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NON-CAUSAL LAWS: AN ALTERNATIVE HYPOTHESIS TO ARMSTRONG'S HYPOTHESIS

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Abstract. Non-causal laws have long been a thorn in David Armstrong's side. This paper aims to provide a more accommodating framework for these laws within Armstrong's metaphysics of laws of nature. Armstrong proposed the hypothesis that non-causal laws supervene upon causal laws. In this paper, I present arguments against Armstrong's hypothesis and propose an alternative hypothesis: non-causal laws are fundamental laws, not supervenient upon causal laws. Additionally, as some non-causal laws are functional laws, this paper will also delve into characterising the nature of functional laws. Finally, I will demonstrate how my conception of non-causal laws solves the identification problem posed by Bas van Fraassen.

Keywords: David Armstrong • laws of nature • metaphysics • functional laws • supervenience

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1. Introduction

According to David Armstrong (1983; 1997a), laws of nature are first-order universals, symbolised by N(F,G): a second-order universal, N, connects first-order universals, F and G. The instances of these laws exist within space-time. Universals are immanent (*in rebus*) and fully present in every instantiation of the law. The laws of nature are nomic necessary but metaphysical contingent. This means that, for instance, in the actual world, electrons repel each other. However, in other possible worlds, electrons may attract each other.

It appears that there are scientific laws that are non-causal laws, such as conservation laws and Boyle's law. It does not seem that potential energy causes kinetic energy, or vice versa. It does not seem that the pressure causes the volume, or vice versa. Rather, there is a kind of coexistence between potential energy and kinetic energy regulated by the principle of energy conservation. Likewise, there is a coexistence between pressure and volume regulated by Boyle's law.

In several passages, Armstrong remarked that non-causal laws were an open problem in his metaphysical system of laws of nature: "[b]ut are there perhaps laws of nature that are both irreducible and non-causal? If there are, what account is to be given of them? This is unfinished business for me" (Armstrong 1993, p.422); "[t]here is much further investigation to be done on this topic, an investigation that may produce surprises" (Armstrong 1997b, p.510). Finally, Armstrong (1997a, p.231) puts forward the following hypothesis: non-causal laws are supervenient upon causal laws.

In this paper, I will argue against Armstrong's hypothesis that *non-causal laws are supervenient upon causal laws*. Instead, I propose an alternative hypothesis: *non-causal laws are fundamental laws*. That is, non-causal laws are not supervenient upon causal laws. This hypothesis holds true for every type of non-causal laws, whether functional or non-functional. A non-causal law is a first-order universal: a second-order universal, *N*, that connects first-order universals, *F* and *G*. The instances of a non-causal law are in space-time. Non-causal laws are an addition to the being. Nomic necessity is not identified with causation. The template is the following:

(_being *F*) nomic necessitates (_being *G*)

Where *_being F* and *_being G* are universals; and the blanks should be filled by the same distinct particular.[1] The state of affairs *type* of the first parenthesis necessitates the state of affairs *type* of the second parenthesis. This relation is one of contingent necessity. For example, let *a* be a particular and *a* is *F*. Then, according to the law, *a* is also *G*:

(*a* being *F*) nomic necessitates (*a* being *G*)

In the next section, I will quote several passages of Armstrong that support his hypothesis. Then, I will introduce Armstrong's definition of supervenience. I will address certain concerns related to the application of Armstrong's definition of supervenience to non-causal laws. Given that some non-causal laws take the form of functional laws, I will characterise the metaphysical nature of functional laws. Then, I will discuss some objections. I will address Bas van Fraassen's identification problem concerning laws of nature. I will show how my hypothesis on non-causal laws can solve this problem.

This paper focuses exclusively on Armstrong's metaphysics, specifically addressing "empirical" non-causal laws within his framework. I will not engage with contemporary discussions on non-causal laws outside of Armstrong's metaphysics (e.g. Kistler 201)), nor will I address recent debates on non-causal explanations (e.g. Reutlinger & Saatsi 2018) or those involving mathematical constraints (e.g. Lange 2016 and Castro 2022). However, in the conclusion, I will briefly comment on the mathematical explanation of physical phenomena in relation to the metaphysical analysis presented here.

