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UNEXPECTED A POSTERIORI NECESSARY LAWS OF NATURE

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In this paper I argue that it is not a priori that all the laws of nature are contingent. I assume that the fundamental laws are contingent and show that some non-trivial, a posteriori, non-basic laws may nonetheless be necessary in the sense of having no counterinstances in any possible world. I consider a law L_S (such as 'salt dissolves in water') that concerns a substance S. Kripke's arguments concerning constitution show that the existence of S requires that a certain deeper level law or variants thereof hold. At the same time, that law and its variants may each entail the truth of L_S. Thus the existence of S entails L_S. Consequently there is no world in which S exists and fails to obey L_S. I consider the conditions concerning the fundamental laws that would make this phenomenon ubiquitous. I conclude with some consequences for metaphysics.

I. Introduction

This paper concerns the metaphysical necessity of the laws of nature. To borrow from Albert Einstein, 'What I'm really interested in is whether God could have made the world in a different way' [quoted in Hawking and Israel 1987: 128]. I shall argue for the following thesis:

(1) It is not a priori that all the laws of nature are contingent.

I also claim, that there is a posteriori evidence that many of the laws of nature are necessary, although I will not be able to argue for this in any detail. And I shall look at some of the consequences of (1) and of the stronger claim that many of the laws of nature are indeed necessary.

In arguing for (1) I shall be arguing that there are certain a posteriori matters, such that if they turn out one way or another, at least some of the laws of nature will be necessary. Depending on how they turn out, it might be that just a few laws are necessary, or that almost all are. Throughout I shall be assuming that the basic (fundamental) laws of nature are contingent. It is true that there are entirely independent reasons for thinking that the basic laws and so all laws are necessary. Such reasons appeal to the nature of properties, asserting that they are essentially dispositional, or that their essences are given by their causal role [Shoemaker 1980; Ellis and Lierse 1994; Ellis 2001]. While I am sympathetic to such views [Bird forthcoming], I shall put them on one side for the purpose of this paper, and

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argue that even if the traditional view that the basic laws are contingent is correct, it is nonetheless the case that some non-fundamental laws might be necessary, as a consequence of the details of the way in which they supervene on the basic laws. (In saying 'some non-fundamental laws might be necessary' the 'might' is epistemic and the 'necessary' metaphysical.)

II. Necessarily Salt Dissolves in Water

The general version of the argument for (1) will be contained in Section III below. In this section I shall briefly recapitulate an earlier argument that concerns a case of one non-basic law that would appear to be contingent if any law is, viz., the law that salt dissolves in water. The latter is a consequence of a single deeper law, Coulomb's law, which is the law that governs the attractive and repulsive forces between charged bodies, what we call Coulomb forces. The underlying science is this. Dissolving is a process whereby the charged parts of water molecules are able to pull the charged ions or atoms of salt off the salt crystal and into solution. For example, the side of the water molecule that has the two hydrogen atoms is positively charged and so is able to attract strongly the negatively charged chlorine ions and pull them into solution. Coulomb's law is what makes this so and is sufficient to make it so.

In the above, by 'is a consequence of' I mean 'entailed by' or 'necessarily is implied by'. In all worlds where there is salt placed in water and where Coulomb's law holds, dissolving takes place. And if we think of the proposition 'salt dissolves in water' as quantifying universally over instances of salt being placed in water, it holds trivially in worlds lacking salt and water, or where salt is not placed in water. Hence in all worlds where Coulomb's law holds, the law that salt dissolves in water holds.[1] It is this sort of relationship that philosophers of science usually have in mind when they think about the relationship between non-basic laws and the deeper level laws underlying them.

But there is another important relationship that is often ignored, and this is the relationship between *substances* and deeper level laws. Substances such as salt and water are not themselves basic kinds of stuff in the way that perhaps quarks or strings are. Rather they are composite, being themselves composed of other more basic substances. And it is not simply that they have other more basic substances as constituents, but that these constituents are combined in the right way. Kripke has argued that constitution is necessary, and I shall take this for granted [Kripke 1980]. But it is not only the substances of constitution that are necessary but also the manner of constitution. That is, if it is necessary that all water contains H_2O molecules, it is not only necessary that water contains hydrogen and oxygen atoms, but also necessary that these are combined in molecules. A mixture of oxygen and hydrogen is not water. And something similar goes for salt. Salt is

[1]What is understood by necessity here is that there is no world with a counterinstance, i.e., in which salt is placed in water and does not dissolve, just as '$a = b$' is taken as necessary when there is no world in which $a \neq b$, even if there are worlds in which a and b do not exist.

sodium chloride. It is not simply a mixture of sodium and chlorine but is rather a compound where charged sodium and chlorine ions are held together in a crystal by the forces of electrostatic attraction—Coulomb forces. The same Kripkean arguments show that this is necessary. These Coulomb forces, the forces of electrostatic attraction, are precisely those governed by Coulomb's law. Hence the existence of salt entails not just the existence of sodium and chlorine ions but also of Coulomb's law or something very much like it.

