# NECESSARY LAWS

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Within the empiricist tradition, it is often taken for granted that the laws of nature are contingent. According to this view, metals could contract upon heating instead of expanding as they actually do. I shall attack this view first, by questioning an essential assumption on which it depends, and second by giving a positive reason to think that at least some laws are necessary. I begin by looking a little closer at the reasons for the contingency view of laws.

## 1. Lewis' and Armstrong's combinatorialism and the contingency theory of laws

David Lewis and David Armstrong adopt radically opposite positions with respect to the metaphysical interpretation of modality. For Lewis, there are other possible worlds that are just as real as ours. For Armstrong, other possible worlds are ways to combine the particulars and universals of our actual world into states of affairs. For Armstrong, there is only one actual world, which is the one we inhabit. It is absolutely actual. For Lewis, actuality is a relative notion: our own world is indeed actual, but only relatively to us. Actuality is an indexical, context-sensitive concept that picks out different worlds at different world-contexts. In this world Lewis is a philosopher, but some other world represents him as being a plumber. The world inhabited by Lewis the plumber is the actual world for Lewis the plumber although it is only a possible world for Lewis the philosopher[1]. From the viewpoint of Lewis' realism with respect to possible worlds, Armstrong is a "linguistic ersatzer" who holds that the conceptual work done by postulating possible worlds can be done by linguistic constructions. If it can be done - a thesis Lewis (Lewis, 1986a) denies – parsimony dictates to prefer a

[1]Lewis denies overlap with respect to individuals between possible worlds, so Lewis the plumber is not the very same individual as Lewis the philosopher but only his counterpart in virtue of some appropriate similarity relation. See below, section 4.

sparse metaphysical doctrine with only one real world to a luxurious doctrine with an infinity of real worlds.

Armstrong and Lewis also adopt radically different positions with respect to the issue of the metaphysical nature of laws. Here Armstrong is the realist who thinks of laws as objectively existing relations between universals[2] whereas Lewis adopts the Humean or anti-realist position that there is no necessity in nature. Laws are defined relatively to a hypothetical ideal science: the laws are the axioms and theorems of an ideal scientific theory[3].

In spite of this important disagreement in the metaphysical interpretation of both possible worlds and laws, Armstrong and Lewis agree in following the pretheoretical intuition that the laws of nature are contingent. Even if in our actual world it is a law that all metals expand when their temperature rises, both hold that it is, nevertheless, possible that a metallic object contracts upon heating. Instead of relying directly on intuitions, both Lewis and Armstrong argue for the thesis of the contingency of laws with some version of the principle of combination. There is however an important difference between Lewis' "principle of recombination" (Lewis, 1986a, p. 87) and Armstrong's (Armstrong, 1989) combinatorialist theory of possibility. For Armstrong, possibilities arise from combining logical atoms, which are the constituents of states of affairs, i.e. particulars and universals. For Lewis, possibilities arise from the rearrangement of the distribution of intrinsic qualities over space-time locations. As we shall see, this difference has important consequences for the issue of the modal status of laws.

At first sight, David Lewis' position with respect to the issue of the modal status of laws seems straightforward: "There might have been altogether different laws of nature" (Lewis, 1986a, p. 1); "there are [...] worlds where [...] totally different laws govern the doings of alien particles with alien properties" (Lewis, 1986a, p. 2). Speaking of the rival doctrine of "strong laws" according to which laws are necessary, he says: "If a theory of strong laws is to be credible, it had better provide not only a sense of 'possible' in which violations of laws are impossible, but also another sense in which violations of laws are possible. Perhaps that second sense cannot be provided. In that case the doctrine of strong laws is not credible enough to deserve consideration." (Lewis and Langton, 1998, p.122) Lewis's reason for holding that the laws are contingent lies

[2]Cf. Armstrong (Armstrong, 1983). Dretske (Dretske, 1977) and Tooley (Tooley, 1987) hold similar positions.

[3]This is the famous "best-system analysis of laws" which Lewis adopts from Ramsey. Cf. Lewis (Lewis, 1973; Lewis, 1983; Lewis, 1994).

in his adherence to the fundamental doctrine of Humean supervenience according to which "all there is to the world is a vast mosaic of local matters of particular fact, just one little thing and then another. [...] For short: we have an arrangement of qualities. And that is all. There is no difference without difference in the arrangement of qualities. All else supervenes on that." (Lewis, 1986b, pp. ix f.) This doctrine implies that objectively, laws are nothing but regularities. To distinguish them from accidental coincidences, the best-system analysis says that, among all regularities, the laws are those that science will eventually pick out as axioms and theorems of the ideal theory. It is an essential part of this Humean doctrine that there are no necessary connections between what happens at different points, between the qualities instantiated at different spatio-temporal locations. A quality instantiated at one point imposes no modal constraint whatsoever on the qualities instantiated elsewhere. Anything can possibly be juxtaposed to anything. To take Lewis' example, it is a lawful regularity obtaining in this world that bread-eating prevents starving (Lewis, 1986a, p. 91). But this regularity might possibly not obtain. There are worlds in which I eat bread and nevertheless starve. Lewis generalizes this idea into a "principle of recombination [...] Roughly speaking, the principle is that anything can coexist with anything else, at least provided they occupy distinct spatiotemporal positions. Likewise, anything can fail to coexist with anything else." (Lewis, 1986a, pp. 87f.)

One important difference with respect to Armstrong's version of the doctrine of the contingency of laws is the following. Lewis' thesis of the contingency of laws applies directly only to laws implying necessary connections between qualities instantiated at *different* space-time locations. The "distinct existences" (to use Armstrong's terminology) that can be, according to Lewis, combined in all ways are qualities that fully occupy a location. This implies that Lewis' Humean combinatorialism does not automatically classify *all* laws as contingent. The thesis that qualities instantiated at different spatio-temporal locations are only contingently linked, implies that what are often called *causal* laws are contingent. Such laws link what happens at different spatio-temporal locations. This is the result Lewis focuses on when he says that the principle of recombination settles "the question whether laws of nature are strictly necessary. They are not; or at least laws that constrain what can coexist in different positions are not" (Lewis, 1986a, p. 91).

However, not all laws are causal laws, and Lewis' Humean principle of recombination of qualities instantiated at different locations does not imply that these other laws, and in particular, the laws of association are contingent. Lewis notes only in passing, and somewhat tentatively, that his strategy "to take a Humean view about laws and causation, and use it instead as a thesis about possibility" (*ibid.*) does not imply free combinability with respect to the qualities that are co-exemplified at the same space-time location. Thus, Lewis admits that "perhaps" (*ibid.*) his Humean argument entails the contingency of laws only "with the exception of laws constraining what can coexist at a single position, for instance the law (if such it be) that nothing is both positive and negative in charge." (*ibid.*) In fact, having noted that the Humean doctrine doesn't force upon him the contingency of such laws, Lewis says that we have no means to know whether such incompatibilities are necessary or not. This is a question on which

> there seems to be no way at all of fixing our modal opinions, and we just have to confess our irremediable ignorance. I think one question of this kind concerns incompatibility of natural properties. Is it absolutely impossible for one particle to be both positively and negatively charged? Or are the two properties exclusive only under the contingent laws of nature that actually obtain? I do not see how we can make up our minds; or what guarantee we have that there must be some way to settle the question. [...] Whatever the truth may be, it isn't up to us. (Lewis, 1986a, p. 114)[4]

His agnosticism about (epistemically) possible natural incompatibilities makes Lewis combinatorialism weaker than Armstrong's. For Lewis, it may be the case that the quality of being positive in charge is not a combinatorial atom. If it is not, then it cannot combine with the quality of being negative in charge at the very same time and place. In that case there would be a link of natural necessity between different qualities instantiated at the same time and place. For Armstrong (Armstrong, 1989), such necessary relations can only have a logical or mereological origin[5]. We can express the difference in the following way: Armstrong takes possibilities to arise from combinations of "distinct existences" which are bare particulars and simple universals whereas Lewis takes possibilities to arise from combinations of "distinct existences" which are "thick particulars": the totality of all qualities instantiated at a given space-time point. Within one combinatorial atom, there may be links of necessity. It follows from this difference in their respective accounts of independence and combinatorial possibility that the existence

[4]I disagree. As I shall argue below, our ignorance in this case is not irremediable. It stems from our scientific ignorance of whether these properties are two different determinates of a given determinable. If they are then it is logically and thus metaphysically impossible that they are instantiated at the same time and place.

