On whether some laws are necessary

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1. Introduction – the 'down-and-up' structure and the ground of a posteriori necessary laws

In Bird 2001 I argued that a law that might seem to many to be contingent is in fact necessary. In short the argument is this. Given the existence of salt and water, Coulomb's law of electrostatic attraction is sufficient to make the former dissolve in the latter. So any possible world in which salt failed to dissolve in water would be one in which Coulomb's law is false. However, it is also the case that the existence of salt depends on Coulomb's law. If Coulomb's law is false then salt cannot exist. So there is no possible world in which salt exists and in which it does not dissolve in water.

When fully elaborated the argument needs to take into consideration the thought that salt might after all be permitted to exist in a world in which Coulomb's law (as it is found in the actual world) is false. A close cousin of Coulomb's law might be true in that world, sufficiently close to allow salt to exist. But the cousin might not be close enough to require dissolving to take place. I suggested that such a world will not exist, given what we know of chemistry. Our knowledge of chemistry allows us to predict what would happen were the laws slightly different. (This sort of thought

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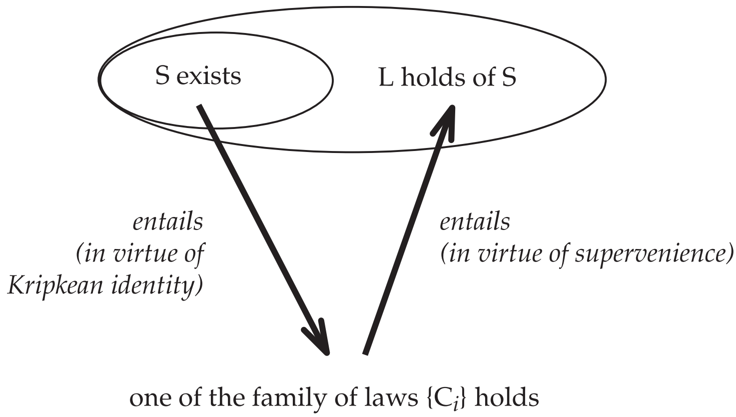
experiment is common in physics.) And, I argued, any cousin of Coulomb's law close enough to allow salt to exist would also require it to dissolve in water. Of course the point of the paper was not to prove some proposition of modal chemistry. Rather, the point is the more general one that some higher level law might turn out to be necessary because of the subtle ways in which it supervenes on lower level laws (even if we assume the lower level laws themselves to be contingent). The structure I have in mind is this. The higher level law L concerns some substance S. Kripkean considerations show that the very identity and existence of S entail that one of a family of closely similar lower level laws $\{C_i\}$ must hold. At the same time, L supervenes on the lower level laws in such a way that were any of the $\{C_i\}$ to hold, L would hold also. Hence the existence of S entails that L holds, and so there is no world in which S exists but L fails to hold of it. The structure can be generalized to cases where we are concerned with the existence of some *phenomenon* regarding which a law L holds, rather than with the existence of a substance. One could call this the 'down-and-up' structure:



Whether such relationships of identity and supervenience obtain is a matter of a posteriori discovery. If we discover some higher level law experimentally but do not know what makes it hold, we will not be in a position to know whether it is necessary or not. It will be easy to imagine (in some sense) the law not holding and it is not surprising that we are accustomed to thinking that laws are contingent. But, as we know, the link between imaginability and possibility is weak. Our untutored modal intuitions are unreliable. (Throughout this paper I shall nonetheless assume for sake of argument that the fundamental laws are contingent.)

2. *Adjusting Coulomb's law – Beebee's objection*

Helen Beebee (2002) argues that in the case of salt and water I overlooked a variant of Coulomb's law that would allow salt to continue to exist but without dissolving in water. (We would then have the downward entailment without the upward entailment.) Let us refer to Coulomb's law as it is found in the actual world as 'Coulomb_A' while Beebee's variant is 'Coulomb_B'. Coulomb_B deviates from Coulomb_A in spatio-temporally limited regions. Imagine a salt crystal placed in water. Beebee's idea is that Coulomb_B is like Coulomb_A within the confines of a salt crystal. Similarly the laws also coincide for the region occupied solely by water molecules. However the laws diverge at the interface of the salt crystal and the water molecules. (This interface is a region that is constantly and rapidly changing over time, because of the Brownian motion of the molecules and ions.) Within the interface Coulomb_B is much weaker than Coulomb_A. So the salt crystal and the water continue to exist as in the actual world but dissolving fails to take place.

