P* would have satisfied the functional characterization of *Q*.

By design, this counterlegal conditional is metaphysically lightweight. It can be accepted by necessitarians and non-necessitarians alike, since it doesn't presume whether properties in nomologically impossible worlds are identical to actual properties. It does presume that it is meaningful to talk about nomologically impossible but metaphysically possible worlds. Those who object to this (Schaffer [2005] calls them *modal*, as opposed to *nomic* and *causal*, necessitarians) can translate my talk of nomologically impossible worlds into something more palatable (see, for example, Handfield [2004]). Likewise, it can be accepted by holists and non-holists about laws (there is no presumption about law individuation) and by those who disagree about whether properties have their causal powers necessarily (there is no presumption about how properties are related to causal powers).

The counterlegal conditional is more lightweight than the structurally similar property counterparts described in Robinson (1993), Heller (1998), Black (2000), and Hawthorne (2001). For example, it can be accepted by those who disagree about whether properties have quiddities, or whether possible worlds are concrete entities. It does presume that actual properties are instantiated in non-actual nomologically possible worlds. Those who object to this (like Heller [1998] and Black [2000]) can translate my talk of such properties in terms of property counterparts. Moreover, the counterlegal conditional is applied in a very specific context, so there is no need for me to take a general position on the connection between the property and the functional characterization, or whether corresponding properties are intrinsically similar.

terms, the superficially-physical properties will be those properties with all the (type-level) causal powers that the physical properties have according to the physical laws, but not those that they have according to the emergent causal laws. There will also be an analogous correspondence between the superficially-physical laws and the physical laws.

Call the union of superficially-physically possible worlds and nomologically possible worlds the *quasi-physically possible worlds*. If physicalism is true, then quasi-physical necessity just is physical necessity, which just is nomological necessity. On the other hand, under strong emergentism, the nomologically possible worlds are a proper subset of the quasi-physically possible ones, so nomological necessity and quasi-physical necessity come apart.

2.c Neutral accounts of physicalism and strong emergentism

In the context of the debate between physicalists and strong emergentists, quasi-physical necessity can play the role of physical necessity, but in a way that does not violate the neutrality condition. We can quantify over the quasi-physically possible worlds, as long as predicates that refer to actual properties are taken to refer to their corresponding properties in the superficially-physically possible worlds if there are any corresponding properties in those worlds, and to fail to refer to any properties in those worlds otherwise. The naïve accounts can be modified in light of this, while retaining the force of the formulation's distinction between nomological necessity and physical necessity.

Physicalism: All broadly scientific properties are *physically acceptable*, that is, they strongly supervene on physical properties with *quasi*-physical necessity.

Strong emergentism: Some broadly scientific properties *strongly emerge from the physical*, that is, they strongly supervene on physical properties with nomological necessity but not with *quasi*-physical necessity. (Furthermore, these strongly emerging properties: (a) lawfully, downwardly cause changes to the distribution of physical properties; and (b) are properties of wholes whose parts have the physical properties from which they strongly emerge.)

These accounts satisfy the neutrality condition. If the conjunction of necessitarianism and holism about laws is true, or if properties have their causal powers necessarily, then actual properties are not instantiated in any nomologically impossible world. Nevertheless, properties corresponding to actual physical properties are instantiated in the superficially-physically possible worlds, while no property corresponding to an actual emergent property is instantiated there. The difference between nomological necessity and quasi-physical necessity remains. This allows for the two kinds of necessity that are needed to contrast physicalism and strong emergentism.

If at least one of necessitarianism and holism about laws is not true, and if properties do not have their causal powers necessarily, then, independent of the existence of emergent properties, superficially-physical properties just are physical properties, and these accounts reduce to the naïve ones.

Alternatively (and more conveniently), as long as we understand physical necessity as quasi-physical necessity, we can preserve the simplicity of the naïve accounts while satisfying the neutrality condition.

This solution to the neutrality problem is specially suited to contrasting physicalism with strong emergentism, because the latter entails an emergent causal law governing only relatively complex systems. Without a principled distinction between physical laws and emergent causal laws, appealing to the non-emergent domain, and thus quasi-physical necessity, is specious.