[5]I shall criticize this thesis of Armstrong's below, in section 6.

of necessary laws is compatible with Lewis' metaphysical framework, but not with Armstrong's.

## 2. Do universals have a quiddity, suchness or haecceity?

One can understand the debate on the modal status of laws in two ways. On a strong reading of the thesis of the necessity of laws, they hold in *all* possible worlds. I agree with Armstrong and Lewis that this is not plausible. The controversial thesis that I try to defend against Armstrong and Lewis is weaker. It says that all possible worlds that share our universals also share our laws. The laws are necessary in the weak sense that they hold in all those possible worlds that share our actual universals. Armstrong and Lewis (and many others, such as Mellor, 1993 and Mellor, 1997) however think that laws are not even necessary in this weaker sense, and that there are possible worlds that share our universals but not our laws. According to this doctrine of the contingency of laws, a given universal $F$ that is nomically linked to a universal $G$ in the actual world is not linked to $G$ in some other possible world. Although it is a law in the actual world that metals expand when heated, there are possible worlds where it is instead a law that metals contract when heated. The contingency thesis I am arguing against holds not only that some possible worlds do not share our laws (this is a thesis I accept and which corresponds to the denial of the strong thesis according to which our laws hold in *all* possible worlds), but that the very same property of being metallic which exists in the actual world might be differently related to other properties, such as expanding and contracting, than it is in the actual world.

I shall now offer the following argument against the contingency view of laws. Presupposing for the sake of this discussion that laws are relations between universals, the contingency theory holds that one universal might have different nomical relations to other universals than it has in the actual world. If laws are contingent, universals are embedded in different laws in different possible worlds. Consider an actual universal $U$ and a non-actual universal $U^*$ in some heteronomic world. According to the contingency view, $U$ and $U^*$ may be identical although their nomological properties differ, in other words, although $U$ and $U^*$ are nomically linked to different properties. There seem to be two ways to construe such a cross-world identity claim for universals. According to the first, one universal can literally exist in more than one possible world. In section 4, I shall argue that this assumption leads to the conclusion that at least some laws are necessary.

According to the second way to construe the trans-world identity of $U$ and $U^*$, they are the same universal although they are not logically and numerically identical (in so far as they differ with respect to the laws in which they are embedded) because they have the same essence[6]. In this section and the following, I attack two arguments for the existence of such an essence. According to this construal of the contingency view, $U$ and $U^*$ are different ways the same universal could have been: they differ nomologically but share a non-qualitative[7] essence, something which has been variously called "haecceity" (Rosenkrantz, 1993), "suchness" (O'Leary-Hawthorne and Cover, 1997) or "quiddity" (Armstrong, 1989). Laws can then be considered as contingent relations between universals because the identity of the universals is independent of the laws, being determined instead by their quiddity. How can we make sense of the hypothesis that universals have a quiddity or non-qualitative essence? One way is to conceive of the quiddity of a universal in a purely formal way. It can equally well be applied to argue for the "haecceity" of individuals, and indeed for the haecceity of anything at all that exists. Each individual, says Rosenkrantz (Rosenkrantz, 1993), has its own haecceity, in virtue of the simple fact of being identical with itself. Given that it is true for every $x$ that $x = x$, one can consider "$= x$" as equivalent to the predicate "being identical to $x$". Then $(\forall x)(x = x)$ is equivalent to

$$(\forall x) \quad F_x x$$

where "$F_x$" is the predicate "is identical to $x$". Rosenkrantz takes it for granted that one is ontologically committed to the reference of the predicate, i.e. to the existence of the *property* $F_x$ which is $x$'s haecceity. In other words, he proves the existence of a haecceity $F_x$ for each and every individual $x$, by supposing that every predicate expresses a property, at least if the predicate is satisfied by something. Given that for each $x$ there is something satisfying the predicate $F_x$, there is a property

[6]Mere similarity is not sufficient for identity. Without an essence, with all properties equally contributing to the identity of a universal, only perfect similarity, i.e. having all properties in common, is sufficient for identity. This is equivalent to the first option.

[7]There seems to be still another possibility. The essence of a universal could consist of part of its properties. As I shall argue below, all second-order properties of a universal are nomological properties, i.e. nomic links to other universals. Therefore, such an essence would consist of part of the nomological properties of the universal. I think this option must be ruled out because there is no principled reason why some of the laws in which a universal takes part, should be more essential to its identity than others.

expressed by that predicate which is $x$'s haecceity[8]. As a definition of what it is to be the haecceity of an individual, Rosenkrantz offers:

> $F$ is a haecceity $=_{df.}$ $(\exists x)(F$ is the property of being identical with $x.)$
> (Rosenkrantz, 1993, p. 3)

With respect to universals, e.g. Redness, he argues in an analogous, purely formal way, that the proposition "that $(\exists x)(x$ is red$)$" (Rosenkrantz, 1993, p. 12) implies the proposition "that $(\exists x)$ $(x =$ Redness$)$" (*ibid.*).

This inference presupposes the thesis, already implicitly relied on in the argument for the haecceity of individuals, that any use of a predicate carries ontological commitment to the reference of the predicate. To arrive at the existence of the haecceity of the universal Redness, Rosenkrantz uses the same argument once again, but on a higher ontological level[9]. He argues that in

$$(\exists x)(x = \text{ Redness })$$

one can consider "=Redness" as a predicate $F_R$, and then spell out the presupposed ontological commitment to the property $F_R$ refers to. This is the haecceity (or quiddity) of Redness, "the property of being identical to Redness".

I think one can grant that there is a sense in which such properties exist. They belong to what Lewis calls "abundant" (Lewis, 1986a, p. 59; Lewis, 1983, pp. 345f.) properties and opposes to the "sparse" or "natural" properties. Natural properties are such that it can only be found out a posteriori that they are exemplified. The property of being

[8]In the case of particulars, Rosenkrantz (Rosenkrantz, 1993, chap. 2), following Adams (Adams, 1979), adds a less formal argument for the existence of haecceities, from the possibility of a world containing strictly indiscernible individuals: if they are nevertheless numerically different, postulating a haecceity for each is the only possible explanation available. I have two objections against this argument: First, such an argument cannot establish that haecceities *actually* exist; second, it is a non sequitur even with respect to those possible worlds where there are strictly indiscernible individuals. As the reasoning about quantum mechanical indistinguishable particles below (section 3) shows, such a possibility only shows that countability does not always go together with individual identity; such individuals are numerically more than one but this alone does not suffice to establish that necessarily each has its own individual identity. Cf. (Lowe, 1998).

[9]In the case of universals, Rosenkrantz (Rosenkrantz, 1993, p. 132; and note 55) explicitly says that such a formal argument suffices if it combined with the principle according to which "necessarily, if something has a haecceity, then everything has a haecceity" (Rosenkrantz, 1993, p. 13). I think that universals do not obey the same criteria of identity as particulars. Therefore, it is not obvious that arguments in favour or against haecceity carry over from the case of particulars to the case of universals. A crucial relevant difference is that it makes sense to say that there are (e.g. in a quantum-mechanical system) countably many indistinguishable particulars, but not to say that there are countably many indistinguishable universals. See below, section 3.

red is a natural property in this sense. However, once the existence of the property of being red is granted, it is a matter of pure logic to show that redness has a haecceity in Rosenkrantz' sense, by showing that it is identical with itself. A haecceity, so understood, is not a natural property, for insofar as some entity $x$ exists, logic alone suffices to establish that $x$ has a haecceity.