I shall examine the problems with Beebee's argument shortly. In keeping with the thrust of my argument, my reply will draw upon the science of the matter. For it is the scientific relationships that generate the necessities in question. Beebee does not address my more general and important point. Even were she right in this case, does she think that there can be *no* cases that have the down-and-up structure? If she thinks that there could be such cases, then I am happy. For then she accepts my conclusion that there can be laws that are necessary but which 'look' contingent. If on the other hand she thinks that every law is contingent and that no such cases can arise (as her title suggests), then I am entitled to ask what argument she has for this view. Or is it just contingentist prejudice? I myself cannot see how one could argue a priori that lower level contingent laws cannot interact in such a way (the down-and-up structure, for instance) that a higher level law turns out to be necessary. As I shall show in §5, whether or not such relationships exist is an a posteriori scientific matter; and furthermore we are not yet in a position to know (even a posteriori) that the down-and-up structure does not hold anywhere.

At this point it is worth pointing out that Beebee's argument, even if valid, cannot be generalized to cover all cases that have the down-and-up structure, let alone to other kinds of case we haven't thought of yet. If Beebee's argument works it is because the law 'salt dissolves in water' concerns the interaction of two spatially distinct substances. But other examples have the down-and-up structure without requiring the interaction of distinct substances. Heated substances emit light radiation not along a continuous spectrum but at distinct, discrete wavelengths. This is a law of nature, discovered and quantified experimentally by Balmer and others.

Could it have been otherwise? Could wavelengths of the light emitted by the excited atoms of neon be continuous rather than discrete? That would require the falsity of quantum mechanics. So could there be a possible world governed by, say, a classical, non-quantum theory of the atom, in which neon emits light within a continuous range of wavelengths?[1] No, there could not, because that would not be a world with atoms of neon. As I argued in Bird 2001 the identity of a substance depends not only on what it is made of but also on how it is made. A mixture of carbon and sulphur is not the same as the compound carbon disulphide. Even if electrons, protons, and neutrons could exist in a world without quantum mechanics, an atom composed of such things held together by completely different laws would not be an atom of any substance we have in this world. A world with our atoms is a world with quantum mechanics and a world with quantum mechanics is a world in which excited atoms emit discrete rather than continuous spectra. Since this is not a matter of an interaction, there is no room for proposing a world in which the laws differ in their application to the substance itself from their application to the interaction between that substance and another. I will admit that in this case I am stretching my scientific knowledge. To be confident we would have to ask an atomic physicist to settle the matter. But that of course is just my point. Whether or not the law in question is necessary is a matter to be decided by a posteriori scientific investigation; we cannot know the answer a priori.

3. *The identity and similarity of laws*

Let us now turn to my reasons for thinking that Beebee's argument is unconvincing as regards the case of salt and dissolving. Beebee supposes that there is no reason for the deviation of Coulomb_B from Coulomb_A. That Coulomb_B behaves as it does is a brute or basic nomic fact. But that cannot be, if Coulomb_B is also supposed to be a relevant variant of Coulomb_A. For there is an explanation as to why Coulomb_A is the way it is. That law is not fundamental and may be explained by reference to deeper level laws. So what of these deeper laws in Beebee's world where Coulomb_B holds? The supposition that the behaviour of Coulomb_B is inexplicable is tantamount to the suggestion that it is a fundamental law in Beebee's world.

Can Coulomb_B be fundamental while Coulomb_A is not, yet the two be close cousins? Quite how one will answer this question will depend on one's view of the nature and identity of laws and properties. I have

[1] Assuming that a consistent classical theory of the atom is possible – which is highly doubtful.

hitherto sought to avoid dependence on controversial metaphysical assumptions. Fortunately it turns out that whatever one's view of laws and properties one is committed to the necessity of some laws.