The results we have so far are that (i) Coulomb's law entails that salt dissolves in water, and (ii) the existence of salt entails that Coulomb's law holds. Putting these together, we see that the existence of salt entails that salt dissolves in water. And so there is no possible world where there is salt but it fails to dissolve in water. And so it is necessary that salt dissolves in water. The very same Coulomb forces that are sufficient for salt's dissolving in water are also necessary for salt's existence.

The argument given needs clarification and modification in various respects.[2] I shall mention just one. I said that the existence of salt entails that Coulomb's law holds—*or something like it*. This is because some slight variations on Coulomb's law (its 'close cousins') might generate Coulomb forces with a strength different from but nonetheless very similar to the actual Coulomb forces, sufficiently similar for the salt crystal to be able to exist. So strictly the existence of salt entails a disjunction of Coulomb's law as it actually is and various variants on Coulomb's law. This does not matter to my argument. The dissolving law will still be necessary, so long as each of these variants on Coulomb's law, variants that permit the existence of salt, also entails the dissolving law. Showing that this set of relationships does in fact hold requires some moderately detailed work in theoretical chemistry.

This structure of relationships between a substance, a lower level law, and a higher level law, that results in the higher level law being necessary, I call the 'down-and-up structure'.

III. Contrast with Shoemaker-style Necessitarianism

Because my argument has a partially necessitarian conclusion, I should emphasize that I take it to be an extension of Kripke's essentialist arguments concerning the necessity of constitution and *not* to imply or require the kind of necessitarianism flowing from the causal-role essentialism for properties associated with Shoemaker, Ellis, et al. The key claim of the latter is that natural properties have their causal or dispositional role essentially. Thus if some property P is essentially the disposition to manifest M in response to stimulus S, then necessarily whenever P and S then M (perhaps *ceteris paribus*). The key claim is motivated by a priori reflections on what it is to be a natural property. Note that on this view the essence of a property typically refers to a stimulus that is extrinsic to the possessor of the property.

[2]For details of the argument see Bird [2001]. For critical discussions see Beebee [2002]; Psillos [2002] and for a defence see Bird [2002].

For example, the essence of inertial mass is arguably a disposition to respond to a force with an acceleration. The impressed force is extrinsic to the possessor of the inertial mass.

No such assumptions are made in my argument. On the contrary, in the previous section I have explicitly assumed that charged objects might not obey Coulomb's law or anything like it—charged objects might not respond to one another with attractions or repulsions. Whereas an application of the Shoemaker-Ellis view could be expected to be that it is of the essence of charge that charged objects exert forces on one another. The essentialism in my argument focuses on the intrinsic features of a substance, viz., the matter and manner of its constitution, and not on its extrinsic interactions.

My argument is an extension of Kripke's arguments concerning constitution because whereas the discussion of the latter have emphasized the *matter* of constitution, I have argued that his arguments extend to the *manner* of constitution also. In the absence of Coulomb's law or its cousins there may be different laws that ensure that atoms of hydrogen and oxygen and ions of chlorine and sodium bind together. As mentioned, mixtures and compounds are different substances. Imagine that we can combine elements X and Y into a compound (in the same ratio) in two different ways, one where the bonding is ionic and another where the bonding is covalent. We would have two different substances. Similarly substance A in w and substance A* in w^* are not the same substance if the laws holding A together are of a different kind from those holding A* together. Let A be sodium chloride in the actual world w, and A* be a substance in w^*, such that sodium and chlorine are bonded in A* by some law that is not Coulomb's law or any variant thereof. Then A and A* are not the same substance. Thus we see that A, salt, requires some law of the same kind as Coulomb's.

Thus although both my argument and the Shoemaker-Ellis view link essences to laws, they do so in fundamentally different ways. My argument says that a law is essential to a *substance*, in virtue of the *intrinsic* character of an instance of that substance (its constitution) whereas the Shoemaker-Ellis view says that a law is necessary to a *property*, thanks to the (typically) *extrinsic* character of a possessor of the property (its interactions with other things). There is no contradiction in asserting the former and denying the latter.