However, Rosenkrantz' shadowy haecceities cannot ground transworld identity of universals embedded in different laws, and therefore cannot help justify the contingency view of laws. For on Rosenkrantz' construal of haecceities, they are not associated with criteria allowing to judge whether two singular expressions referring to haecceities refer to the same or different haecceities. So how could the defender of the contingency of laws rely on them to ground the claim that universals $U$ and $U^*$, being in different worlds and embedded in different laws, share *the same* haecceity? Rosenkrantz' way to introduce them only guarantees that each has *a* haecceity (in a sense in which any existing entity whatsoever has a haecceity), but not that both have the same haecceity.

## 3. An argument for quiddity from the possibility of indistinguishable universals

O'Leary-Hawthorne and Cover (O'Leary-Hawthorne and Cover, 1997) give a less formal argument for the thesis that it is at least possible that universals have quiddity (they call it "suchness", leaving "haecceity" for individuals). They ask us to conceive of the possible situation in which there are two indistinguishable universals, $F$ness and $G$ness. It may indeed seem plausible at first sight that if it were possible that there exist two numerically different but qualitatively perfectly indistinguishable universals, this would give us a reason to postulate that each has its own nonqualitative quiddity which makes it different from the other.

Against this reasoning, I offer two arguments. First, the hypothesis of two indistinguishable universals violates the Causal Criterion of Identity that follows from another traditional and widely shared metaphysical principle, the Causal Criterion of Reality (CCR)[10]. This latter principle says that something is real if and only if it is capable of making a difference to causal interactions or causal processes[11]. Now the

[10] I develop this argument in Kistler, 2002.

[11] The status of this principle as an ultimate criterion of reality can and has been doubted. Armstrong has argued that it is "not [...] a necessary truth, but merely good methodology" (Armstrong, 1984, p. 256). This is correct but I think that, in metaphysics, good methodology is the only accessible criterion of truth: God's point of view being inaccessible, we are condemned to adopt a naturalistic standpoint. When we make the metaphysical claim that

Causal Criterion of Identity (CCI) follows if the CCR is applied to the properties of an entity. The identity of an entity is determined by those of its properties whose exemplification makes a causal difference. The situation imagined by O'Leary-Hawthorne and Cover's is incompatible with the CCI: For the universals $F$ness and $G$ness to be different, it must be possible that it makes a difference, whether it is $F$ness or $G$ness that is exemplified in a given situation. And if it makes a difference, one has a nomological property the other lacks. From the perspective of the CCI, to say, "there is no guarantee that two universals at a world have different causal powers" (O'Leary-Hawthorne and Cover, 1997, p. 107), just means: There is no guarantee against counting the same universal twice over; but counting it twice does not make it into two really different universals. The CCI gives us grounds to judge them identical if they share all their causal powers. In this clash of doctrines, it seems to me that the burden of proof lies on the opponent of the CCI who postulates that there may be real differences which make no causal difference, because the CCI gains some a priori plausibility from the fact that it is the metaphysical generalisation of a methodological principle, grounding existence claims in science.

My second argument is more significant because less question begging than the first. Even if we granted the possibility that there be two or more indistinguishable yet numerically different universals, this would not justify the conclusion that each has its own quiddity, making them intrinsically different although they are qualitatively indistinguishable. The argument from numerical difference with qualitative indiscernability to a non-qualitative essence (or quiddity or haecceity) is in general not valid, because it can be shown that it is not valid in the case of particulars. So let us consider the analogous case for particulars.

Quantum mechanics teaches that there are systems of interacting fundamental particles of the same type and in the same state that contain a number of perfectly indistinguishable particles. The particles constitutive of such a system are numerically different yet qualitatively indistinguishable. With respect to these particles, let us construct an argument that runs parallel to O'Leary-Hawthorne and Cover's argument for the quiddity of universals. Its premise says that there is a set of partic-

$x$ exists, our only justification is that the best available interpretation of all available facts – an interpretation that will be either scientific or compatible with science – gives us reason to believe in the existence of $x$. Such an inference to the best explanation does not of course establish that those entities, in whose existence we have for the moment no good reason to believe, do really not exist. It is only that there is no rational justification to believe in the existence of anything that neither belongs to the empirical facts nor must be postulated to account for these facts.

ulars that are perfectly indistinguishable. (This corresponds to their premise that there are the perfectly indistinguishable universals $F$ness and $G$ness.) The premise is true for such particles. Nevertheless the following reasoning shows that its conclusion is false: indistinguishable particles do not have any individual haecceity making them intrinsically though non-qualitatively different from each other. Redhead and Teller (Redhead and Teller, 1992) call the hypothetical non-qualitative essence of particulars – what I have called "haecceity" – "Transcendental Individuality" and characterise it as "that unifying principle of an individual which is thought to transcend its attributes" (Redhead and Teller, 1992, pp. 202f.). It "is not another property, but [. . . ] that by which an entity allegedly acquires its identity" (*ibid.*). One of the roles of this concept of a principle of individuation transcending the attributes (or qualitative properties) of a particular – in our words, of a haecceity – is to be "that in virtue of which the individual can bear a label, and that in virtue of which the individual can be thought of as persisting through time as one individual" (Redhead and Teller, 1992, p. 203). However, the quantum statistics that correctly describes such systems of indiscernible particles seems to be incompatible with the hypothesis that the particles have a haecceity and can therefore be labelled differently. The point can relatively simply be brought out in the following case. Consider two indistinguishable particles (more precisely, bosons) each of which can be in one of two pure quantum states $|a^h>$ and $|a^t>$ (as "head" and "tail"). Then if these particles have haecceity, and can thus be labelled 1 and 2, there seem to be four possibilities which should be equally probable:

1 $|a_1^h>|a_2^h>$: both particles are in state $|a^h>$

2 $|a_1^t>|a_2^t>$: both particles are in state $|a^t>$

3 $|a_1^h>|a_2^t>$: particle 1 is in state $|a^h>$ and particle 2 is in state $|a^t>$

4 $|a_1^t>|a_2^h>$: particle 1 is in state $|a^t>$ and particle 2 is in state $|a^h>$

However, this a priori conception of the possible states of the system is incompatible with the best available interpretation of the observed phenomena. Quantum statistics requires counting what appears in this presentation as two possibilities 3 and 4 as in fact only one possibility. This makes an empirical difference for if the classical statistics were true of the system, it would be twice as probable to find one particle in each state, i.e. to find the state "3 or 4" than to find both particles in the same state, $|a^h>$ or $|a^t>$, whereas it is, as a matter of empirical fact, equiprobable. Quantum mechanics accounts for this fact by postulating that our two-particle system does not have four possible states available, as it would have in a classical representation, but only three. These correspond to the states 1 and 2, whereas the third is a mixed state which can be represented as a superposition of the classical states 3 and 4[12].

O'Leary-Hawthorne and Cover (O'Leary-Hawthorne and Cover, 1997) and others take the existence of systems of indistinguishable particles as an argument *in favour* of haecceity[13]. However, Redhead and Teller (Redhead and Teller, 1992) show that it doesn't constitute such an argument, and that on the contrary, the supposition of the existence of haecceities implicit in the labelling of the particles creates a puzzle, which is dissolved by dropping that supposition. The puzzle is that, as long as one rests with the classical representation and its idea that each particle has its individual identity, which justifies attributing a label to it, the states 3 and 4 seem to be genuine possibilities, which are never actualised. However, the existence of such possibilities has no scientific grounding, the appearance of their existence flowing from a metaphysical prejudice in favour of haecceities, reflected in labelling. The empirical fact that such systems obey a statistics that corresponds to the existence of three states suggests that there really are only three possibilities, which can be explained by the hypothesis that such particles do not have any haecceity[14]. The situation seems to plead for

[12]What I have said is true only for bosons, which require a symmetric state description. Fermions whose state description must be asymmetric cannot be in states 1 and 2, but must be in a mixed asymmetric state. Cf. French and Redhead, 1988.