One natural approach is to think of the identity of laws and properties as analogous to substances. So the identity of a law or property will depend on the identity of its nomic or causal basis. This approach will be natural for those who regard properties as identical to their causal bases. I shall pursue this line shortly. A different view may be taken by those who regard the nature of a property to be characterized entirely by its own causal powers, and hence independent of the identity of whatever causal basis there exists for those powers.

The latter, dispositionalist view would support Beebee's contention that $\text{Coulomb}_{\text{B}}$ and $\text{Coulomb}_{\text{A}}$ are genuinely similar, even if one is fundamental and the other is not. For the laws confer or reflect largely similar causal powers. But this view is not going to be congenial to Beebee's general view that the laws of nature are always contingent, never necessary. This is because a dispositionalist account of properties and laws is one that entails the necessity of at least some laws of nature. If the identity of a property is given by the causal powers it confers, then necessarily anything that has that property will have those powers. Hence we have a necessary law of nature.[2]

If Beebee wants to avoid the necessitarianism of a dispositionalist view of properties and laws, she will have to think of the identity of properties as depending on their causal bases. The identity of substances we learn from Kripke is not settled by the identity of their apparent properties. The identity of substances is a matter of their constitution, which is what explains the apparent properties. On the view now under consideration, the same is true for properties themselves. And also for laws of nature, since the identity of a law depends on the identity of the properties it concerns. Imagine (again for sake of argument) that there is a world in which negative and positive charge do not have any intrinsic power to attract one another. However, a powerful spirit applies a force to every individual charged object. The spirit calculates this force by taking into consideration its distance from every other charged object and so forth in such a way that this world simulates the action of Coulomb's law. Does this world have Coulomb's law? If the identity of properties and laws depends on the identity of their causal or nomic basis, then clearly not. This world has something that 'looks' like Coulomb's law but isn't (it is 'twin-$\text{Coulomb}_{\text{A}}$').[3]

2 For a detailed exposition of this view, see Bird (forthcoming); and also Mumford 1998, Ellis and Lierse 1994, Shoemaker 1980.

3 'Looks' here is not a perceptual verb – it means something like 'appears to the imagination'.

(And, incidentally, it therefore has something that 'looks' like salt but isn't.) In the actual world Coulomb's law is not fundamental. We look to quantum mechanics to explain what charge is, how it is exists, and why it interacts according to Coulomb's law. Change significantly or expunge the laws of quantum mechanics and charge would not exist. Since quantum mechanics makes charge what it is, without quantum mechanics a world would not have the property of charge and would not have Coulomb's law. Which is not to say that such a world could not have a property (twin-charge) that is superficially analogous to charge and obeys a law (twin-Coulomb) superficially analogous to Coulomb's law.

So if in Beebee's world Coulomb_B is fundamental, that world does not have charge and nor is Coulomb_B a cousin of Coulomb_A, any more than Jane and Sarah can be made to be cousins merely by looking alike. (Coulomb_B is a cousin not of Coulomb_A but of some twin-Coulomb_A). And since that world does not have charge nor any relevant variant of Coulomb's law it does not have salt. So that world is no counter-example to my claim.

The dilemma then is this. If the identity and similarity of properties and laws is settled by their functional (causal, nomic) role, then a world with Coulomb_B might indeed be sufficiently similar to ours to permit the existence of salt. But this view of the identity of properties leads to necessitarianism about (at least some) laws. On the other hand, the view that this identity depends on the identity of the causal or nomic basis is consistent with contingentism about laws. But this horn of the dilemma leads to the conclusion that Beebee's world does not have salt, if Coulomb_B is a fundamental law.