I conclude this section by noting a limiting case of the extension of Kripkean essentialism I am employing. The latter concerns both matter and manner of constitution. However, not everything is made up of something else. So far as we know protons have quarks as constituents but electrons have no more fundamental parts. But that does not mean that the existence of electrons is a mere brute fact that has no explanation. On the contrary, it is both hoped and expected that a satisfactory development of the theory of fundamental particles will explain why electrons exist, and why electrons have the properties they do. So although there is no essence of an electron in virtue of its matter of constitution, there is a limiting sense in which there is an essence in virtue of its 'manner of constitution', which essence will be the law (or kind of law) that explains its existence. This law will, if fundamental, be contingent (or, rather, is not required to be necessary), according to my account. To reiterate, this account is different from a Shoemaker-Ellis essentialism. The former identifies an essence of electrons that relates to (explains) an intrinsic feature of electrons, that they exist, while the latter finds an essence in the property of being electrically charged, that relates to an extrinsic feature of electrons (and any other charged entity) viz., their disposition to behave in certain ways.

IV. Generalizations

Now I want to examine ways in which this argument might be generalized and extended. It might appear to be some local accident, a fluke, that in this case the same lower level law is both sufficient for the holding of a higher level law but also necessary for the existence of the substance involved in that law. But further investigation shows that the down-and-up structure might well be a far more common, indeed ubiquitous feature of the world.

Kripkean essentialism gave us that a world with salt is a world with sodium and chlorine ions. We can go further. The same necessity of constitution gives us that a world with sodium and chlorine ions is a world with protons, neutrons, and electrons. And a world with protons and neutrons is a world with quarks, which are the constituents of protons and neutrons. And so on. If there is an elementary, or fundamental kind of entity that is a constituent of all substances, then we may conclude that a world with any substance is a world with that elementary kind of entity.

As we saw, the necessity of constitution yields not only the necessity of the existence of the constituent substances but also of the manner of constitution. The existence of salt required the existence of electrostatic forces and hence of Coulomb's law or something like it. Similarly, the existence of sodium ions entails the existence of the strong nuclear force. This is because the strong nuclear force is that force which binds the protons and neutrons into the atomic nuclei. Hence the existence of the sodium ions, and any other atoms, ions, or nuclei entails the law that actually governs the strong force or something like it. We can now see that the existence of any substance not only entails the existence of the most fundamental kind of entity but also entails the existence of whatever law or laws governs those entities (or something like it/them). And I think we can go further. The fundamental or elementary entities won't have a constitution in the sense that they are not made up of any other kind of entity. But there will be laws that are responsible for their existence. These laws (or more strictly, the disjunction of these laws and their close cousins) will be essential to the elementary entities in the way that Coulomb's law (or its cousins) are essential to salt. Either way, the existence of some macro substance entails the holding of laws of a certain class at a very deep level. I will call the actual lower level law (or conjunction of laws) governing the elementary entities 'F'. So the existence of salt or any other macro substance (call it 'S') entails the existence of the elementary entities and thereby entails that either F or some close cousin of F holds. Let us signify the set of laws F and its close cousins by 'Γ_F'. And let us signify the disjunction of the propositions expressing those laws by '$\vee\Gamma_F$'. Hence we have:

(2) $\Box$(S exists $\rightarrow \vee\Gamma_F$).

V. Some Empirical Assumptions

In this section I want to consider the disjunction $\vee\Gamma_F$. Since we do not know the nature of F, we do not know what the range of laws is included in Γ_F. For all we know for certain, Γ_F might contain an infinite range of laws. If F is a law or is a conjunction containing a law with a fundamental constant k that may take a continuous range of real values, then Γ_F will contain variants on F that differ from F only by minute differences in the value of k. If in Section II we were to treat Coulomb's law as a fundamental law and the permittivity of free space ε_0 as a fundamental constant, then the cousins of Coulomb's law will include laws that differ from Coulomb's law by varying ε_0. However, whether Coulomb's law does indeed have such cousins is not in fact known. For the law is not an independent fundamental law of physics and, more importantly, ε_0 may not be a fundamental constant. Instead its value may be constrained by the structure of deeper laws and other constants. Thus when we consider F and the set Γ_F we do not know whether F does contain a real valued constant such that Γ_F contains an infinite variety of cousins of F. It is epistemically possible that the structure of F is such that Γ_F is itself tightly constrained. Indeed it is epistemically possible that Γ_F contains just one (non-conjunctive) law, viz., F itself.