[13]Black presents a famous a priori argument for the same conclusion: It "is logically possible that the universe should have contained nothing but two exactly similar spheres" (Black, 1952, p. 156). Similarly, Adams (Adams, 1979, p. 22) and Armstrong (Armstrong, 1997, p. 108) argue for haecceity in some possible world in which there exist two indistinguishable counterparts of Earth one of which, at a certain time, ceases to exist. As Swinburne (Swinburne, 1995, p. 394) notes, an important weakness of such arguments is that they could at best show that the objects existing in some possible world very distant from the actual one have a haecceity – or "thisness", as Swinburne calls it –, whereas it does not address the question that primarily interests us, whether the material objects in the actual world have a haecceity. Although it fails, the argument from the existence of indistinguishable particles discussed in the text is relevant for this latter question, for quantum mechanics tells us that they exist in the actual world.

[14]This reasoning seems to contradict Lewis' view that "we do not find out by observation what possibilities there are" (Lewis, 1986a, p. 112). If I am correct, then science is more directly relevant for metaphysics than Lewis allows. Even if possibilities are established by a purely a priori logical principle of recombination (Lewis, 1986a, p. 87), it is science that determines the nature of the entities, particulars and properties, to be recombined. The conflict can be resolved by observing that the relevance of science reaches only over the range of nomologically possible worlds whereas Lewis notes the irrelevance of science with respect to the determination of the full range of possibility, nomologically impossible possibility included.

Lowe's (Lowe, 1998, p. 193) thesis that identity and countability do not always go together: two indistinguishable particles do not have their own individual identity although they are countable as two.

If this reasoning is correct, quantum mechanics shows that numerical difference does not suffice to establish the existence of a non-qualitative essence, or haecceity, in the case of particulars. Therefore this is not a valid argument pattern that can be used, as O'Leary-Hawthorne and Cover (O'Leary-Hawthorne and Cover, 1997) do, to argue in the case of universals that the hypothesis of two numerically different yet indistinguishable universals would imply that such universals would have quiddity. To conclude the reasoning of the two preceding sections, we have seen that O'Leary-Hawthorne and Cover's argument for the existence of a non-qualitative essence of universals is invalid, whereas the kind of essence of universals whose existence Rosenkrantz' argument allows to establish, is too weak to be able to ground the contingency view. For we have seen that the contingency view needs the essence of universals as a ground for their identity across different possible worlds, and Rosenkrantz' haecceities are not up to that task. Let us now look at the second and stronger way to construe the identity of universals across worlds: the claim that they are literally present in different worlds. It will turn out that this conception has implications incompatible with the contingency view.

## 4. Universals existing in different possible worlds

Here is the way Lewis (Lewis, 1986a) conceives of the possibility that a universal takes part in different laws in different possible worlds. According to Lewis, universals are subject to overlap between possible worlds, in the sense that one and the same universal is part of several worlds. Lewis refutes the idea that different worlds may overlap with respect to *individuals* by arguing that this raises the paradox of accidental intrinsics (Lewis, 1986a, p. 201). An accidental property is a property an individual *c* has at some worlds but lacks at other worlds. An intrinsic property[15] is determined exclusively by what is the case at the spatiotemporal location of *c*, not by its relations to things located elsewhere. To take Lewis' example, if Humphrey himself (not Humphrey and his counterpart, but one and the same individual Humphrey) exists in two possible worlds, then the following inconsistency threatens. Having five fingers on his right hand is an accidental intrinsic property Humphrey

[15]See (Lewis, 1999, chap. 5 and 6) on the difficulty of defining that concept.

has in the actual world. It is intrinsic because it doesn't depend on anything distinct from Humphrey. And it is clearly accidental or contingent. He has it at this world $W_1$. But he might have had six fingers instead of five. He lacks the property of having five fingers at world $W_2$ where he has six fingers on his right hand. However, it is inconsistent that the same Humphrey has both five and six fingers on his right hand[16]. Therefore, Lewis concludes that the hypothesis that Humphrey exists in more than one possible world is wrong. There is no overlap between worlds with respect to individuals.

However, Lewis thinks that no such inconsistency threatens in the case of universals and that therefore there is no parallel reason pleading against the possibility that different worlds overlap with respect to universals. "A universal can safely be part of many worlds because it hasn't any accidental intrinsics." (Lewis, 1986a, p. 205, note) According to Lewis, the absence of accidental intrinsic properties makes it possible to allow for an overlap between worlds in the case of universals: "I do not see any parallel objection if worlds are said to overlap by sharing a universal. What contingent, nonrelational property of the universal could we put in place of [the] shape of the coin in raising the problem? I cannot think of any." (Lewis, 1983, p. 345, note 5)[17] Lewis says, somewhat hesitantly, that first, "there isn't much to the intrinsic nature of a universal" (*ibid.*), and second, to the extent that a universal has intrinsic properties at all, they seem to be essential to it. He thinks of such properties as being simple or composed. The extrinsic properties are contingent and change from world to world, such as the property of being instantiated $N_1$ times in $W_1$ and $N_2$ times in $W_2$. To sum up, according to Lewis, the following is true of the properties of universals: If they are intrinsic then they are essential (example: being simple or being composed) and if they are extrinsic, then they are accidental (example: the number of instantiations a universal has in a given world). If we accept the claim that universals do not have any accidental intrinsic properties, we can coherently suppose that a universal exists in more than one possible world.

What properties do universals have? Those mentioned by Lewis – being simple or composed, or being instantiated a certain number of times – cannot be its only properties. The reason is that if these were

[16]As Lewis notes, there is no such problem with relational properties. Humphrey can possess three dogs in $W_1$ and four dogs in $W_2$; he can be in a possession-relation to three $W_1$-dogs, and at the same time, without contradiction, in a possession-relation to four $W_2$-dogs.

[17]If a coin was present in two different possible worlds, it could be the case that it was both wholly round (in one world) and wholly octogonal (in the other world). This is the problem of accidental intrinsics for objects.

their only properties, all simple universals would be identical[18] or at least, if the number of instantiations were also taken into account, it would be impossible that two simple universals be instantiated the same number of times. However, this seems to be a quite realistic possibility: if there is an exceptionless law linking primitive universals $A$ and $B$ then they have the same number of instantiations. This is not question-begging in favour of the necessity of laws, for it just supposes that there is an exceptionless law that $A$s are $B$s in *one* world, e.g. in the actual one. That this is possible is not controversial.

So universals must have other properties distinguishing them. Setting aside the non-qualitative essences or quiddities discussed above, the only plausible candidates seem to be their lawful dependencies on one another. Our question is: are such relational properties accidental or essential to the universal? Someone who holds, like Armstrong and Lewis and in order to preserve modal intuitions, that they are accidental, must hold that they are extrinsic, on pains of falling victim to the contradiction of accidental intrinsics, this times concerning properties of universals.

It turns out to be sufficient to show that universals have intrinsic properties, in order to show that, if they exist in more than one possible world then those properties are essential to them (for if they exist in several possible worlds, then they cannot have accidental intrinsic properties). If there are such properties, the link between the universal and these properties has the strength of nomological necessity: it exists in all worlds where the universal itself exists. Our question becomes: Are there intrinsic properties which give rise to lawful dependencies of a universal on other universals? These properties would be essential, and so would be the links between universals, which are necessary laws. Such intrinsic and essential properties of a universal would give rise to nomological necessity in the sense given above: Truth in all worlds in which the universal exists.