This paper falls within the domain of the metaphysics of science. It is on laws of nature. It assumes a distinction between scientific laws and laws of nature: laws of nature are the truthmakers for scientific laws. In other words, scientific laws are considered true or approximately true because laws of nature exist. Examples of scientific laws include Newton's laws, Boyle's law and the kinetic theory. This paper assumes that certain scientific laws are causal, while others are non-causal. It is important to note that the specific assumptions made here are not crucial to the paper's arguments. For instance, the paper does not engage in an epistemic argument regarding whether Boyle's law and conservation laws are *genuinely* non-causal scientific laws. If someone believes that these scientific laws are not "ideal" examples of non-causal laws and prefers to replace them with other scientific laws, they are free to do so.[2]

2. Armstrong's hypothesis for non-causal laws

How to square the non-causal laws in Armstrong's theory of laws? Initially, Armstrong defended that causal laws were a sub-species of the laws of nature, but he did not mark off these laws: "Causal laws are a mere sub-species of the possible laws of nature. What marks off the sub-species is not investigated in this work" (Armstrong 1983, p.157). Moreover, he emphasised that "we cannot identify causation with (natural) necessitation (...) we cannot identify causal laws with laws of nature" (Armstrong 1983, p.95).

Later, he tried to mark off the causal laws:

> We distinguish between laws that are causal from those that are not. If singular causes are nothing but instantiations of (strong) laws, then what makes law into a *causal* law? After all, some laws are causal, some are not. It may seem that the special nature of causality is still eluding us. A suggestion for answering this important difficulty will be proposed in the next chapter. In brief, the suggestion is that all *fundamental* laws are causal. (Armstrong 1997a, p.219)

> All laws that are both *first-order* and are *fundamental* are causal. To say that a law is first-order is to say that is not a law that itself governs laws (as may be the case with functional laws). To say that a law is fundamental is to say that it does not supervene on any other law or laws. (Armstrong 1997b, p.508)

Then, Armstrong shifted his position. He identified singular causation with instantiation of nomic necessitation and he identified causation with nomic necessitation. In particular, he claimed "[f]or N I am now substituting C for cause" (Armstrong 1997a, p.228).

Finally, he claimed that non-causal laws are supervenient upon causal laws.

> Not all scientific laws are causal laws. What is the nature of the connection between universals in a non-causal law? The hypothesis now to be put forward is of a sort that the reader has become familiar with, one hopes not sickened by! Given all the causal laws, then any further laws that there are *supervene,* are entailed. (Armstrong 1997a, p.231)
>
> What we still do require, though, is a distinction between laws strictly so-called, and mere nomic truths. It is these latter that supervene, and perhaps include the 'non-causal laws'. (Armstrong 1997a, p.233)

This is Armstrong's hypothesis:

(H) Non-causal laws are supervenient upon causal laws.

3. Armstrong's supervenience

Armstrong illustrates the relation of supervenience using Boyle's law as an example. Boyle's law establishes a correlation between pressure (P), volume (V) and temperature (T), for an ideal gas: $PV = kT$, where k is a constant. According to Armstrong, this law supervenes on the molecular gas movement. The molecular gas movement is described by the kinetic theory of gases. For the sake of simplicity, let us assume that the kinetic theory of gases is a causal law that governs the molecular gas movement, while Boyle's law is a non-causal law. In this scenario, we can conclude that Boyle's law supervenes on the kinetic theory.

Armstrong's definition of supervenience differs slightly from the traditional definition of supervenience based on properties:

> We shall say that entity Q supervenes upon entity P if and only if it is impossible that P should exist and Q not exist, where P is possible. (...) supervenience in my sense amounts to entity P *entailing* the existence of entity Q, but with the entailment restricted to the cases where P is possible. (Armstrong 1997a, p.11)
>
> No difference in what supervenes without some difference in the base that it supervenes upon, with absolute necessity. (Armstrong 1997a, p.45)

Armstrong adds the following premise: the supervenient is not an addition to the being. This is known as *the doctrine of ontological "free lunch"*. For instance, given two individuals, a and b, the set $\{a, b\}$ is supervenient on the individuals. The supervenient entity, $\{a, b\}$, is not an ontological addition to the subvenient base (Armstrong 1982, p.4). That is, $\{a, b\}$ exists, because a and b exist.

The doctrine of "free lunch" is controversial. Several authors have argued that this doctrine is incoherent. They claim that if the supervenient is distinct from the subvenient, then the supervenient should be considered an addition to the being.