Under what conditions would Γ_F be so constrained that its sole member is a single non-conjunctive law? Consider the following empirical assumptions concerning F:

(i) F is among the fundamental laws of the universe;

(ii) the existence of the fundamental entities is highly sensitive to variation in F—that is, were any of the laws that are variants of F more than slightly different from F, the entities would not exist;

(iii) F is highly rigid—the form of F or its constituent laws do not permit minor variations;

(iv) there is only one fundamental law. The true Theory of Everything is encapsulated in a single law.

Now I want to show that were these assumptions true, it would follow that the down-and-up structure and the concomitant necessity of the higher level law would be ubiquitous. Later I shall briefly consider whether all the assumptions are required for this conclusions, and whether any weakenings (e.g., of assumption (iv)) would do the trick.

Let L_S be a higher level law governing the substance S. The argument in Section III gave us $\Box$(S exists $\rightarrow \vee\Gamma_F$)—that is, S entails the disjunction of the law or conjunction of laws F governing the fundamental entities and any variants on F that permits the fundamental entities (and so S) to exist. Assumption (ii) tells us that the alternatives to F in Γ_F must be very similar to F. On the other hand, by (iii) no such minor variations on F exist. Therefore there just are no relevant variations on F. So $\Gamma_F = \{F\}$ and $\vee\Gamma_F = F$. Hence (II) is just:

(2*) $\Box$(S exists $\rightarrow$ F).

By assumption (i) F is a fundamental law of the universe. And by assumption (iv) there is only one fundamental law, and so F is it. Now the point of being the unique fundamental law is that every non-fundamental law is a consequence of it. Therefore every non-fundamental law is a consequence of F. (That is what it is to be a non-fundamental law.) In particular then, L_S is a consequence of F. Hence F entails L_S, i.e.:

(3) $\Box(F \rightarrow L_S)$.

Putting (2*) and (3) together we have:

(4) $\Box$(S exists $\rightarrow L_S$).

So the existence of the substance S entails the holding of the law governing it. Hence there is no possible world in which S exists but the law fails to hold of S. That is, L_S is necessary. S and L_S were arbitrary; so any law involving any substance is necessary. The down-and-up structure is therefore ubiquitous.

Note that the assumptions (i)–(iv) are neither a priori true nor a priori false. More importantly, we do not know a priori that the conjunction of these assumptions is false. The truth values of these propositions, individually and in conjunction, is knowable, if at all, only through a posteriori scientific investigation. Furthermore, what evidence we do have from the development of modern physics suggests that these assumptions are at least plausible (which itself is good evidence that the propositions are individually and jointly consistent). I will discuss these assumptions a little more in Section VII below.

VI. Intermediate Conclusions

We are now in a position to see why the original assertion (I) has been established. We have an argument whose conclusion that all higher level laws involving substances are necessary. This was achieved by employing the following assumptions:

(a) Kripkean essentialism about constitution;

(b) the empirical assumptions (i)–(iv).

Since we have an argument from a posteriori premises to the conclusion that many laws of nature are necessary, it cannot be a priori that they are all contingent. (If it were a priori that all laws of nature are contingent, then it would be a priori that at least one of the premises is false. But as I argued it seems that their truth values, individually and jointly are a posteriori.) Since it is not a priori that the laws of nature are all contingent and we do not know a posteriori that the above premises are false, it follows that it is at the very least epistemically possible that some laws of nature are necessary, even assuming the contingency of the most basic ones.

Indeed it is epistemically possible that most of the non-basic laws are necessary. And I think that in some particular cases, such as salt dissolving in water, we can know that the law is necessary, since the relevant a posteriori facts are known to us. But even if the latter case, like the general case, depends on as yet unmade discoveries concerning the fundamental laws, the fact remains that whether the law is contingent or necessary is not an a priori matter. This is so even if the empirical assumptions turn out to be false.

VII. Concerning the Empirical Assumptions

The assumptions made in deriving the ubiquity of the down-and-up structure are not known to be true. But there are reasons from science to believe that they may well be true. For example, considering (i), it is plausible to suppose that the fundamental entities of the universe are governed by its fundamental laws. After all, one might ask, what do they govern if not the fundamental entities? And even if the fundamental laws do not govern the fundamental entities they will be responsible for their existence. And the Kripkean arguments will apply here. The laws that are responsible for the existence of the fundamental entities are such that it is essential to those entities that either they or some close variant on them holds.