## 5. Necessary relations between determinate and determinable universals

One intrinsic property of some universals is the property of determinate universals to be subordinate (in Fregean terminology) to their determinable universals. I shall argue that this relation is *internal*[19]

[18]I ignore the possibility of different but indistinguishable universals against which I have argued above (section 3).

[19]I shall say of relations that they are internal if and only if they supervene on their terms, and of a property that it is intrinsic if and only if it supervenes on its possessor.

and that therefore the relation of subordination between a determinate universal and its determinables is part of the essence of the determinate universal. Being an equilateral triangle is a complex universal built from the constituents: being a closed plane figure, of three sides, all sides of equal length. Being a triangle is a determinable relative to being an equilateral triangle, which is one of its determinates. $E$, *being an equilateral triangle*, has the second-order property of being related – in fact subordinate – to $T$, *being a triangle*[20]. The crucial point is that the relation of subordination between determinate and determinable universal is *internal*. An internal relation strongly supervenes on its terms; necessarily, if both of the terms exist, they are so related. In other words, in every world in which $E$ and $T$ exist, they are internally related so that $E$ entails $T$. In those worlds, necessarily, if something is $E$ it also is $T$. Moreover, the mere existence, in a world, of $E$, entails the existence in that world, of $T$. There could not be a world in which $E$ exists but not $T$. Every world that contains equilateral triangles necessarily contains triangles. Taken together, these two necessary implications entail that being internally related to $T$ is an internal relational property of $E$. It is not only the case that if $E$ and $T$ both exist, they are necessary internally related by subordination of $E$ under $T$, but also that if $E$ exists then it is necessarily internally related to $T$, for $E$'s existence alone is sufficient for the existence of $T$. Being subordinate to $T$ (by an internal relation) is an *essential intrinsic* property of $E$: It is intrinsic because the fact that $E$ is subordinate to $T$ does not depend on anything else than $E$. To be subordinate to $T$ is also an essential property of $E$: $E$ has it in every world in which it exists, because $T$ is a constitutive part of $E$. ($T$'s identity is determined by a proper part of the terms of the conjunction determining the identity of $E$.) Analogous arguments show that $E$ is essentially subordinate to all determinables corresponding to any one of its constituents or to conjunctions of some (but not all) of its constituents.

Our reasoning only depends on the premise that a determinate is complex, conjunctively composed of its constituents. Nothing depends on the particular example chosen. Therefore, it can be taken to establish the following general claim on the relations between determinates and determinables:

[20]One can, following Armstrong (Armstrong, 1997, chap. 4.13), conceive of determinate universals as of complex universals resulting from a conjunctive combination of several constituents. Suppression of one of its constituents yields a universal that is determinable relatively to it. Worley (Worley, 1997) has elaborated Armstrong's account of determinate and determinable universals in a similar way.

1 It is essential (nomologically[21] necessary) for a determinate to be subordinate to each of its determinables.

I would now like to propose an argument for the necessity of one law of association, which uses 1 and the following premise.

2 It is essential (nomologically necessary) for a determinable $D$ that each of its instantiations is also an instantiation of at least one of its determinates $D_1, \ldots, D_n$.

$$(\forall x)(\forall D)[\mathrm{Det}(D) \rightarrow \Box(Dx \rightarrow \exists D_i \in \{D_1, \ldots, D_n\} D_i x)]$$

where "Det" is the predicate "is a determinable", and $\{D_1, \ldots, D_n\}$ is the set of determinates of the determinable $D$.

The reason for 2 is that determinable universals exist only insofar as they are constituents of determinate universals. To be instantiated alone, the determinable would have to exist independently of all its determinates, in which case it would not be a determinable after all.

On the basis of these very general premises bearing on the relations between determinables and their determinates, I shall now argue for one case of a law of association[22] that if it is true at all, then it is necessary[23]. We may obtain this result if we add the following premise to 1 and 2.

Consider, as an example of a law of association, the Boyle-Mariotte law of ideal gases. It says that an ideal gas which has pressure $P$, has temperature $T = PV/nR$ (where "$V$" is the volume occupied by the gas, "$n$" is the number of moles and "$R$" the universal gas constant).

3 In ideal gases[24], $T$ and $P$ are two different determinables with respect to the same set $D$ of determinates[25]: the set of all states of motion of the molecules composing the gas that share the mean kinetic energy specific for $T$ and $P$, given a fixed volume $V$.

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[21] The qualifier "nomological" means that the relation holds in all worlds in which the property exists.

[22] This argument bears only on laws of association, not on causal laws. But I shall argue later that one may generalize from this case because it would be implausible that these kinds of laws differ in their modal status.

[23] This claim must of course be distinguished from the obviously false claim that the law is a priori. Kripke (Kripke, 1972) has made a convincing case for the existence of necessary yet a posteriori truths. My thesis is that true law statements belong to this category.

[24] This restriction must be specified because $T$ is multiply reducible; the temperature of empty space, e.g., reduces to a different property.

[25] Similarly, Hooker (Hooker, 1981, p. 497) construes the relation between a liquid's property of boiling and the underlying microscopic property of the liquid as lying on the extreme ends of a "determinate/determinable hierarchy".

From 3 alone it follows that, with the volume $V$ fixed, the state of motion determines both $P$ and $T$. Given 3 we already know that it is naturally necessary that any gas in one of the states in this set has both $T$ and $P$.

The crucial question is: Is the relation between the macroscopic properties $T$ and $P$ that is the content of the Boyle-Mariotte law also necessary? We can derive a positive answer from our premises in the following way. By premise 2, the instantiation by the gas of the determinable property $P$ is necessarily also an instantiation of at least one determinate property, which is in set $D$. By 1, each instantiation of a determinate is also an instantiation of each of its determinables, but by 3, $T$ is such a determinable property for all states in $D$. Hence, an instantiation of $P$ is necessarily an instantiation of $T$. On the construal of the Boyle-Mariotte law given in 3, as a relation between two determinables that have the same set of determinates, it follows from general properties of the determinate/determinable relation that the law is necessary if true. The necessity of this law is however not of a logical nature because the necessity of premise 3 is not logical. The analysis of the determination of the macroscopic properties of an object by the properties and relations of its parts is a controversial topic, but this determination is certainly not logical[26].

Without trying to argue for this claim here, it seems that an analysis along these lines is available for many laws of association between different higher-level properties of macroscopic complex objects, such as the Wiedemann-Franz law (stating the proportionality between electrical and thermal conductivity in metals) or the Dulong-Petit law (stating that the specific heat of solids has a constant universal value, which is independent of the type of solid and of the temperature within a given range). It is the empirical discovery of micro-reductions that must justify the truth of a premise analogue to 3 in each case. Therefore, the argument cannot be generalised to establish the necessity of laws of association between *fundamental* properties of microscopic particles. But if our argument is correct and if premise 3 is correct for the Boyle-Mariotte law, then we have shown that there exist necessary laws of association. And then it can be argued that it is implausible for different laws of association to differ in modal status.

What about causal laws? Causal laws are laws linking what happens at different spatio-temporal locations. Conservation laws are an important class of such laws. There are two reasons to consider that they are

[26] Armstrong (Armstrong, 1989) denies the existence of non-logical necessity. His arguments will be discussed shortly.

necessary in the same non-logical sense as laws of association. First, it is implausible to attribute a different modal status to causal laws and to laws of association for their modal status should be a consequence of their lawful status. Second, we can apply the Causal Criterion of Identity to conserved quantities. Take the conservation of mass-energy. The law of its conservation is necessary in the nomological sense that it holds wherever this quantity exists: it is constitutive for being the total energy-mass of a closed and isolated system to be conserved[27]. If some energy-like quantity of such a system is not conserved, we conclude that it is just one *form* of energy, such as potential energy or kinetic energy, but not total energy. The law of the conservation of total energy – which is a causal law in the sense that it determines what happens over time (and space[28]) – is necessary because mass-energy and other fundamental conserved quantities are conceptually linked to conservation. A property which exists in some possible world but which is not conserved is not one of them. Once again this is less than one might have hoped for. I have tried to show, not that all causal laws are necessary but only that there exist necessary causal laws[29].