Might we not adjust Beebee's argument so that in her world Coulomb_B is not after all fundamental? It supervenes on the laws of quantum mechanics that operate in that world, and those laws are cousins to the laws of quantum mechanics in the actual world.[4] But now a familiar problem arises for the adjusted argument. To be convincing the argument should present an appropriate variation on the laws of quantum mechanics and show that this variation entails that Coulomb_B holds without entailing the non-existence of salt. That work will involve doing some pretty complex quantum physics. There is no a priori guarantee that it can be done. Indeed, one might suppose for a posteriori reasons that it cannot be done. A sup-

[4] It should be pointed out that Coulomb_B is not easy to accommodate even within classical physics. It will be very difficult to formulate a version of Maxwell's equations that incorporate Coulomb_B. This is because as we know them those equations depend on charge producing a symmetrical electric field. Coulomb_B will require the charges in the water molecule to produce a field that differs according to direction (it is weaker in the direction of the salt crystal and stronger away from it).

porter of Beebee might think that she could look for a variant on the laws of quantum mechanics that behaved differently at the interface of the salt and water, in order to make $Coulomb_B$ behave differently there. That, however, is to assume that the laws of quantum mechanics are the sort of laws that could hold in one way in one place without consequences for the way that they hold in another place. But for all I know they are not that sort of law. In particular the non-locality of quantum mechanics might preclude this sort of neat geographical nomic apartheid. As I shall argue in §5, since the consequences of adjusting a higher level law ramify all the way down to the fundamental laws upon which they supervene, it is very difficult to be able to say what consequences a change in a higher level law will have. In particular it is very difficult to rule out occurrences of a down-and-up structure.

So one thing we may conclude is that to show that it is contingent that salt dissolves in water, along Beebee's lines, will be very difficult, requiring knowledge of quantum mechanics and deeper level laws. More generally, to show that all laws are contingent will require showing that the down-and-up structure occurs nowhere in nature. And since neither Beebee nor anyone else has enough knowledge to show this, we do not know that contingent laws rule. However, I presented an argument that, I hoped, would be enough to permit us to know that one particular law is necessary. Does the fact that Beebee's argument has pushed the discussion down to quantum mechanics mean that the original argument has failed? First let us consider what the consequences are of admitting that it has. We would still have to conclude that we do not know whether this law is contingent. But that is itself an important result, since one of the key lessons of my argument was that we are not entitled to rely on the intuition that laws of nature are contingent. That lesson still holds. Even so, I think my argument is in better shape than that. Note first that it is an a posteriori argument, and an a posteriori argument can give us knowledge without covering every possible objection in detail. Secondly, an argument can give a preponderance of reason to believe a proposition, even if it is not strong enough for knowledge. In this case I suggest that the weight of scientific evidence is on my side. This is particularly so when we consider the general claim that because the down-and-up structure exists somewhere in nature, some laws are necessary. As I shall argue, what we already know about the fundamental laws of nature is enough to make it highly likely that the down-and-up structure does exist, indeed is pervasive, in nature.

4. *Changing water – Psillos's objection*

Stathis Psillos's (2002) approach to undermining the necessity claim is different from Beebee's. Psillos supposes that Coulomb's law could remain as it is but without water dissolving salt, if water were different from the way it actually is (but still is water nonetheless). The relevant difference is that for some reason (to be discussed) H_2O is not an asymmetrical molecule but a linear one. It is because actual H_2O is asymmetrical that it has a dipole moment, i.e. one part has an overall positive charge and another part is overall negative. This dipole moment is what enables water to dissolve salt. So, if the molecule were linear and had no dipole moment, dissolving would not occur.

I think that Psillos is right that if such a molecule could exist, it would be water. Kripkean arguments do allow some room for difference – not every property of a kind is essential. However, is this molecule possible after all? Psillos *claims* that the proposal is consistent with the laws of nature. If he means all the actual laws of nature, then this is false. If he means just Coulomb's law and whatever laws are required for the existence of salt, then I have to ask, how does Psillos know this? As I shall argue in the next section, knowing this would require rather more knowledge than anyone has, since it would require knowledge of the fundamental laws of physics and how other laws supervene upon them.