Empirical assumptions (ii) and (iii) amount to the claim that the law or laws governing the fundamental entities are such that any possible change to those laws would result in a world that is radically different, sufficiently different that those entities do not exist.

Assumption (ii) asserts the sensitivity of the existence of the fundamental entities to the most basic laws. The sensitivity of the existence of higher substances to deep laws is well explored in physics. In particular it is often pointed out that the existence of the chemical elements is sensitive to the value of the fine structure constant, and that the existence of chemical compounds is highly sensitive to the ratio of the mass of the electron to the mass of the proton. Vary these constants by much and the processes leading to the creation of elements such as carbon and those heavier than carbon will not occur and the chemical combination of atoms will not be possible. Other sensitivities of this kind have been explored and their existence has in some quarters motivated various Anthropic principles.

In such cases the constants in question are assumed to be such that they can take any real value. So at least very slight variations on their values are possible. If so, then these values and the relevant laws are not rigid in the sense of assumption (iii). It is a speculation that this is in fact not the case, and that the constant could not have taken slightly different values. Nonetheless, it is a plausible speculation. The physicist Steven Weinberg notes that the history of physics is marked by the increasing rigidity of its theories [Weinberg 1993: 189–91]. What seems in one theory to be a constant that could have been otherwise subsequently becomes explained as a consequence of some theoretically important feature of some deeper theory. The changing mathematics of our theories also shows a shift in this direction. A theory that is expressed as equations in the mathematics of the real numbers seems to allow room for variation, because constants might always take slightly different values. And if there are no constants they might be added arbitrarily. However, it might be that the mathematical description appropriate to the most fundamental laws is not analysis and the theory of real numbers but is group theory. Imagine that the fundamental structure of the universe is described by a small finite group. Then a very slightly different universe is not available. A group with a different order (number of elements) will have radically different properties, just as a square and a triangle have very different properties, and there is no intermediate regular polygon that is, as it were, not a square but very close indeed to being a square.

Assumption (iv) asserts that the fundamental law in question is unique. That is, there is one all-encompassing law. This is also speculative. We don't know what a Theory of Everything will look like. But the success of science in providing unified explanations for a variety of phenomena is reason to hope that a single law underlies everything. If physics were able to come up with a satisfactory and seemingly fully general theory that contained two fundamental laws, it would become an important question whether the two laws were in fact independent or whether both might be regarded as manifestations of a single underlying law.

The possibility of two or more fundamental laws raises the following possibility. Let the two laws be A and B. It might be that while substance S entails that A holds, S does not entail that B holds since B is irrelevant to the existence of S. At the same time it might be the case that for the holding of the higher level law, L_s, A is not sufficient, but B is required also. Hence the existence of S would not entail L_s.

Even so, a world with more than one fundamental law might nonetheless be a world where the down-and-up structure is ubiquitous or almost ubiquitous. Imagine that the laws are tightly integrated, so that the explanation of phenomena, including deep level phenomena such as the existence of the fundamental constituents of matter, requires all the laws together. Then it would turn out that the existence of substance S entails that each of the fundamental laws holds. Although none of the laws is individually sufficient for L_s, clearly the conjunction of the laws is. In effect, if they are tightly integrated at a deep level, we can for current purposes treat the conjunction of the laws as a single law that is entailed by S and which entails L_s. Once again S entails L_s. Summarizing we can replace (iv) by:

(iv*) the fundamental laws form a set that is tightly integrated at a deep level.

Clearly (iv) entails (iv*). And even if we may suspect that (iv) is indeed true, there is rather more convincing evidence that (iv*) is true. Similarly, it need not matter if (i) is strictly true. The laws in question might not the utterly basic ones, but they may include all the laws at that near-basic level.

VIII. Space and Time

A classical conception of space and time regards them as independent of the laws of nature. One might think of space and time as the stage upon which the laws of nature play themselves out, and hence not a constituent of the play themselves. Such a conception allows for different articulations depending upon whether one is a substantivalist or relationist and whether one is a conventionalist or not. What is common to the classical views is that space and time are parameters in all laws but not entities whose natures are governed by the laws.

This classical conception allows for a certain kind of flexibility in laws and hence for a degree of insensitivity. Standardly laws are thought of as genuinely universal in space and time. That is we can think of laws as preceded by universal quantifiers ranging over all space and all time. Although this is what we tend to expect of laws, it is nonetheless conceivable that there should be laws in which the quantification over space and time is restricted. A nomic relation or regularity might hold only in certain regions of space or periods of time. Certainly nothing in the nature of space and time prevents this.