3. The collapse problem

The second problem faced by accounts of strong emergentism (and thus by the contrast between physicalism and strong emergentism) is the collapse problem. Taylor (2015) provides a recipe for generating the problem for any purported case of emergence. Any account of strong emergentism must appeal to macro-level features that are autonomous from micro-level features characteristic of the physical. But for all such macro-level features, there are associated micro-level features that account for them, “crossing the barrier that marks emergent autonomy” (Taylor 2015, 734). Once we adopt the micro-level features into our physical ontology, the purported case of emergence is no longer incompatible with physicalism.

Taylor applies the recipe to several accounts of emergence, the most relevant of which is that of Broad (1925, 61). For Broad, emergent properties are characteristic properties of wholes composed of certain combinations of physical parts. What makes them autonomous is that they cannot be deduced, even in principle, from the properties of the parts in isolation or in other combinations.[12]

Taylor uses as an example Broad’s (now dated) belief that sodium chloride is an emergent whole composed of sodium and chlorine,[13] with the emergent (macro-level) property of being soluble in water. But, as she observes, sodium has the dispositional property of generating a compound that is soluble in water when combined with chlorine into sodium chloride, and likewise for chlorine. By Broad’s own standards, these dispositional properties are micro-level properties. Therefore, there are micro-level properties that account for the supposedly emergent solubility of sodium chloride. By expanding our understanding of the physical to include such dispositional properties, the emergent collapses into the physical.

A principled distinction between emergent causal laws and physical laws solves the collapse problem. Suppose there is such a distinction. Then it is not the macro-micro distinction that makes a property strongly emergent or physical. Rather, it is whether the property is governed by an emergent causal law or just physical laws. In this specific case, if sodium chloride being soluble in water is governed by an emergent causal law, then it is an emergent property. The associated dispositional properties of sodium and chlorine individually would also be governed by the emergent causal law, and so wouldn’t be physically acceptable despite being micro-level.[14] On the other hand, if (as is actual) sodium chloride being soluble in water is not governed by an emergent causal law, then it is not a case of strong emergence.

Two further examples illustrate this point. According to Wilson (2015), a property is strongly emergent from a physical property if and only if (1) its type nomologically supervenes on the physical property’s type, and (2) it has a token causal power distinct from any of the physical property’s token causal powers. The second condition encodes emergent autonomy: the macro-level property *causes* distinctly from its parts.[15] Applying Taylor’s recipe, we find micro-level

[12]These properties are meant to be causal. He says “the characteristic *behaviour* of the whole could not, even in theory, be deduced from the most complete knowledge of the *behaviour* of the components, taken separately or in other combinations, and of their proportions and arrangements in this whole” (Broad 1925, 59; emphasis mine).

[13]See Broad (1925, 59).

[14]This approach is well suited to Shoemaker’s (2002) account of emergentism. He distinguishes between two kinds of causal powers had by fundamental physical properties: those that manifest when physical properties combine in ordinary situations (micro-manifest powers), and those that manifest when physical properties combine in emergence engendering situations (micro-latent powers). The macro-level properties in ordinary situations are *physical* micro-structural properties (the micro-manifest properties and relations among the components); these are physically acceptable properties. The macro-level properties in emergence engendering situations are *emergent* micro-structural properties (the micro-latent properties, the micro-manifest properties, and relations among the components); these are emergent properties. However, as Taylor (2015, 744n25) observes, without a prior conception of the difference between an ordinary situation and an emergence engendering one, this distinction is ad hoc. According to my argument, a principled distinction between emergent causal laws and physical laws can provide this conception.