Proving inconsistency is of course much easier than proving consistency. So there is no tension between what I have just said and what I say next. What we do know strongly points in the direction of Psillos's molecule *not* being consistent with Coulomb's law and the laws of nature required for salt's existence. If the charge on an electron is what it actually is and Coulomb's law holds, then the molecule is not possible, since the forces of electrostatic repulsion are in equilibrium only if the molecule is asymmetric. Hence, as Psillos suggests, the charge on an electron must be less than it is. There are two things to say to this. First, epistemically speaking, the charge on an electron might be a fundamental constant, independent of any other law of nature. But it might not be, and that is the direction in which current physics is pointing. Hence a change to electronic charge will mean a difference in some general fundamental law, and that in turn may have consequences that Psillos is not in a position to consider. For example, the very same law that makes electronic charge what it is might also be what makes Coulomb's law what it is. So there will not be a world where the one changes but not the other. Similarly it may be (and is epistemically probable) that the fundamental law responsible for electronic charge is also responsible for the laws of quantum mechanics that make atoms possible. So a change to electronic charge might makes atoms (and so salt and water) impossible. This is a theme to which I shall return in the next section.

Secondly, if electronic charge were both fundamental and 'minute' as Psillos suggests, then the charge on a proton would be minute also (otherwise the charges in the water molecule will not balance). Now let us turn to salt. If electronic and protonic charge are minute then the electrostatic attraction between Na^+ and Cl^- will be minute also. But it is that electrostatic attraction which holds Na^+ and Cl^- together as an ionic crystal. And so the proposal of minute electronic charge threatens to do away with salt. For that matter, it does away with water as a liquid too (as Psillos says), since it is the dipole nature of water molecules and their mutual electrostatic attraction that makes water liquid at standard temperatures and pressures. What is needed for a counter-example to the claim that necessarily salt dissolves in water is a possible world where salt exists and liquid water exists but dissolving does not take place. It seems that Psillos's proposal leaves us without salt and without liquid water. I will concede that I haven't shown conclusively that there is no half-way house where electronic charge is sufficiently smaller than it actually is to give water only a very weak dipole moment (so dissolving does not occur) yet not so much smaller that salt and liquid water cannot exist at standard temperature and pressure. I think it unlikely. But the important point is that deciding this question will require doing some theoretical chemistry. What is necessary and what is possible here are a posteriori matters.

5. *Fundamental constants and fundamental laws*

Helen Beebee's Coulomb_B is supposed to differ from Coulomb_A in that sometimes the electrostatic force is proportional to r^{-4} rather than to r^{-2}. Such a change seems acceptable if the exponent of r is a fundamental constant. In classical physics it was held to be so, as was the corresponding exponent of r in Newton's law of gravitation. But we now know that neither exponent is a fundamental constant. They have their explanations in the *structure* of deeper level laws. Thus a world in which Coulomb_B holds is a world with very considerable changes to at least one deeper level law. Consider the following illustration. It is a law that the light intensity at a point displaced r from a constant and uniform light source is also proportional to r^{-2}. We can conceive of someone investigating light intensity experimentally and discovering this law as an extrapolation from the data. Such an investigator might think that the exponent of r is a fundamental constant whose value could easily have been different. However, the same law, with the exponent being precisely –2, can readily be shown to be a consequence of the law of conservation of energy (along with simple geometry).[5] Were, therefore, there to be a world in which the light intensity is

[5] The argument is as follows. Since energy is conserved, the energy falling on the surface of any sphere of radius r around the light source will be the same. The area over which it is distributed is equal to $4\pi r^2$. So the quantity of light energy falling on a unit area at distance r is proportional to r^{-2}.

proportional to r^k for any value of k other than –2, that world would be a world in which energy is not conserved.

And so, if a constant is not fundamental, then 'adjusting' that constant, even (perhaps especially) in an innocuous higher level law, is likely to have very considerable consequences for changes in deeper level laws.