The classical picture permits a degree of insensitivity that threatens to rule out the down-and-up structure for some kinds of laws, in particular those that involve interactions between substances. Let substance S be subject to a law N that relates S to substance T in some interaction (such as salt dissolving in water). And let S depend for its existence on some fundamental law L. L may also entail that N is true. However S might be permitted to exist by L* which differs in important respects from L. L* might be like L for precisely those regions of space and time where S exists, but unlike L outside those regions. In particular therefore L* may diverge from L in the regions of space and time between particles of S and T where S and T interact. Note that chemical reactions do not take place by mechanical action between molecules and atoms but via electrical interactions in the intervening spaces. So (Coulomb's law)* may hold within the space occupied by a salt crystal, hence keeping the sodium and chlorine ions together but not hold in the area between the surface of the salt crystal and the surrounding water molecules.

I think that there are a number of things wrong with this suggestion.[3] But the most important is that is assumes a classical picture of space and time, according to which there is nothing in the nature of space and time themselves that prevents quite different things happening in different regions. And we know that the classical picture is false. Space and time are not a stage or container within which the laws operate. They themselves, like other features of the universe, are subject to the laws of nature. Indeed, according to admittedly speculative but nonetheless plausible work by Hawking and Hartle, the existence of space and time can be seen as emerging from the most fundamental laws of nature.[4] Given the falsehood of the classical picture, the possibility of the sort of variability and insensitivity we have seen cannot be taken for granted. For L* or (Coulomb's law)* to be genuinely possible there must be an appropriate permissible variability in the laws governing spacetime that generate precisely L*. But there is no guarantee that the laws will permit this. Indeed we can easily see how they might not. For the fundamental laws F that actually generate spacetime will not themselves have space and time as parameters. Consequently there may be no way of rewriting those laws to permit local variations in the nature of spacetime in term permitting laws such as L*.

IX. Consequences and Applications

The view that the laws of nature are all contingent is an assumption that is widespread in metaphysics and indeed in philosophy generally. In this section I will look at some of the consequences of accepting that many of the laws of nature may be necessary. I will first show how the argument I have given amplifies the lessons of Kripke's earlier achievement in divorcing the necessary from the a priori. I will then illustrate the significance for metaphysics of the admission that many laws may be necessary with two very different cases where it has been assumed that all laws are contingent. The first is David Lewis's account of counterfactuals and the second is the problem of physical evil. In neither case do I have a particular agenda to promote. The choice is intended merely to draw attention to the widespread significance of giving up the contingentist assumption about laws.

Necessity and the A Priori

The argument draws upon Kripkean necessity of constitution and identity and in one respect yields an analogous result. According to Kripke identity is necessary: George Orwell is necessarily Eric Blair. But this does not require that Orwell/Blair exists at every world, but rather that Orwell is Blair

[3]Beebee [2001] presents a response of this kind. See Bird [2002] for some of the problems, other than that discussed here, with such a response.
[4]Cf. the Hawking-Hartle no-boundary proposal (and also the Linde and Vilenkin tunneling proposal) in Quantum Gravity [Hartle and Hawking 1983]. For a philosophical discussion see Butterfield and Isham [1999].

at all worlds where Orwell or Blair exists. So the necessity might be expressed thus:

$\Box$(Orwell exists $\rightarrow$ Orwell = Blair).

Which is analogous to our conclusions:

$\Box$(S exists $\rightarrow L_S$).

$\Box$(salt exists $\rightarrow$ salt dissolves in water).

As with Kripke's necessity of identity, my necessary laws are not knowable a priori. But the conclusion of the broader argument goes beyond Kripke's in an important way. For Kripke's arguments are a priori arguments with the conclusion that identities and constitutions are necessary. So, for example, the following is knowable a priori:

Orwell = Blair $\rightarrow$ $\Box$(Orwell = Blair).

But unlike Kripke's my discussion draws on empirical, a posteriori assumptions. And so, as we have seen, the analogous proposition from my discussion is not knowable a priori, but only a posteriori:

salt dissolves in water $\rightarrow$ $\Box$(salt dissolves in water).

Similarly Kripke's a priori arguments yield the conclusion that it is not contingent whether Orwell is Blair. If you are ignorant of literary history you may not know whether Orwell is Blair; but you do know that it is either necessary that Orwell is Blair or necessary that Orwell is not Blair. However, you do not know a priori whether it is contingent that salt dissolves in water. To discover whether that proposition is contingent or not you have to engage in science.