[15]Contrast this with physically acceptable macro-level properties, whose causal powers are token-identical to those of the micro-level physical properties on which they supervene.

https://doi.org/10.1017/can.2020.7 Published online by Cambridge University Press

properties that are sufficient for the macro-level causation of the emergent property. By the first condition, the emergent property's subvening physical properties are together nomologically sufficient for any effect it causes, and they are equally positioned to be the cause (they are located at the same space-time point as, and are as proximal to the effect as, the emergent property). The subvening physical properties thus have causal powers that together yield the emergent property's token-distinct causal power. Again, a principled distinction between emergent causal laws and physical laws can avoid this collapse: the emergent property has its token-distinct causal power (and hence the subvening physical properties have the powers that yield it) according to an emergent causal law, not just according to physical laws.[16]

According to O'Connor (1994), a property (of a whole) is strongly emergent if and only if (1) it strongly supervenes on the properties of the parts with whatever necessity causation has, (2) it is non-structural, and (3) it demonstrates novel causal influence. (Non-structurality ultimately means the property is not constituted [even in part] by the properties of the parts, unlike structural macro-level physically acceptable properties.) The second condition encodes a new kind of emergent autonomy: emergent wholes have properties that their parts don't constitute.[17] Applying Taylor's recipe, we find that the structural/non-structural distinction is ad hoc. A paradigmatic case of a structural property is total mass. But it is a matter of natural law whether total mass is constituted by the arithmetic sum of component masses or by a relativistic combination of mass and energy.[18] Likewise, by the first condition of the account (and the plausible connection between causation and laws), it is a matter of natural law that a non-structural property will be had by a whole given the properties of its parts. The physical properties of the parts thus account for the macro-level autonomous behavior, collapsing the emergent to the physical. Again, this time transparently, a principled distinction between emergent causal laws and physical laws can avoid collapse: non-structural properties are those governed by emergent causal laws, while structural properties are those governed by physical laws.

We might worry that this solution is too easy. Supposing a principled distinction between emergent causal laws and physical laws feels like just supposing a solution to the collapse problem. After all, collapsing emergent causal laws into physical laws plays a prominent role in Pepper's (1926) version of the problem. And Taylor looks at a series of proposed solutions to the collapse problem, distinctions that might allow certain micro-level properties not to count as physical (extrinsic/intrinsic, dispositional/non-dispositional, non-natural/natural), and finds them all wanting. We have to have reasons to believe that the distinction between emergent causal laws and physical laws will succeed where these other distinctions fail. Because of this, it is best to think of the collapse problem as a constraint on good, principled distinctions between emergent causal laws and physical laws. This is what I do in section 4, using Pepper's version of the collapse problem to provide the appropriate context.

Nevertheless, it is worth considering the possibility that any solution to the collapse problem entails a principled distinction between emergent causal laws and physical laws. Suppose there is a solution to the collapse problem. Then it makes sense to talk about autonomous, macro-level

[16]The above discussion illuminates one of the responses that Baysan and Wilson (2017) argue are available to secure Wilson's powers-based account against the collapse problem. The response is as follows: powers are had relative to a set of fundamental interactions, and the novel powers of emergent properties, and the powers of the subvening physical properties that yield them, are not had relative to the set of only fundamental physical interactions. This response transparently depends on there being a principled distinction between fundamental physical interactions and fundamental non-physical interactions. Given the plausible connection between fundamental interactions and laws, the response therefore presupposes a principled distinction between emergent causal laws and physical laws.

[17]The role of the third condition in autonomy and collapse is treated in the Wilson (2015) example above.

[18]In a Newtonian world, the total mass of a sodium chloride molecule is the arithmetic sum of the masses of a sodium atom and a chlorine atom. In our world, the total mass is somewhat less, because of the binding energy of the molecule and the relationship between energy and mass.

behavior of systems instantiating emergent properties. Governing this behavior will be an emergent causal law, as distinct from the micro-level physical laws governing the behavior of the parts in isolation or in other combinations. Since the autonomy is genuine (it doesn't collapse into the physical), the distinction between the emergent causal law and the physical laws is not arbitrary. So there is a principled distinction between emergent causal laws and physical laws.