That is, the supervenient entity should be considered an addition to the subvenient entity. For instance, Edward Lowe (2011) claims that a free lunch is a *lunch*. It is an addition to the base. On the contrary, Armstrong claims that the supervenient is not an addition to the being, yet it is not unreal. For instance, second-class states of affairs are supervenient on first-order states of affairs, but "this does not make the second-class properties unreal (...) that does not make it non-being" (Armstrong 1997a, p.45–46).[3]

4. Non-causal laws and supervenience

In Armstrong's metaphysical system there are three types of entities: particulars, universals and states of affairs. Particulars instantiate universals. The outcome of this instantiation is a (first-order) state of affairs. Thus, "all that there is, is a world of states of affairs" (Armstrong 1997a, p.1). These states of affairs are constituted by particulars and universals, where each universal is either a property or a relation. Applying Armstrong's definition of supervenience to hypothesis (H), it follows that all non-causal laws are no addition of being, but they are not unreal. I have some concerns regarding the application of the definition of supervenience to non-causal laws.

First, there are certain issues concerning supervenience and identity. Armstrong claims that if Q supervenes upon P, the definition of supervenience "leave[s] it open that P also supervenes upon Q" (Armstrong 1997a, p.12). That is, supervenience can be symmetrical. Armstrong also claims that "symmetrical supervenience yields identity" (Armstrong 1997a, p.12). For instance, if the whole supervenes in its parts and the parts supervene upon the whole, then the whole is identical to its parts.[4] Armstrong (1997a, p.231–232) speculates to some extent whether the causal/noncausal relation is one of symmetrical supervenience: "[c]ould it be that non-causal laws supervene on the causal laws and the causal laws supervene on the noncausal laws?". He concludes that symmetrical supervenience does not undermine his account.

It seems to me that if symmetrical supervenience yields identity, then the causal/non-causal relation cannot be one of symmetrical supervenience. The argument goes as follows. If the causal/non-causal relation were one of symmetrical supervenience, then causal laws would be identical to non-causal laws. That is, "the two systems of law were ontologically identical" (Armstrong 1997a, p.231). This would not make sense. Boyle's law is not identical to the kinetic theory. Boyle's law is a non-causal law, whereas the kinetic theory is a causal law. They have different metaphysical natures. They connect different universals. Therefore, by *modus tollens*, the causal/non-causal relation cannot be one of symmetrical supervenience.

Armstrong is silent about asymmetrical supervenience and identity. Nevertheless, it seems that, in every case, "asymmetrical supervenience must yield non-identity" (David 2005, p.148). For any P and Q, if P supervenes upon Q, but Q does not supervene upon P, then P is not identical to Q. However, if P is not identical to Q, then P cannot be considered a "free lunch". In our present analysis, if the causal/non-causal relation is one of asymmetrical supervenience, then non-causal laws are not identical to causal laws. However, if non-causal laws are not identical to causal laws, then non-causal laws cannot be seen as a "free lunch". A similar issue arises with non-symmetrical supervenience, as non-symmetrical supervenience is partially contained in asymmetrical supervenience.[5]

Second, in light of Armstrong's hypothesis (H), there are some open questions regarding the relation between the supervenient laws (non-causal laws) and the subvenient laws (causal laws). For the sake of simplicity, let us assume that BL law (a non-causal law) supervenes upon KT law (a causal law).

a) Let W_1 be a possible world. In W_1, KT law is exactly the same as the law of the actual world. Is it possible for BL law to be different from the BL law of the actual world? Armstrong does not address this issue.
b) Let W_1 be a possible world. In W_1, KT law is different from the law of the actual world. Must BL law to be different from the BL law of the actual world? Armstrong remains silent about this issue.

Third, recall that, according to Armstrong's conception, laws of nature (whether causal or not) are metaphysical contingent laws. For instance, in this world, electrons repel each other, but in other possible worlds, electrons may attract each other. However, if we apply Armstrong's definition of supervenience to non-causal laws, then non-causal laws do not appear to be "fully" metaphysical contingent laws. They seem more like *semi*-metaphysical contingent laws. In other possible worlds, for example, Boyle's law cannot exist if the kinetic theory does not exist. In worlds where the kinetic theory exists, Boyle's law must also exist (however, supervenience does not imply that Boyle's law is exactly the same law as in the actual world). As far as I know, Armstrong never acknowledged this tension in his view of non-causal laws.

Fourth, could it not be considered a law of nature that *every non-causal law is supervenient upon a causal law*? That is, could the preceding italicised sentence be considered as a sort of higher-order law of nature? Thus far, we do not have any idea of what the higher-order scientific law would be, true or approximately true, for this correspondingly higher-order law of nature. Given that scientific laws reflect laws of nature, it seems unlikely that this alleged higher-order law of nature holds. However, for the sake of argument, if it were a law of nature, then clearly, it would be a non-causal law. By definition, a higher-order law of nature concerning all non-causal laws cannot itself be a causal law of nature. Furthermore, it would be a non-causal law that does not supervene upon a causal law. This non-causal law would also be a metaphysical law concerning a common property of all non-causal laws. Metaphysical laws do not supervene upon causal laws of nature. Rhetorically, what fundamental causal law of nature would serve as the basis for such a metaphysical law?