Propositions with similar properties can be constructed within the framework that Kripke has given us, without recourse to my argument. For example, let q be an identity and r some clearly contingent proposition. The proposition $q \vee r$ is necessary if q is true and is contingent if q is false. If we do not know the truth value of q we do not know whether $q \vee r$ is contingent or necessary. If q is a proposition such as 'Orwell is Blair', a posteriori investigation is required to discover its truth value. Thus the status of $q \vee r$ as necessary or contingent may also be a posteriori. Even so, it is instructive to find cases 'in nature' so to speak, in addition to manufactured cases. And so, I maintain, the link between the a priori knowable and the necessary is weakened yet further. It is weakened in a way that invites a certain kind of naturalization of metaphysics. Traditionally one characterization of metaphysics has been that metaphysics is the investigation of the necessary structure of the world. If the latter includes the investigation of all necessary truths, then Kripke's a posteriori necessities would be a case where metaphysics requires empirical input. However, such an understanding is clearly too liberal in any case since it would make mathematics part of metaphysics. And it seems odd to think that knowing that Blair is Orwell is part of metaphysics. Nonetheless, it is plausibly part of metaphysics to know that the propositions of mathematics and identities are, if true, necessarily true. On that understanding of what one of the tasks of metaphysics is, metaphysics may still be an a priori discipline as far as Kripke's advance is concerned. For, as discussed, it is a priori that if true the proposition that Orwell is Blair is necessarily true. But the necessities I have been discussing are not like that. For in these cases discerning the borderline between the necessary and the contingent cannot be done a priori, but needs the a posteriori input of science. And thus to the extent that this task, drawing the boundaries of the necessary, remains a task of metaphysics, metaphysics must be naturalistic in that it makes use of the deliverances of natural science.

Counterfactuals

The necessity of the laws of nature is incompatible with Lewis's account of counterfactuals [Lewis 1973; cf. Stalnaker 1968]. The latter is in fact closely integrated into the rest of Lewis's philosophy. But it is often regarded as a self-contained package (e.g., by those who reject his modal realism but nonetheless think they can buy into the theory of counterfactuals). That, however, would be a mistake if one accepts Kripkean essentialism and the extension I have given to it.

Let us take for example the proposition 'had the apple not fallen while he was under the tree, Newton would not have discovered the law of gravity', which according to fable is true. On Lewis's view this requires that in the nearest possible world in which the apple did not fall, Newton does not discover the law of gravity.[5] That nearest world in which the apple did not fall is one which is just like the actual world until a short time before the time of the apple falling. Then the other world diverges from the actual world in some way such as to prevent the apple falling. This requires that the laws of nature differ in that world from ours. There is, from the point of view of our laws, a violation of the laws; what Lewis calls a small miracle [Lewis 1973: 75]. The small miracle having occurred, sufficient to prevent the falling, the laws of the other world fall into line with those in the actual world again. But because the small miracle has brought about a divergence of particular facts, the subsequent sameness of laws leads to a divergence of the worlds' histories thereafter (including, allegedly, a difference in the discoveries made by Newton).

This can make sense only if it is indeed possible for two worlds to have laws that govern the same kinds of entity but nonetheless diverge in the way that Lewis's small miracle requires. Lewis assumes a thoroughgoing

[5]Strictly, either there is no world in which the apple fails to fall or there is some world such that the apple does not fall and Newton does not discover the law of gravity that is closer to the actual world than all worlds where the apple does not fall and Newton does discover the law of gravity.

contingentism about laws. But if the argument of this paper is sound, such an assumption is unwarranted. There is no a priori guarantee that there can be two worlds with similar but divergent laws governing the same kinds of entity. And there is a posteriori evidence that it is not possible. Suppose, for example, the small miracle required to prevent the apple from falling is that the stalk holding it to the tree does not weaken and break until Newton leaves the orchard. Now the processes by which a stalk does weaken and break involve biochemical and physical processes such as dissolving. Let us assume that the down-and-up structure is ubiquitous. In which case the supposition that dissolving takes place is inconsistent with the supposition that we have the same substances and kinds involved as in the actual world. And the same goes for the other processes that are involved in the weakening and breaking of the stalk.