More speculatively, it might be said that the collapse problem and the neutrality problem are in fact the same problem, but approached from different perspectives. The neutrality problem takes for granted that physicalism and strong emergentism can be contrasted, and the inability of supervenience-based accounts to contrast them reveals a problem in their formulation. The collapse problem doesn't take for granted that physicalism and strong emergentism can be contrasted, and the inability of accounts to contrast them reveals a metaphysical problem. So it is perhaps unsurprising that a principled distinction between emergent causal laws and physical laws solves both. I suspect this distinction can be interpreted as a representation of a more general metaphysical structure that distinguishes the modal relations in which emergent properties and physical properties must stand if the former are not to blur into the latter. Wilson (2015) and O'Connor (1994) are both sensitive to the neutrality problem, and both satisfy the neutrality condition by introducing what are probably best understood as attempts at other representations of the same structure (token-distinct vs. token-identical causal powers, non-structural vs. structural properties).[19]

4. Emergent causal laws and physical laws

A principled distinction between emergent causal laws and physical laws can solve both the neutrality problem and the collapse problem. In this section, I will propose such a distinction, using the collapse problem as a constraint. First, I will raise the collapse problem again in the context of a dilemma described by Pepper (1926) between collapse and no downward causation. Then, I will argue that distinguishing emergent causal laws and physical laws on the basis of a finite discontinuity in the behavior of physical systems as they become more complex is both necessary and sufficient to avoid the dilemma.

4.a Pepper and emergent causal laws

Pepper (1926) remarks that any candidate emergent law faces a dilemma: either it lacks downward causation (in which case it is not a genuine case of strong emergence) or it is properly classified as a physical law. The main part of his argument can be summarized as follows. The laws of physics describe the mathematical relations that govern the transformation of lower-level characteristics ("shifts"). If there are emergent laws, they must instead describe transformations of higher-level characteristics ("cumulative change") that cannot be deduced from the those at the lower level (i.e., unpredictable change). In order to be an emergent *causal* law, the higher-level characteristics must have a bearing on the transformation of the lower-level characteristics.

The lower-level transformation can be described in terms of a function of several variables (say, q, r, s, and t), and some range of values for some of the variables (say, r and s) constitute a level of

[19]Unsurprisingly, these thoughts apply to Baysan and Wilson's (2017) defense of Wilson's powers-based account against the collapse problem. They provide four available responses to the problem. See footnote 16 for a discussion of one of them. The remaining responses are: emergent properties have their novel causal powers *directly*, while the subvening physical properties have the powers that yield them *indirectly*; the novel powers of emergent properties are *substantial* dispositions consistent with ordinary causation, while the powers of the subvening physical properties that yield them are *lightweight* dispositions more akin to preconditions; and emergent properties bestow their novel powers to strongly emergent objects. To the extent that these responses (a) don't just push the collapse problem back a step, and (b) keep the truth of strong emergentism empirically accessible, they appear to be even more specific representations of the metaphysical structure described above.

https://doi.org/10.1017/can.2020.7 Published online by Cambridge University Press

integration at which the emergent causal law obtains. The transformations governed by this law cannot be described by a different function of the same set of variables, since only one function can accurately describe the relationships among the variables that actually obtain. Thus, the higher-level transformation has to be described by a function of a different set of variables (say, *r*, *s*, *a*, and *b*), which includes some genuinely novel emergent variables (*a* and *b*).

Pepper then presents his dilemma: either the new variables (*a* and *b*) are functionally related to the (remaining) lower-level variables (*r* and *s*), or they are not. Suppose they are not. In this case, there is no downward causation; the new variables are not governed by an emergent causal law, and so it is not a genuine case of strong emergence. But now suppose that the new variables are functionally related to the remaining variables. Then the new variables are part of the correct description of the lower-level transformation as well. This would mean that they are, properly speaking, physical variables. As Pepper says, "they have to drop down and take their place among the lower level variables as elements in a lower level shift" (242–43). Even if the new variables look very different from what is typically taken to be physical,[20] such variables are needed to describe the transformations at the fundamental level, and so are physical. This collapses the emergent causal law into the physical.