Something is wrong in Armstrong's hypothesis (H): non-causal laws are not identical to causal laws; we do not get a "free lunch" in every case of supervenience; non-causal laws are *semi*-metaphysical contingent laws. If we put all the blame on Armstrong's definition of supervenience, we risk throwing the baby out with the bathwater. Moreover, I will endorse one of Armstrong's characterisations of functional laws, where Armstrong's supervenience is essential to articulate that characterisation (see below). Given that some functional laws are non-causal laws, I cannot entirely dismiss Armstrong's definition of supervenience. Therefore, a more cautious approach is required: 1) non-causal laws must be dissociated from causal laws; 2) the alleged supervenient relation between non-causal laws and causal laws does not hold.

5. Functional laws

Some non-causal laws can be functional laws. Thus, it becomes necessary to present a characterisation of functional laws that is consistent with my hypothesis concerning non-causal laws. I will endorse one of Armstrong's characterisations of functional laws: functional laws are contingent relations that connect determinable properties. While this characterisation is consistent with my hypothesis regarding non-causal laws, it raises a challenge when it comes to causal functional laws. In this section, I will provide a hint to solve this issue.

Functional laws are laws of the form $f(P) = Q$, where P and Q range over different possible values of the magnitudes P and Q. P and Q are second-order universals. Initially, Armstrong (1983, p.111) argued that a functional law is a conjunction of simple laws. A simple law is a law for individual values of P and Q, such as the pair (P_1, Q_1), that is, $f(P_1) = Q_1$. Every value of P and Q is a first-order universal. That is, each P_i (respectively, Q_i) is a different first-order universal ($i = 1$ to n). $P = \{P_i\}$ and $Q = \{Q_i\}$ are second-order universals ($i = 1$ to n). The functional law is the conjunction of all $f(P_i) = Q_i$. Synthetically, if $N(P, Q)$ is a functional law, then N is a third-order universal that connects second-order universals, P and Q, and $N(P, Q)$ is a second-order universal. This account is identical to the account for $N(F, G)$ mentioned earlier but constructed one order higher. Armstrong clarifies $N(P, Q)$ in the following terms:

> This second-order state of affairs $[N(P, Q)]$ will also be a second-order dyadic universal (...) and its instances will be pairs of first-order universals of which

> the first member is an instance of P and the second member is the appropriate instance of Q. The instances of the law will thus be first-order laws of nature. (...) Since N is the same relation as that to be found in $N(F, G)$, then (...) first-order laws can be deduced. For example, it can be deduced that something's having the property P_1 necessitates that that same thing has Q_1, where $Q_1 = f(P_1)$. In this case, the second-order law not only governs the first-order law, but fully determines its content. (Armstrong 1983, p.114)

Later, Armstrong made certain adjustments to this proposal. Functional laws contingently connect determinable properties. Functional laws are determinable laws. In each of these determinable laws falls a class of determinate laws (Armstrong 1997a, p.242).

Let us illustrate this view using Newton's law of gravitation. Basically, this law states that there is an attractive force between two distant masses. Formally, f — the force — is a function of three variables, such that $f = f(m_1, m_2, r)$. For simplicity, let us assume that this function is a real function, i.e., $f(\mathbb{R}^3) \to \mathbb{R}$. Each set of triple values (m_1, m_2, r) generates a determinate law. All these determinate laws fall under the functional determinable law — i.e. the law of gravitation. This law is a higher-order law that unifies and explains the determinate laws that fall under it.

Supervenience also plays a role in this characterisation: determinable properties supervene upon determinate properties. For example, mass property is a determinable property that supervenes upon all specific mass properties. Mass property is a property of all determinate mass properties. It is a non-relational universal. Furthermore, the existence of determinable properties is necessary. In the actual world, if the determinable property of mass supervenes on the determinate properties of mass, then there is no world with determinate mass properties that lacks a supervenient determinable property of mass (Armstrong 1997a, p.247).

However, functional laws do not supervene on determinate properties. Functional laws are non-supervenient laws; they are contingent relations that connect determinable properties. Only determinable properties are supervenient on determinate properties.