Let me prevent a misinterpretation that might easily arise. We have not shown that laws are necessary in the strong sense of holding in all possible worlds. Nothing I have said prevents the existence of strange possible worlds in which there are no conservation laws. It is just that such worlds do not contain conserved quantities. The conservation of total mass-energy is necessary only in this sense: in all those worlds in which mass-energy exists, it is conserved.

[27]Bigelow, Ellis and Lierse argue that our actual world is the unique individual of a natural kind, and that conservation laws are grounded in this natural kind. "Conservation laws are best understood as ascribing properties to the world as a whole, properties which are essential to the natural kind to which our world belongs" (Bigelow et al., 1992, p. 385). Within this framework, the view defended here could be formulated in the following way. To be conserved is an essential property of a property of the whole world, the property of having a given total mass-energy.

[28]An energetically closed system may travel through space.

[29]If all laws were reducible to laws of association, it would not be necessary to argue separately for the existence of necessary causal laws. Against Russell (Russell, 1986) who argues that functional laws of association are the only laws, Cartwright (Cartwright, 1979) argues that causal laws cannot be reduced to such laws of association. Without trying to settle this issue here, the fact that conservation laws put constraints on the evolution of systems *over time*, whereas laws of association only constrain the properties of a system *at one time*, pleads prima facie against the possibility of a reduction of the former to the latter.

## 6. Incompatibilities between different determinates of one determinable

There is another source of nomological necessity: it follows from the incompatibility of different determinates of the same determinable. It is essential (nomologically necessary) for determinables that their instantiations are instantiations of only one of their determinates. In other words, different determinates exclude each other. No closed plane figure can be both triangular and quadrilateral, and no object (Lewis' example) can have both a positive and negative electric charge at the same time. In this section, I try to show that these are cases of nomological necessity, against Armstrong's (Armstrong, 1989) attempts to show that all cases of apparent nomological incompatibility can be reduced to logical or otherwise analytical necessity, and are therefore not cases of natural necessity.

According to Armstrong's combinatorial theory of possibility, any two states of affairs, $a$'s being $F$ and $a$'s being $G$, are compossible if the universals $F$ and $G$ are entirely distinct. Armstrong's strategy to deal with apparent examples of natural necessity is to recognise the necessity of logical and other analytic relations, to count mereological relations as analytic, and then to show that wherever there are necessary relations between states of affairs, their necessity can be traced back to a logical or mereological source. He concludes that there is no genuinely *natural* but only logical necessity.

Let us see whether Armstrong can establish this reduction of nomological to logical/mereological necessity. Among the many cases of states of affairs which consist in the attribution of different determinate properties of a given determinable to one particular at one time[30], Armstrong analyses the property of mass[31]. A given particular can have only one determinate mass at a given time. Armstrong reduces the incompatibility of two states of affairs attributing two different masses to the same particular at the same time, to a mereological and thus purely analytic, not natural incompatibility. Masses are structural universals. Mereo-

[30]We can see Armstrong's analysis as a reply to Lewis' refutation of the "linguistic ersatzer", by way of showing that not everything that can be stated is a genuine possibility. "It is consistent, says Lewis, in the narrowly logical sense, to say that something is both positive and negative. [...] This seems wrong: here we seem to have an inconsistency which is not narrowly logical, but arises because positive and negative charge are two determinates of one determinable." (Lewis, 1986a, p. 154) According to Lewis, the "ersatzer" must introduce an axiom into his world-making language to prevent that the theory predicts that it is possible that a thing is both positive and negative. If such axioms are indeed necessary, it shows that modality cannot be reduced to linguistic combinations (which is what the "ersatzer" claims).

[31]Cf. Armstrong, 1989, p. 78f. Elsewhere (Armstrong, 1997, chap. 4), he applies the same strategy to duration.

logical considerations of the relation of the constituents of a structural universal to the whole explain the incompatibility of two states of affairs according to which the same particular $c$ has both a quantity of one and of five kilograms. The explanation is that $c$'s having a mass of five kg is equivalent to a conjunction of five states of affairs according to which five parts of $c$ have one kg of mass each. But if the whole particular $c$ instantiates the structural universal of having a mass of five kg, then it is necessary in the sense of "analytic" (Armstrong, 1989, p. 80) that it cannot also have the property of having a mass of one kg because this is, analytically – as a consequence of the meaning of the predicate "having a mass of five kg" – the property of one of $c$'s proper parts. In Armstrong's words, "to attempt to combine the two properties in one thing would involve the thing's being identical with its proper part" (Armstrong, 1989, p. 79; similarly Armstrong, 1997, chap. 4.13). In Lewis' terms, no special non-logical axiom has to be introduced in order to guarantee that something cannot have both one kg and five kg of mass. The axioms of mereology suffice, if one makes the hypothesis that determinate universals are structural.

Armstrong's strategy to deal with the incompatibility of different determinates of one determinable consists in reducing the incompatibility between universals to a mereological kind of impossibility: that a whole cannot share a universal with one of its proper parts. Several objections have been raised against this analysis some of which are relevant to our topic. Let me mention two cases in which Armstrong's analysis seems to fail: the masses of fundamental particles and colours.

Armstrong's attempt to explain incompatibilities by partial identities presupposes that all those quantities that are not freely combinable are structural properties. But it is implausible that all quantities are structural: The masses of fundamental particles are not. As Menzies (Menzies, 1992, p. 733) notes, it contradicts current scientific doctrine to suppose that the masses of fundamental particles are structural properties. The properties of fundamental particles directly contradict Armstrong's claim that "if an individual has an extensive quantity, then it has parts which lie outside each other, that is which are numerically different from each other, and which go together to make up the individual and to give the individual the particular quantity that it has." (Armstrong, 1989, p. 80) The electron doesn't have its mass $m_e$ by virtue of having two proper parts having each $1/2m_e$[32]. So why isn't it possible

[32]One might try to replace the claim that determinate universals are "structural" by the claim that they are "complex". The sense Armstrong (Armstrong, 1978, chap. 18) gives the term "structural" as applied to universals, implies that a structural universal can only

that an electron has both $m_e$ and $1/2m_e$? Armstrong anticipates the objection that his mereological analysis may be inapplicable to incompatibilities between extensive quantities of fundamental particles. He notes that "there are grounds for thinking that, at a fundamental level, our example of mass is irreducibly intensive. For the truly fundamental particles are thought of as *point*-masses." (Armstrong, 1989, p. 80) Let us then turn to Armstrong's attempt to explain incompatibilities between intensive qualities.

Some intensive qualities, such as density, are according to Armstrong reducible to extensive quantities. Density is reducible to volume and mass, which are both extensive. "As a result, incompatibilities of density can be resolved into incompatibilities of volume and mass." (Armstrong, 1989, p. 80) But presumably (as already hinted at with respect to mass) there are also what seem to be irreducibly intensive qualities, which cannot be thus reduced to a proportion of extensive quantities. For these Armstrong proposes the strategy to apply a sort of mereological analysis based on the postulation of non-spatial parts. "Why should we not say that if science sees fit to postulate apparently irreducible intensive quantities, then what is really being postulated is the simultaneous presence of many individuals at the same place?" (Armstrong, 1989, p. 81; similarly Armstrong, 1997, chap. 4.22) If we follow Armstrong in considering the mass of fundamental particles as intensive, we could try to consider that a neutron has a proton and an electron as non-spatial parts.