4.b Emergent causal laws and finite discontinuities

To respond to Pepper's dilemma, I propose to distinguish emergent causal laws and physical laws not by the nature of the law, and not (entirely) by the nature of the regions of the state space they govern, but rather by finite discontinuity at the boundaries of the regions. Let *S* be the state space of the universe in terms of all its fundamental physical constituents, and let *P* be those parts of the state space that represent the least complex states. A law is an emergent causal law if and only if (1) there is a region of *S*, *R*, such that the evolution of physical systems as a function of its state has a finite discontinuity along every path from every point in *P* to every point in *R*, and (2) the law holds in and only in *R*.

Let's elaborate this proposal in terms of Pepper's dilemma. Recall that the evolution of a physical system can be described as a function of physical variables. In Pepper's toy universe, variables *q*, *r*, *s*, and *t* are sufficient to describe a system in any way that matters to its evolution. The physical laws that together describe a change in the system are some function, f_1, of the four variables. By convention, f_1 describes the change in a region of (q, r, s, t)-space that includes the least complex configurations of the system. Call it the *non-emergence* region. If strong emergentism is true, then there is some other region of (q, r, s, t)-space, an *emergence* region, at which f_1 does not adequately describe the evolution. Some other function, f_2, does. A path in (q, r, s, t)-space from the non-emergence region to the emergence region has a finite discontinuity at some point if and only if the limit of f_1 as (q, r, s, t) approach the point along the path exists, the limit of f_2 as (q, r, s, t) approach the point along the path in the other direction exists, and the limits are not equal.[21] My proposal is that a principled distinction between emergent causal laws and physical laws requires that every path from any point in the non-emergence region to any point in the emergence region has a finite discontinuity at their boundary, i.e., that the boundary is finitely discontinuous. If f_1 and f_2 are landscapes in (q, r, s, t)-space, the boundary between the non-emergence region and the emergence region is a sheer cliff.[22]

[20] Pepper uses Lovejoy's (1924) example of the movement of complexes of particles being functions of the future movement of other complexes.

[21] Contrast a finite discontinuity with the infinite divergences discussed in Batterman (2011).

[22] This is not to say that the functions themselves can't give objective probabilities for discrete final states. But it does assume that the function that describes the change that a system undergoes is (for the most part) locally linear. If the variables themselves are discrete, this characterization would have to be modified accordingly.

https://doi.org/10.1017/can.2020.7 Published online by Cambridge University Press

Using finite discontinuities in this proposal has several virtues. First, a finite discontinuity is metaphysically significant. It is natural to see a finite discontinuity as indicating something genuinely new—where otherwise there is one, a discontinuity signifies two. Second, finitely discontinuous behavior would be an objective feature of the physical system. So a finitely discontinuous boundary delineates an objectively distinct region. Third, a finite discontinuity as a function of complexity conforms to our prior understanding of strong emergentism: the sudden appearance of a novel and brute law at a high level of complexity (McLaughlin, 1992); behavior on one side of the boundary being unpredictable from the behavior on the other side (Broad, 1925); manifesting a new causal power (Wilson, 2015; O'Connor, 1994).

Metaphysically, such a finite discontinuity can be interpreted in several ways. The natural interpretation, and the one that is relevant to this paper, is that it represents the appearance of a new law of nature. Because of the discontinuity, the function describing the interaction of elementary particles in the emergence region can be distinguished from the function describing their interaction in the non-emergence region. Two distinct functions are naturally interpreted as two distinct sets of laws. Relatedly, the finite discontinuity can be interpreted as marking a new force, which is felt by the particles only when they are in a configuration on one side of the discontinuity. Alternatively, the finite discontinuity can be interpreted as indicating that some fundamental force that already exists at low levels of complexity has a finite discontinuity in its intensity as a function of complexity. These interpretations may not ultimately be distinct; perhaps there is no difference between a force with a finite discontinuity in intensity and two forces, and perhaps there cannot be distinct forces without distinct laws. But in any case, they are operationally the same, since the finitely discontinuous boundary can be used to ground a principled distinction between emergent causal laws and physical laws.