Imagine that the world is governed by just one very simple law upon which all higher level laws supervene. Adjusting any higher level law will require changing this one fundamental law. Since the fundamental law is simple in structure, there is no room for fine tuning changes to that law. A world with a different fundamental law will have a significantly different fundamental law. That in turn will mean that *all* the higher level laws will be significantly different too. And since the existence of substances and other phenomena depends on those higher level laws, we will find that many such substances and phenomena do not exist in the world with the adjusted fundamental law. In other words, in a world with a single, simple fundamental law, the consequences of changing a higher level law will first go all the way down and then all the way – and everywhere – up. In such a world the down-and-up structure will be pervasive. If a world has more than one fundamental law, it need not be that a change to a higher level law has consequences for all other higher level laws – some among the latter might supervene on a subset of the fundamental laws not affected by the changes in the first higher level law. On the other hand a world might have a small number of fundamental laws which have few or no fundamental constants and which are closely integrated, so that all or almost all higher level laws are consequences of all the fundamental laws acting together. In such as world the down-and-up structure will be a common feature of the world.

Our best scientific theories strongly suggest that if the world has more than one fundamental law then those laws are of the simple, highly integrated kind; it is plausible that there is indeed only one fundamental law. Furthermore, physicists (e.g. Weinberg 1993: 189–91) tell us that there is every reason to speculate that the number of genuinely fundamental constants is very small. It might even be zero. (And so Beebee will not be able to save her case by considering an adjustment to the dielectric constant ε_0.) Hence we have very good scientific reason for supposing that there are higher level laws of nature that are necessary in virtue of the down-and-up structure.

Note that this consequence cannot be side-stepped by considering spatiotemporally limited derogations from the actual (higher level) laws. For the existence and nature of space and time are themselves consequences of the fundamental law(s).

The lessons are as follows:

(i) In a world with a small number of simple and integrated fundamental laws, adjusting one higher level law will have significant consequences for the fundamental laws and hence will have consequences for the nature of many or all other higher level laws (and for the existence of substances and phenomena dependent on them).

(ii) To know fully what the consequences of adjusting a higher level law would (or would not) be requires knowing what the fundamental laws of nature are and how the higher level ones depend on them.

(iii) The down-and-up structure I described above would generate necessary laws were it ever to exist. To know that it does not exist anywhere in nature would require knowing everything mentioned in (ii). Since we do not know what the fundamental laws of nature are, let alone how all the higher level ones supervene on them, we are not in a position to know that the down-and-up structure does not exist anywhere. Hence we are not in a position to know that there are no necessary laws.

(iv) Because we have good scientific reasons for thinking that there are only a small number of simple fundamental laws, (i) permits us to conclude that there is good reason for thinking that the down-and-up structure does exist somewhere, and hence that some higher level laws are necessary.

(v) We *can* have good scientific reasons for thinking that particular higher level laws are necessary, since we can have reasons for thinking that the down-and-up structure exists in certain cases (such as in the cases of the dissolving of salt and of atomic spectra). We can have such reasons (and perhaps knowledge) since for this only local knowledge of the supervenience of higher level laws is required. (Not in every case need the reasons involve knowledge of their supervenience on fundamental laws; sometimes knowledge of supervenience on intermediate level laws is sufficient.)

6. Ceteris paribus *laws and substances*

Before concluding I should like to consider a second approach to Beebee's case. Let us assume that a world such as she describes is indeed possible. Even so it is not clear that it constitutes a counter-example to my claim. This is because, as I pointed out in Bird 2001, the law in question is probably a *ceteris paribus* law and is permitted exceptions.

Let us think first of a world that Beebee does not describe, but is superficially like it. In this world the law says that electrostatic forces between the electrons and protons making up the ions in the salt crystal satisfy $F = \varepsilon_0(pq/r^2)$ and similarly the forces between the electrons and protons in the water dipoles obey the same equation. However, the forces between electrons and protons in the salt on the one hand and the electrons and protons in the water obey $F = \varepsilon_0(pq/r^4)$. Somehow the law is able to detect whether interacting electrons or protons are parts of the salt crystal or parts of a water molecule and applies a different formula accordingly. Clearly such a world is not a minor deviation from ours (even ignoring what requirements this would have for the fundamental laws) – in our world all electrons are identical and obey the same laws whatever substances they are part of. Let us consider just the 'salt' crystal. The forces holding it together are the same as in the actual world. But the law generating these forces is entirely unlike any law of the actual world. The forces are nothing like electrostatic forces, which exist in virtue of charge – these forces exist in virtue of charge-on-an-electron-in-a-crystal-composed-of-sodium-and-chlorine. If (*per impossibile*) the sodium and chlorine ions could be held together by gravitational forces, the result would not be salt. And so there is no reason to suppose that what we have been calling 'salt' in this possible world is really salt after all.