If the down-and-up structure is ubiquitous then small miracles are not possible—there are no possible worlds where there are laws governing the same kinds and substances but which diverge at points from ours.[6] So one must either buy into the remainder of Lewis's philosophy, with a rejection of Kripkean essentialism. Or one must look for another theory of counterfactuals.[7]

The Problem of Evil

I opened this paper with a quotation from Einstein: 'What I'm really interested in is whether God could have made the world in a different way'. Theological sceptics say that if God exists, he ought to have made the world in a different way, for the way it is brings suffering and misery to millions. A truly beneficent God would have made the world in such a way as to permit those people to avoid physical suffering they cannot control. This problem of physical evil seems to many to be more problematic that the problem of moral evil, since the existence of evil deeds may be ascribed to free-will. But the existence of earthquakes, floods, droughts, and so on seem to be a consequence of the way God made the world and could have been avoided either by God's having designed a different world or by God's intervening to prevent these things occurring in such a way as to cause harm to innocent individuals.

[6]One could avoid a violation of law, perhaps, if the initial conditions were different and would lead to the stalk remaining intact. If they were different, then the whole history of the universe would be different also. Furthermore, if another world shares our laws but is slightly different a long time ago then it will be significantly different now—and there is no guarantee that any initial conditions will lead to the same or even similar scene of Newton, the branch, the apple, but with just a small difference, viz., no breaking. Similarly, if another world shares our laws but is slightly different in the recent past, then its more distant past must be very different. Lewis [1986, 45–8] regards such worlds as less similar to the actual world than one where the particular facts match for a long period then diverge thanks to a difference in law at the point of a small miracle. It is true that the need for small miracles can also be obviated by appealing to the quantum indeterminacy of our laws. This move, however, faces two problems. First, it would be odd if the (non-trivial) truth of counterfactual talk *required* our laws to be indeterministic. Secondly, Lewis's account is framed within an assumption of determinism. Bringing in indeterminism may help with this problem but it does create trouble elsewhere Lewis [1986: 58–65].

[7]For example, Igal Kvart's [1986] theory of counterfactuals or a return to the meta-linguistic approach. (I take the former to be in the spirit of the latter [cf. Goodman: 1954].)

As we have seen, miracles are metaphysically impossible. While some theologians may not like that, it lets God off the hook as far as failure to intervene is concerned. So if God is to bear responsibility for physical evil, it must have been possible for him to have created the world in a different way. It might be thought that this would mean either God could have created the world with different laws or that he created it with the same laws but with different initial conditions. As we have seen, if the down-and-up structure is ubiquitous, different laws would mean a world different from ours in the most fundamental respects. The world wouldn't even have the substances we have, let alone humans and so on. So God could not have created a world at all like ours with different laws. So to avoid physical evil what would be required are different initial conditions.

To this there are two responses. The first has already been discussed in the section above on space and time. The second reminds us that there is no guarantee that it is possible to have initial conditions that in conjunction with our laws would lead to a world that remains free of sources of physical evil. To take a simple example, even if the weather is today benign throughout the world, we know that in due course it will not be. The weather is chaotic, thanks to the nature of the laws governing it. Via the butterfly effect and so on, there will inevitably be hurricanes. There is no possible initial set of weather conditions that will never produce destructive storms, so long as the laws governing the weather are as they are. More generally, given that the laws of nature are held fixed, it is implausible that the initial conditions could have been different in a way that would have allowed for the existence of the Earth and its human and animal inhabitants but would not permit the physical evil that occurs. Variations on the initial conditions that would remove the latter would remove the former also. The existence of humanity and the existence of the physical conditions in which humanity finds itself are not independent but are parallel effects of a common cause. No alternative cause would yield humanity but without its actual environment.

X. Conclusion

I suspect that the widespread belief that all the laws of nature must be contingent is one of the more powerful effects of the legacy of empiricism. But as mentioned at the outset, the view that all laws are necessary is beginning to find favour. Such a view clearly entails the truth of the principal assertion of this paper, (1), that it is not a priori that all laws are contingent. To the extent that the proposition that all laws are necessary can be established a priori, the intermediate conclusion reached here, that it is a posteriori whether certain laws are necessary, will be weakened. Nonetheless, it is dialectically useful even for a priori necessitarians to be able to show that contingentism fails even on its own terms. Even if we grant the premise that the basic laws of nature are contingent, we can see that there is no guarantee that the non-basic laws will all be contingent also. Indeed there is good a posteriori evidence that many will not be. Once that fact is appreciated the power of intuition and the hold of contingentism might be weakened sufficiently for a more thoroughgoing necessitarianism to be on the cards.

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