This proposal appears to be sufficient to avoid Pepper's dilemma. Suppose strong emergentism is true, and there is a finite discontinuity at the boundary between two regions of (q,r,s,t)-space, a non-emergence region and an emergence region, the changes within which are described by f_1 and f_2 respectively. While it is true that f_2 may also be a function of new variables (a and b) that are required to describe lower-level changes in the emergence region, it does not follow that they must be treated as physical variables. There is no continuous function that describes the changes described by f_1 and f_2 in terms of all the variables simultaneously. The only way to describe the changes with a single function is to compose a piecewise function that disjoins f_1 and f_2, each to the appropriate region. But this composition introduces a new constant, one that delineates the emergence region.[23]

Furthermore, the proposal appears to be necessary to avoid Pepper's dilemma. Suppose there is no finite discontinuity at the boundary between the non-emergence region and the emergence region. Then there *is* a continuous function, f_3, that describes the changes described by both f_1 and f_2 in their respective regions in terms of all the variables simultaneously. The laws that hold at the lowest levels of complexity are therefore subtly different from those that are believed to hold, and this difference is revealed when they give rise (as a natural consequence) to supposedly emergent behavior at higher levels of complexity. Nevertheless, these laws hold at the lowest level of complexity and therefore are physical laws. Such is Pepper's conclusion above, and I think it holds absent a finite discontinuity.

[23]A piecewise function, f_3, can be defined as the disjunction of f_1 and f_2 :

$$f_3 = \begin{cases} f_1 & : \ (q,r,s,t) \notin R \\ f_2 & : \ (q,r,s,t) \in R \end{cases}$$

The new parameter, R, represents the emergence region, as delineated by the finite discontinuity.

https://doi.org/10.1017/can.2020.7 Published online by Cambridge University Press

It might be argued that even a piecewise function with a finite discontinuity is an acceptable function for describing how a system changes according to a physical law. A function is a function after all, and both continuous and discontinuous functions map the values of the variables in (q, r, s, t)-space to values describing the change in the system. This would take Pepper's conclusion the rest of the way, making an emergent causal law metaphysically impossible. If so, strong emergentism becomes a metaphysically suspect position. So much the worse for strong emergentism.

If my proposal is correct, to say that strong emergentism is true is to say that there is a finite discontinuity in the behavior of the fundamental constituents of matter as they evolve into some configuration. By convention, the set of laws that include only physical laws are those that govern the simpler configurations, and the set of laws that include emergent causal laws are those that govern the more complex ones.[24]

5. Conclusion

It seems to me that the best hope for a satisfactory understanding of strong emergentism is finitely discontinuous behavior as a function of complexity, defining a boundary between non-emergent and emergent regions in the state space of fundamental physical constituents. A finitely discontinuous boundary can ground a principled distinction between emergent causal laws and physical laws. This in turn allows us to define two kinds of necessity, nomological and quasi-physical, for simple, contrasting, supervenience-based formulations of physicalism and strong emergentism that are neutral with respect to unrelated metaphysical issues. We can talk once again about physically acceptable properties strongly supervening with physical necessity on physical properties, as long as we understand physical necessity as quasi-physical necessity.

It also provides a solution to the collapse problem, allowing for a metaphysically non-arbitrary strong emergentism as distinct from physicalism. It is not the nature of the property itself that makes it emergent. An emergent property can a priori be anything at all. Perhaps solubility in water is physically acceptable in the actual world, but it (or something functionally equivalent) might be emergent in a possible world with very different physics. What makes a property emergent is the relationship that the laws that govern it bear to those that govern the least complex systems.

On the other hand, if a finitely discontinuous boundary is unsatisfactory in some way, and a principled distinction between emergent causal laws and physical laws cannot be made, then it's not obvious that strong emergentism is metaphysically distinct from physicalism. Such a result would not be wholly unwelcome. If strong emergentism were indeed metaphysically suspect, then the naïve account of physicalism is as good as any, and the lives of physicalists are made that much easier. Physical possibility can be interpreted as nomological possibility, and the detour through quasi-physical possibility can be avoided entirely.

Ranpal Dosanjh is an assistant professor at Iowa State University. He works primarily in metaphysics and philosophy of mind.