I have three objections against this idea. First, it would explain just two incompatibilities (something cannot be both a neutron and a proton nor a neutron and an electron) and leave many others unexplained. It cannot, e.g., explain why nothing can be both a proton and a photon.

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be exemplified by complex particulars (the parts of which exemplify constituents of the structural universal), which is not necessary for all determinates. (In Armstrong, 1997, chap. 3.71, he says that this is true only of "paradigm structural properties". One could also call conjunctive properties "structural" although in its case, "the constituents, the conjuncts, are properties of the very same particular that has the conjunctive property".) One could make the hypothesis that determinate universals are not structural but rather "complex" universals, which could be exemplified even by fundamental particles that have no parts. But this move would destroy the terms of Armstrong's above-mentioned argument, to the effect that the incompatibility of the exemplification of different determinates of the same determinable by one particular at one time has a purely mereological (and thus analytic) origin. It could be saved only by making the hypothesis that the particulars exemplifying complex universals have non-spatial parts even if they have no spatial parts. I discuss this hypothesis shortly.

Second, the hypothesis seems to be ad hoc[33]: Armstrong's justification to rely on mereology for explaining apparent incompatibilities was that such incompatibilities are clearly understood, in the end because they are analytical. But this certainly isn't true for a hypothetical theory that would be in some sense analogous to mereology but where non-spatial parts are combined into non-spatial wholes. No such theory has been worked out, and it seems gratuitous to rely on the hope that there could be such a theory that would provide the correct results. Third, such a theory would not be analytic in the same sense as the theorems of mereology. Even if we grant that there is a sense in which a neutron results from the "addition" of a proton and an electron, this sort of addition is not a logical operation: the properties of the resulting whole are not predictable on the grounds of logic alone, but require the knowledge of empirical laws. The masses of the "parts", the electron and the proton, do not, e.g., add up to the mass of the "whole", the neutron, according to the arithmetic law of addition but according to a more complex empirical law.

Armstrong faces a similar dilemma in the case of the incompatibility of determinate colours. In the case of colours – which Armstrong proposes to consider as extensive structural properties in the same way as mass – it is not only possible but on the contrary normally the case that the proper parts of a red object are themselves red[34]. So why cannot both the whole and one of its parts share the universal of having a mass of five kg?

Armstrong argues that colours are only phenomenologically simple but can be reduced to structured physical properties. Taking up a suggestion of the Tractatus (6.3751), Armstrong (Armstrong, 1989, pp. 82–84) holds that secondary qualities such as colours are to be identified with "primary-quality structures" (Armstrong, 1989, p. 83). He suggests that incompatibilities between the latter can always be reduced to incompatibilities between extensive quantities. But he doesn't show this in detail for any secondary quality. What he does instead is show how this strategy works for explaining the incompatibility between different velocities, and then declare without further argument that the same strategy works for secondary qualities. But it seems that if colours, e.g., can be reduced to complex physical structural properties, such as the capacity of reflecting light of certain wavelengths, these reducing prop-

[33]Only in this context does Armstrong consider such a possibility. Elsewhere, he takes it as obvious that "two material objects cannot be at the same place at the same time." (Armstrong, 1968, p. 240)
[34]Cf. (Macdonald, 1991, p. 162).

erties are intensive. The impossibility of a photon's being both of the wavelength 500 Å and 1000 Å, does not stem from its being composed of two parts with a wavelength of 500 Å each, short of making the doubtful hypothesis of non-spatial parts (Cf. Menzies, 1992, 733)[35],[36].

In the end, after this look at Armstrong's suggestion to account for incompatibilities between intensive qualities in terms of a speculative non-spatial mereology, we arrive at the conclusion that these incompatibilities are irreducible to logical or mereological incompatibilities. Against both Armstrong and Lewis, I suggest that these incompatibilities are instances of natural necessity, which have the same origin as necessary laws of nature, for which we have argued above[37].

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[35]My objection is that Armstrong's strategy to show that the incompatibility is grounded on a partial identity between the incompatible states of affairs, and thus on a mereological incompatibility, doesn't work. Bradley (Bradley, 1989, p. 36) objects that it is ad hoc: I think that this objection is justified only where Armstrong applies it to properties for which our best current scientific theories gives us grounds for thinking that they are simple. It is ad hoc to overrule science and simply postulate that there must be hidden structure in order for there to be a solution to a difficulty encountered by the philosophical theory. This looks like, in Lewis words, "letting philosophy dictate to science" (Lewis, 1992, p. 212). But with respect to colours, the objection seems misdirected for here science does give us grounds for thinking that colours are complex properties.

[36]Wittgenstein (Wittgenstein, 1966, p. 35) considers a similar analysis of intensive qualities as conjunctions of their parts, and rejects it for reasons similar to those indicated in the text.

[37]Several authors have defended the thesis that laws of nature are necessary although not always in the sense intended here, of holding in all worlds that share our actual universals, and for reasons different from those presented in this paper. Cf. Shoemaker, 1980, Shoemaker, 1998, Swoyer, 1982, Fales, 1993, Bigelow et al., 1992, Ellis and Lierse, 1994, and Ellis, 1999, Ellis, 2000, Ellis, 2001. This is not the place for a detailed analysis of the differences between the accounts offered by these authors and mine (Cf. Kistler, 2002). Let me just note that the position defended here differs from Ellis' and Lierse's "dispositional essentialism" (DE) in several important respects. First, according to DE, laws are grounded in dispositions that are essential properties of *natural kinds*, which are primitive and fundamental kinds of entities. On the view defended here, it is the essential nomological properties of *properties* (here construed as universals) that provide the grounding of laws. My main reason for holding that (simple) properties are more fundamental than natural kinds is that kinds are complex types of substances, which share structural properties. But the constituents of the structure are held together in virtue of laws governing those constituent properties. So it seems that the identity of a kind depends on the identity of its constitutive properties. Second, the fundamental essences of DE are *causal powers* belonging to natural kinds. I have argued more generally for the existence of essential *nomological properties* of properties, of which causal powers are only a special kind. Third, according to DE, if a disposition $\langle C, E\rangle$ to have the effect $E$ in circumstances $C$ is "causally determinate", then "an event of the kind $E$ must occur to $x$ [...] as a result of a $C$-type event occurring to $x$ at $t$" (Ellis, 2001, p. 130). However, perfectly deterministic dispositions do not obey this condition because their effects are typically *themselves dispositional* and do not always manifest themselves in a way that only depends on $C$. For example, a negative electrical charge at point $P$ has the disposition (in virtue of a deterministic law) to create an electrical field that has, at some point $Q$ distant from $P$, the strength $E$. But if, as will generally be the case, the charge is not the only one around, the total electrical field strength at $Q$ will not be $E$, as determined by the charge at $P$; the total field strength will result rather from the superposition of many dispositions for an electrical field at $Q$.

## 7. Conclusion

Starting from the idea that laws are second-order relations between properties, and thus equivalent to second-order relational properties of properties, I have argued for the thesis that at least some of these nomological properties of properties are essential to them, in the sense that the first-order property would not be the property it is if it did not possess the second-order nomological property. If this is true then the laws corresponding to these nomological properties are necessary in a particular sense: although they do not hold in all possible worlds – they are not logically necessary – they hold in all worlds in which the first-order properties exist.

To establish the thesis of the nomological necessity of at least some laws, I have first argued against two important ways of justifying a crucial requirement for the opposite thesis: if the laws of nature were contingent, the universals taking part in them would have to have an essence independent of their lawful relations to other universals. I have tried to show that Rosenkrantz' "haecceities" are not tied to criteria of identity which could ground their identity and difference across different possible worlds. Furthermore, I have shown Cover and O'Leary-Hawthorne's argument for the existence of "quiddities" of universals, based upon the alleged possibility of the existence of indistinguishable universals, to be invalid.