This is why it is important that in Beebee's world there is no reason why the law deviates from Coulomb_A at the interface between the salt and the water. The chance deviations could happen anywhere; they just so happen in such a way as to prevent dissolving. In which case there is nothing about the *laws* themselves in Beebee's world that prevents dissolving. Since the deviations from normal Coulomb_A are supposed to be rare, we would expect dissolving to be the norm. By sheer accident dissolving does not take place in Beebee's world. Let us now focus on the law that salt dissolves in water. If this is a strict law, stating that on every occasion on which salt is placed in water it dissolves, then indeed Beebee has given us a counter-example. But if the law is not a strict one, and says instead, *ceteris paribus* salt dissolves in water, then Beebee's case is no counter-example. For the distribution of deviations is highly abnormal. Another way to look at this is in terms of dispositions. We can understand the law as stating that salt is disposed to dissolve in water. Dispositions do not entail the corresponding conditionals.[6] Salt can be disposed to dissolve in water even if it is not always true that were salt placed in water it would dissolve. So again, Beebee's world is no counter-example. For we can say that in her world salt is indeed disposed to dissolve in water; it is just that for no nomic reason a flukish coincidence interferes with the normal operation of this disposition.

I admit that I do not think that this line of resistance is, on its own, *clearly* conclusive against Beebee. She might consider a world in which $F = \varepsilon_0(pq/r^4)$ is much *more* likely than $F = \varepsilon_0(pq/r^2)$, so that an interaction (between charges) of the kind that does support dissolving is not the norm.

[6] This is because of finks and antidotes. See Martin 1994 and Bird 1998 for explanations.

In such a world $F = \varepsilon_0(pq/r^2)$ operates by chance between Na^+ and Cl^- ions, so (it would seem) salt exists. Since the much more common $F = \varepsilon_0(pq/r^4)$ predominates between the salt ions and the water, dissolving does not take place and this failure to dissolve is not counter to the law-induced norm. However, since the persistence of a Na^+Cl^- lattice *would* be contra-normal, there is good reason to question whether or not such a lattice, supported by a law which typically expresses itself as $F = \varepsilon_0(pq/r^4)$, is indeed salt. The law is not quite as alien as the law considered two paragraphs back. But it is very much unlike the law we have, and so it is at least questionable whether the substances it produces can be identified with those we find in this world.

To sum up the thrust of this section. If Beebee's law deviates only slightly from Coulomb_A and makes failure to dissolve a rarity in worlds with that law, then a world with failure to dissolve would still be a world where the law 'salt dissolves in water' holds, so long as the law is conceived of as a *ceteris paribus* or dispositional law. If on the other hand Beebee's law is adjusted to make failure to dissolve the norm in worlds where it holds, then it will, one way or another, have to deviate quite considerably from Coulomb_A. In which case, even if it expresses itself with regard to Na^+ and Cl^- in a way analogous to a salt crystal in the actual world, the result is plausibly not salt at all.

7. *Conclusion*

In arguing with Beebee and Psillos over whether the law that salt dissolves in water is necessary and whether it is necessary that atomic spectra are discontinuous, a certain amount of science has been invoked. This is because the issues can be decided only by looking at the science. Assuming that the fundamental laws are contingent, it is an a posteriori matter whether, in virtue of the down-and-up structure, a certain higher level law is necessary. Even if it is true of the actual world that no higher level laws are necessary, knowing this would require knowing more science than we currently do know. As it is, what science we do know strongly suggests that it is likely that the down-and-up structure does exist somewhere, and hence that some laws are necessary.[7]

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