> This point was for long a stumbling block for me in working out an account of functional laws, which I thought of as contingent like all other laws. But it seems that it should not have been an obstacle. Just because a ton or a kilo is necessarily a mass, and a mile necessarily a distance, is no reason why the determinables of mass and distance, taking them to be real universals, should not be *contingently* connected with the force they generate, according to some functional relationship.(...) It is a non-supervenient law [law of gravitation] involving (and here is the trick) the supervenient determinable property of mass and the supervenient determinable relation of distance. (Armstrong 1997a, p.247–248)

I think that this characterisation is correct. Functional laws are contingent relations that connect determinable properties. Determinable properties are universals and are supervenient on determinate properties. Functional laws, on the other hand, are non-supervenient laws. However, contrary to Armstrong, according to my hypothesis, I claim that functional laws are non-supervenient laws *tout court*, that is, non-causal functional laws are non-supervenient laws. Non-causal functional laws are not supervenient upon causal laws.

However, this characterisation faces a challenge in regard to *causal* functional laws. Let us recall Newton's law of gravitation. At the determinate level, various specific values of mass and distance *cause* different values of force. However, causation cannot operate at the determinable level, as the determinable level is an acausal domain. The properties of *being mass* and *being distant* cannot cause the property of *being force*. Functional laws can only operate at the causal determinate level. How can we solve this issue?

Here is a hint. Causal functional laws are governed by two different types of nomic necessity. First, determinate causal functional laws are governed by nomic causal necessity. That is, they are causal connections between determinate properties. Second, determinable functional laws are governed by nomic acausal necessity. The determinate properties of a given law fall under a common functional determinable law. This functional determinable law is governed by nomic necessity. However, this is not causal necessity. This is the same kind of necessity of the non-causal functional laws. That is, they are necessitarian connections between acausal determinable properties.

Armstrong (2010, p.43) attempts to solve the above problem by adopting a different approach. He discards the earlier characterisation and proposes an alternative one for functional laws. He argues that determinable properties are not genuine universals. He restates his position from Armstrong (1978, chap. 22, sec. I). While determinables are properties, they are not strictly identical in their various instantiations. Thus, functional laws are not necessary connections between determinables. Instead, Armstrong claims that functional laws are mathematical relationships between determinable properties concerning bundles of particularised laws.

> The determinables, very important properties but not universals, when suitably connected by some mathematical relationship, give, as it were, 'instructions' for the particularized laws where the work of the world is done. (Armstrong 2010, p.43)

For instance, the law of gravitation is a bundle of determinate laws. Functional laws do not govern the particularised laws, but rather provide "instructions" for the particularised determinate laws. At the end of the day, this approach leads to a more austere ontology. Functional determinable laws are not states of affairs. This "new" characterisation of functional laws implies some serious tensions within Armstrong's metaphysical system.

First, as far as I can see, the necessitarian finds themselves in a position similar to that of the Humean regularist. Both acknowledge the existence of a bundle of determinate laws, but neither can find a unifying genuine determinable functional law! A necessitarian would say that there are multiple necessitarian connections concerning the specific values of the functional law. A regularist would say that there are multiple regularities concerning the specific values of the regular functional law (Mumford 2007, p.45). For both, the functional law would be just about these instantiated values.

However, according to our best science, functional laws are not solely about the instantiated specific values of the functional law. They are about all possible values of the functional law. That is, functional laws are about instantiated and uninstantiated values. Moreover, they are about the properties of properties — universals. The determinable law connects these universals. It is an atomic state of affairs. For instance, Newton's law of gravitation is about the second order properties of *mass*, *distance* and *force*. The specific values of mass, distance and force are first order properties – universals. Each determinate law connects these universals. These determinate laws are grouped under the functional law of gravitation. This functional law both governs and explains the determinate laws. It is not merely a matter of "instructions"; it is a matter of governing and of explanation.

Second, the problem of uninstantiated values of the functional values becomes very acute for the necessitarian. For instance, if we assume that the domain of the law of gravitation is the domain of real numbers, then the possible values for m_1, m_2 and r do not instantiate "all" possible real numbers! How can we solve this problem? Initially, Armstrong solved this problem by a counterfactual scenario.

> Sometimes there is, strictly, no determinate law for certain particular values falling under the determinable law, because the antecedent value is omnitemporally never instantiated. But we can conjoin the statement of determinable law with the false statement that the antecedent is somewhere instantiated, and then deduce the determinate law that would have obtained given this false condition. (Armstrong 1997a, p.245)

Here, the counterfactual scenario is sustained in a genuine law of nature (a necessitarian connection between determinable (universal) properties). However, in light of the "new" definition of Armstrong on functional laws, he attempted to sustain the counterfactual scenario in a pseudo-law: a mathematical relationship.