References

Batterman, R. 2011. "Emergence, Singularities, and Symmetry Breaking." *Foundations of Physics* 41: 1031–50.

Baysan, U., and Jessica Wilson. 2017. "Must Strong Emergence Collapse?" *Philosophica* 91: 49–104.

Black, R. 2000. "Against Quidditism." *Australasian Journal of Philosophy* 78: 87–104.

Broad, C. D. 1925. *The Mind and Its Place in Nature*. London: Kegan Paul, Trench, Trubner & Co.

Fine, K. 2002. "The Varieties of Necessity." In *Conceivability and Possibility*, edited by T. S. Gendler and J. Hawthorne. Oxford: Clarendon Press.

Handfield, T. 2004. "Counterlegals and Necessary Laws." *Philosophical Quarterly* 54: 402–19.

[24]It might be that a finite discontinuity separates two regions both of which are maximally simple, and so both have equal claim to being the non-emergence region. In that case, plausibly, the finite discontinuity represents not a set of laws that includes an emergent causal law, but a new set of physical laws.

https://doi.org/10.1017/can.2020.7 Published online by Cambridge University Press

Hawthorne, J. 2001. "Causal Structuralism." *Philosophical Perspectives* 15: 361–78.
Heller, M. 1998. "Property Counterparts in Ersatz Worlds." *The Journal of Philosophy* 95: 293–316.
Kim, J. 1998. *Mind in a Physical World*. Cambridge, MA: MIT Press.
Kim, J. 2005. *Physicalism, or Something Near Enough*. Princeton, NJ: Princeton University Press.
Lovejoy, A. O. 1924. "The Discontinuities of Evolution." In *Essays in Metaphysics: Lectures Delivered Before the Philosophical Union, University of California, 1923–1924.* University of California Publications in Philosophy 5, edited by G. P. Adams and J. Loewenberg, 173–220. Berkeley, CA: University of California Press.
McLaughlin, B. P. 1992. "The Rise and Fall of British Emergentism." In *Emergence or Reduction? Essays on the Prospects of Nonreductive Physicalism*, edited by A. Beckerman, H. Flohr, and J. Kim, 49–93. Berlin: de Gruyter.
McLaughlin, B. P. 1997. "Emergence and Supervenience." *Intellectica* 25: 25–43.
O'Connor, T. 1994. "Emergent Properties." *American Philosophical Quarterly* 31: 91–104.
O'Connor, T., and Hong Yu Wong. 2005. "The Metaphysics of Emergence." *Noûs* 39: 658–78.
Pepper, S. C. 1926. "Emergence." *Journal of Philosophy* 23: 241–45.
Robinson, D. 1993. "Epiphenomenalism, Laws and Properties." *Philosophical Studies* 69: 1–34.
Schaffer, J. 2005. "Quiddistic Knowledge." *Philosophical Studies* 123: 1–32.
Seager, W. 2012. *Natural Fabrications: Science, Emergence and Consciousness*. Heidelberg, Ger.: Springer.
Shoemaker, S. 2002. "Kim on Emergence." *Philosophical Studies* 108: 53–63.
Taylor, E. 2015. "Collapsing Emergence." *The Philosophical Quarterly* 65: 732–53.
Van Cleve, J. 1990. "Emergence vs. Panpsychism: Magic or Mind Dust?" *Philosophical Perspectives* 4: 215–26.
Wilson, J. 2002. "Causal Powers, Forces, and Superdupervenience." *Grazer Philosophische Studien* 63: 53–78.
Wilson, J. 2005. "Supervenience-Based Formulations of Physicalism." *Noûs* 39: 426–59.
Wilson, J. 2015. "Metaphysical Emergence: Weak and Strong." In *Metaphysics in Contemporary Physics*, edited by T. Bigaj and C. Wüthrich, 251–306. Amsterdam, Nether.: Rodopi Brill.

Cite this article: Dosanjh, R. 2020. Emergent Causal Laws and Physical Laws. *Canadian Journal of Philosophy* 50: 622–635, doi:10.1017/can.2020.7