Second, I have given two positive arguments for the necessity of at least some laws of nature. The first concerns laws of association linking different properties that are instantiated at the same time at the same place. If a law linking macroscopic properties such as the Boyle-Mariotte law linking the temperature, pressure and volume of an ideal gas can be construed as linking different determinables of the same class of determinates, then the logic of the relations between determinates and determinables allows to establish that it is necessary if it is true.

The second argument regards the impossibility of several determinates of the same determinable to be instantiated by the same particular at a given time. I have tried to show that such incompatibilites require the postulate of a specific nomological type of necessity, against Armstrong's argument that it can be reduced to analytic (more precisely mereological) necessity. Insofar as this necessity is not analytic, it gives us a reason to postulate nomological necessity as a fundamental kind of necessity.

As we have seen in the beginning of the paper, Lewis' Humean combinatorialism allows laws of association to be necessary insofar as they constrain relations between different aspects of events, in other words because they constrain only what is the case at one spatio-temporal location. Although Lewis (Lewis, 1986a, p. 114) thinks that we have neither reasons for nor against the hypothesis that laws of association are necessary, the latter thesis is compatible with Lewis' Humean combinatorialism, which postulates independence only between what happens at different space-time regions. However, Armstrong's stronger Tractarian combinatorialism requires that even relations between facts obtaining at the same spatio-temporal location are contingent except if they are reducible to logical or otherwise analytic relations. Our conclusion, that laws of association are necessary, is therefore incompatible with Armstrong's metaphysical framework. Furthermore, our conclusion that causal laws, such as laws of conservation, are necessary is incompatible with both Lewis' and Armstrong's metaphysics.

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## References

Adams, R. M. (1979). Primitive thisness and identity. *Journal of Philosophy*, 76:5–26.

Armstrong, D. (1968). *A Materialist Theory of the Mind*. Routledge, London.

Armstrong, D. (1978). *Universals and Scientific Realism*, volume: *A Theory of Universals*. Cambridge University Press, Cambridge.

Armstrong, D. (1983). *What is a Law of Nature?* Cambridge University Press, Cambridge.

Armstrong, D. (1984). Replies. In Bogdan, R. J., editor, *D. M. Armstrong, Profiles*, volume 4, pages 225–269, Dordrecht. Reidel.

Armstrong, D. (1989). *A Combinatorial Theory of Possibility*. Cambridge University Press, Cambridge.

Armstrong, D. (1997). *A World of States of Affairs*. Cambridge University Press, Cambridge.

Bacon, J., Campbell, K., and Reinhardt, L., editors (1993). *Ontology, Causality and Mind. Essays in Honour of D. M. Armstrong*, Cambridge. Cambridge University Press.

Bigelow, J. (1999). Scientific ellisianism. In Sankey, H., editor, *Causation and Laws of Nature*, pages 56–76, Dordrecht. Kluwer.

Bigelow, J., Ellis, B., and Lierse, C. (1992). The world as one of a kind: Natural necessity and laws of nature. *The British Journal for the Philosophy of Science*, 43:371–388.

Black, M. (1952). The identity of indiscernibles. *Mind*, 61:153–164.

Bradley, R. (1989). Possibility and combinatorialism: Wittgenstein versus Armstrong. *Canadian Journal of Philosophy*, 19:15–41.

Cartwright, N. (1979). Causal laws and effective strategies. *Noûs*, 13:419–437. (Reprinted in Cartwright, 1983).

Cartwright, N. (1983). *How the Law of Physics Lie*. Clarendon, Oxford.

Dretske, F. (1977). Laws of nature. *Philosophy of Science*, 44:248–268.

Ellis, B. (1999). Causal powers and laws of nature. In Sankey, H., editor, *Causation and Laws of Nature*, pages 19–34, Dordrecht. Kluwer.

Ellis, B. (2000). The new essentialism and the scientific image of mankind. *Epistemologia*, 23:189–210.

Ellis, B. (2001). *Scientific Essentialism*. Cambridge University Press, Cambridge.

Ellis, B. and Lierse, C. (1994). Dispositional essentialism. *Australasian Journal of Philosophy*, 72:27–45.

Fales, E. (1993). Are causal laws contingent? In Bacon et al., 1993.

French, S. and Redhead, M. (1988). Quantum physics and the identity of indiscernibles. *The British Journal for the Philosophy of Science*, 39:233–246.

Hooker, C. A. (1981). Towards a general theory of reduction. *Dialogue*, 20:38–59, 201–236, 496–529. Part I: *Historical and Scientific Setting*, Part II: *Identity in Reduction*, and Part III: *Cross-categorical Reduction*.

Kistler, M. (2002). The causal criterion of reality and the necessity of laws of nature. *Metaphysica*, 3:57–86.

Kripke, S. (1972). Naming and necessity. In Harman and Davidson, editors, *Semantics of Natural Language*, Dordrecht. Reidel.

Lewis, D. (1973). *Counterfactuals*. Basil Blackwell, Oxford.

Lewis, D. (1983). New work for a theory of universals. *Australasian Journal of Philosophy*, 70:211–224.

Lewis, D. (1986a). *On the Plurality of Worlds*. Basil Blackwell, Oxford.

Lewis, D. (1986b). *Philosophical Papers*, volume II. Oxford University Press, Oxford.

Lewis, D. (1992). Review of Armstrong, 1989. *Australasian Journal of Philosophy*, 70:211–224.

Lewis, D. (1994). Humean supervenience debugged. *Mind*, 103:473–490.

Lewis, D. (1999). *Papers in Metaphysics and Epistemology*. Oxford University Press, Oxford.

Lewis, D. and Langton, R. (1998). Defining 'intrinsic'. In Lewis, 1999.

Lowe, E. J. (1998). Entity, identity and unity. *Erkenntnis*, 48:191–208.

Macdonald, C. (1991). Review of Armstrong, 1989. *Philosophical Books*, 32:163–164.

Mellor, D. H. (1993). Properties and predicates. In Bacon et al., 1993, pp. 101–113. (Also in: Mellor, D.: *Matters of Metaphysics*. Cambridge University Press, Cambridge).

Mellor, D. H. (1997). Introduction. In Mellor, D. H. and Oliver, A., editors, *Properties*, pages 1–33, Oxford. Oxford University Press.

Menzies, P. (1992). Review of Armstrong, 1989. *Philosophy and Phenomenological Research*, 52:731–734.

O'Leary-Hawthorne, J. and Cover, J. A. (1997). Framing the thisness issue. *Australasian Journal of Philosophy*, 75:102–108.

Redhead, M. and Teller, P. (1992). Particle labels and the theory of indistinguishable particles in quantum mechanics. *The British Journal for the Philosophy of Science*, 43:201–218.

Rosenkrantz, G. S. (1993). *Haecceity : An Ontological Essay*. Kluwer, Dordrecht.

Russell, B. (1986). On the notion of cause. In *Mysticism and Logic*, London. Routledge.

Shoemaker, S. (1980). Causality and properties. In *Identity, Cause, and Mind*, Ithaca (N.Y.). Cornell University Press.

Shoemaker, S. (1998). Causal and metaphysical necessity. *Pacific Philosophical Quarterly*, 79:59–77.

Swinburne, R. (1995). Thisness. *Australasian Journal of Philosophy*, 73:389–400.

Swoyer, C. (1982). The nature of natural laws. *Australasian Journal of Philosophy*, 60:203–223.

Tooley, M. (1987). *Causation: A Realist Approach*. Clarendon Press, Oxford.

Wittgenstein, L. (1966). Some remarks on logical form. In Copi, I. M. and Beard, R. W., editors, *Essays on Wittgenstein's Tractatus*, London. Routledge and Kegan Paul.

Worley, S. (1997). Determination and mental causation. *Erkenntnis*, 46:281–304.