> The truthmaker would be the connection between the determinable properties that explains the observed connections in the actual cases. Given the law plus the imaginary case, the outcome is determined. (Armstrong 2010, p.43–44)

I think that this last solution is incorrect. Actually, there is no law at all! A mathematical relationship between non-universal determinable properties is not a genuine law. It is a pseudo-law. On the contrary, laws are necessary connections between universals. They are irreducible laws. Without universals there are no laws; without laws there are no counterfactual scenarios.

6. Objections met

It may be objected that, in every case, non-causal functional laws are not an addition to the being. For instance, Boyle's law describes a correlation between the determinables of pressure, volume and temperature. These determinables are supervenient upon determinate values. According to Armstrong's definition of supervenience, these determinables are not an addition to the being. For instance, the determinable *volume* is supervenient upon the collection of determinate volume properties. Thus, Boyle's law is not also an addition to the being because it connects determinables. By definition, determinables are not an addition to the being.

The previous objection presupposes three different things: a) functional laws, b) non-causal laws and c) the relation of each other to the being. 1) According to Armstrong's view on functional laws (1997a), functional laws are an addition to the being because they are non-supervenient laws. That is, *the functional determinable laws* being + *the functional determinate laws* being = *the functional determinable laws* being + *the functional determinate laws* being. 2) According to Armstrong's view on non-causal laws, non-causal laws are not an addition to the being because they are supervenient upon causal laws. That is, *the causal laws* being + *non-causal laws* being = *causal laws* being. I agree with 1) but I disagree with 2). That is, *the causal laws* being + *non-causal laws* being = *causal laws* being + *non-causal laws* being because non-causal laws are non-supervenient laws. The objection misunderstands the cases 1) and 2).

My discordance with Armstrong is on the nature of non-causal laws. I think that Armstrong's definition of supervenience does not apply to non-causal laws. Boyle's law establishes a correlation between the determinables of pressure, volume and temperature. These determinables are universals. According to Armstrong's definition of supervenience, they are not an addition to the being. They are entailed by the determinates (and conversely). However, contrary to Armstrong, Boyle's law itself is an addition to the being. It is a third-order universal, N, connecting second-order universals (the determinables). The law is non-supervenient. It is a state of affairs. Specifically, it is an atomic state of affairs that nomically ensures that each particular determinate law obeys a functional relationship.

It may be objected that there is a tension in claiming that 1) supervenience does not apply to non-causal laws and 2) supervenience applies to determinables.

I have raised some concerns regarding the application of Armstrong's definition of supervenience to non-causal laws. However, I am not entirely rejecting Armstrong's definition of supervenience. The determinable/determinates relation is different from the causal/non-causal relation. Determinates are linked by partial identity. That is, there is a uniting principle in each class of determinates that fall under the determinable. The determinable is constituted by the determinates that fall under it. On the contrary, causal laws are not linked by partial identity. Moreover, a non-causal law is not constituted by causal laws. For instance, there is no uniting principle between the kinetic theory and, let us say, Kirchhoff's law.

Ted Sider (2005, p.691) objects that, in the case of whole/parts relation, the "free lunch" doctrine "is the eerily attractive yet scarcely intelligible claim that a *single* thing is identical to its *many* parts". I think that this objection does not intersect with my point. Specifically, the determinable/determinates relation is not a whole/parts relation. Paris and Lyon are part of France, but 1 kg of mass and 2 kg of mass are not part of mass. The determinates falling under a determinable resemble each other. They are linked by partial identity. However, two different partial identical things cannot be strictly identical to a same single thing.

It may be insisted that non-causal laws are not an addition to the being, as they occupy the same space-time position as causal laws. For instance, in the case of an ideal gas, Boyle's law occupies the exact space-time position of the kinetic theory that governs the molecules of that ideal gas. Even if these laws connect different universals, say, $N(F,G)$ and $N^*(H,J)$, the universals, $N(F,G)$ and $N^*(H,J)$, remain precisely located in the same space-time position.

Boyle's law is about the determinables of pressure, volume and temperature. Boyle's law is about the behaviour of macroscopic entities, namely, it is about ideal gases. The kinetic theory concerns the determinables of mass, velocity and energy. The kinetic theory concerns the behaviour of microscopic entities, namely, the molecules of an ideal gas. From a scientific point of view, it does not make sense to say that molecule x has pressure p; and, for the same reason, it does not make sense to say that the ideal gas y has velocity v. Given these clarifications, for an ideal gas, it is obscure to claim that Boyle's law is exactly located in the same space-time position of the kinetic theory. These two laws concern different determinable universals.

Michael Tooley remarked that if Newton's third law is a non-causal law, as it seems to be, then this law is supervenient "upon the force laws together with a 'totality fact' (...) this totality fact, however, is not itself a law, let alone a causal law" (Tooley 2003, p.427).[6] Thus, Newton's third law is a non-causal law; and this law is not only supervenient upon causal laws. This is an alleged counterexample to my proposal because I claim that non-causal laws are fundamental laws, that is, they are not supervenient laws. I reply that Newton's third law is not a law of nature. It is a simple regularity. Thus, this example does not contradict my proposal.

7. Non-causal laws and the identification problem

My hypothesis on non-causal laws must address a major problem: the identification problem of Bas van Fraassen (1989, chaps 5, section 1).[7] The identification problem is the issue of identifying the law-making relation between the universals of a law. Which relation is the nomic necessitation relation?

Armstrong (1993; 1988) solves this problem in the following way. The pressure on our body is a particular impression of causation. From this impression, we can derive the idea of causation. Around us, the phenomena of singular causation exhibit a pattern: the same causes entail the same effects. There is singular causation between tokens. Then, we can transfer this notion of singular causation to a higher level — the level of universals. This is a posit. It is postulated that there is also causation between the universals that instantiate these tokens. This postulation is an inference to the best explanation (Armstrong 1983, p.98). Specifically, there is causation between states of affairs types. Armstrong solves van Fraassen's problem of identification by equating causation with nomic necessitation. Needless to say, this solution cannot be applied to non-causal laws. That is, causation cannot be equated with nomic necessity.

Tooley (2003, p.428) remarked that the identification of causation with nomic necessity implies that backward causation is logically possible. That is, symmetrical cases of necessitation, $N(F, G)$ and $N(G, F)$, are logically possible. This is the argument. It seems to be a law of nature — a basic law — that every state of affairs, say, Fa, must have a prior cause: that is, every state of affairs necessitates a prior cause. This law is consistent with the possibility that the prior cause necessitates the state of affairs Fa. If necessity is identified with causation, then the prior cause *causes* Fa and Fa *causes* the prior cause. This implies backward causation! Armstrong (1983, p.157) denied backward causation. Thus, in that book, he conceded that nomic necessity cannot be identified with causation. There is room for necessities that are not causal necessities.[8]

The relation of nomic necessity is not exhausted by causation. There are both causal and non-causal phenomena. Regarding the identification problem, causal phenomena, if governed by law, are explained by Armstrong's solution outlined above. Non-causal phenomena, if governed by law, are metaphysical explained by an analogous solution.

We observe some regularities in nature that are non-causal. For example, in an ideal gas, we observe a correlation between pressure, volume and temperature. This correlation is exactly the same in every observed ideal gas. The correlation obeys a mathematical relationship. This is not a fluke. Our best science seems to indicate that Boyle's law is a non-causal law. Moreover, some conservation laws seem to be non-causal laws and there is evidence that some physical phenomena are explained by mathematical propositions. These mathematical cases seem to be additional cases of non-causal laws (see conclusion below). Thus, it seems wise to postulate that these token non-causal cases are necessarily connected by universals. It is a case of inference to the best explanation once again.

Armstrong himself allows for the possibility that the identification problem could be solved by postulation, if there were "no such direct awareness of singular causation" (Armstrong 1997a, p.228). However, he does not make such a move in the case of non-causal laws.

Postulation is a common procedure in science. By way of comparison, Quine (1981) established a criterion to determine the ontological commitments of our best scientific theories. According to this criterion, an entity x exists if, and only if, x is the value of a bound variable in one of our best scientific theories (regimented in first-order logic). We postulate entities within our scientific theories. We conduct experiments against these scientific theories. We evaluate these theories considering some theoretical benefits, such as simplicity, scope and empirical confirmation. Some of these entities are causal entities and others are non-causal entities. Quine argued that we should also commit to abstract entities, such as numbers, because mathematical entities are indispensable to our best scientific theories. Here, we do not need to fly into the Platonic heaven. Non-causal entities, like non-causal laws, but within space-time, suffice. Quine was not committed to laws of nature because he rejected relations and states of affairs. For a Quinean, particulars and (mathematical) classes are what exist. However, our best scientific theories can only be true if there are laws behind them. We must also postulate the existence of these laws — strong laws.

Jonathan Schaffer (2016), in his attempt to solve the second problem of van Fraassen (the inference problem), proposes axioms for the notion of law of nature. Laws are posits, but they are outfitted with axioms. Otherwise, laws would be an "idle wheel" in the system. I do not have objections to the attempt to establish axioms for Armstrong's conception of law of nature. However, it seems to me that axioms are dispensable. Our scientific theories are full of scientific posits. Many of these theories are not axiomatised. For instance, what are the axioms that outfit Galileo's law of falling bodies? Nobody is interested in formulating those axioms. The law is sufficient for the task.

Brand Blanshard (2013) claims that necessary connections are not exhausted by sense experience. According to him, our experience of nature has other faculties, such as reason or intelligence: "[f]or the contention of the non-Humeans is that they do in fact apprehend (if not by sense, then by some other appropriate faculty such as reason or intelligence) necessary connections between certain sensibly presented qualities" (Blanshard 2013, p.449). I am not advocating the existence of other faculties for (direct) access to nomic necessity. Necessary connections are *a posteriori* posits, based on our best science. This is a rational process. It is wise to postulate what best explains our observations.

8. Conclusion

There has been an extensive analysis regarding mathematical explanations of physical phenomena. Some case studies have become famous, such as the crossing of the bridges of Königsberg, the life cycle of North American cicadas and the distribution of strawberries.[9] Most of these analyses reject the type of metaphysical analysis presented in this paper. Paradigmatically, Marc Lange claims that the dispute over the explanation of the parallelogram law of forces "should not be settled by philosophical accounts of scientific explanation or natural law. Rather, it should be settled empirically" (Lange 2016, p.152).

Nonetheless, I believe that there is a connection between the metaphysical analysis pursued here and the contemporary discussion surrounding mathematical explanation. This connection should be explored in two steps. First, it must be settled whether laws of nature can indeed provide explanations for physical phenomena. Second, it must be ascertained *how* some mathematical propositions can be non-causal laws of nature. Concerning the first step, Armstrong (1997a, p.235; 1983, p.102–105) argued that laws of nature (best) explain our observed regularities. As far as I know, the second step remains *terra incognita*.

The hypotheses inform the analyses. My hypothesis differs from Armstrong's hypothesis. Thus, our analyses also differ. However, I think that the main difference lies elsewhere; it is merely a psychological difference. Armstrong has an attraction to the Eleatic Principle. I simply do not share any attraction to that principle. "Everything that exists makes a difference to the causal powers of something" (Armstrong 1997a, p.41) seems false to me. *Non-causal laws exist, and they do not make any difference in the causal powers of something*. As I see it, if we combine an attraction to the Eleatic Principle with a taste for the Australian desert landscapes, then we might get an idea of what lurks behind Armstrong's hypothesis. I have the same taste for desert landscapes. However, we cannot get rid of everything. Some entities must be posited if we want to solve some problems. Non-causal laws must be fundamental laws and additions to the being if we want to overcome some of the weaknesses that Armstrong's hypothesis entails.

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Notes

[1]This is a simplification of Armstrong's analysis of causal necessity. Armstrong (1997a, p.229) considers a more complex case involving someone being decapitated, symbolised by (_1 being *F* & _1 having *R* to _2 & _2 being *G*) *causes* (_2 being *H*).

[2]According to our best physics, Boyle's Law and Newton's Law of Universal Gravitation do not qualify as fundamental. Boyle's Law is derived from kinetic theory, and Newton's Law is derived from General Relativity. However, according to Kuhn (1962), these derivations are illegitimate. For Boyle, temperature is not the average kinetic energy of colliding atoms; for Newton, there is no equivalence between mass and energy. Those who believe that these laws are not "good" examples of *fundamental* laws may substitute them with other (e.g. conservation laws).

[3]For further developments on this idea, see Orilia (2016).

[4]There are some counterexamples to the idea that symmetrical supervenience yields identity. For example, Marian David (2005, p.148) argues that truth supervenes on truthmaking and truthmaking supervenes on truth. That is, the relation between truth and truthmaking is one of symmetrical supervenience. However, truth and truthmaking are not identical. Truth is a monadic property, while truthmaking is a dyadic relation.

[5]Non-symmetrical supervenience: there are *P* and *Q* such that *P* supervenes upon *Q*, but *Q* does not supervene upon *P*.

[6]The 'totality fact' is the conjunction of all the types of Newtonian forces.

[7]I will not address the other problem of van Fraassen — the inference problem — because I think that Armstrong's solution is correct. That is, the observed regularities are instances of the law. The law analytically entails the regularity.

[8]As we saw in section 2, later, he (Armstrong 1997a, p.228) identified causation with necessity.

[9]See, for example, Lange (2016), Baker (2005) and Pincock (2015).

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