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THINKING OUTSIDE THE TOOLBOX: TOWARDS A MORE PRODUCTIVE ENGAGEMENT BETWEEN METAPHYSICS AND PHILOSOPHY OF PHYSICS

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ABSTRACT

The relationship between metaphysics and science has recently become the focus of increased attention. Ladyman and Ross, in particular, have accused even naturalistically inclined metaphysicians of pursuing little more than the philosophy of A-level chemistry and have suggested that analytic metaphysics should simply be discontinued. We shall by contrast argue, first of all, that even metaphysics that is disengaged from modern science may offer a set of resources that can be appropriated by philosophers of physics in order to set physics within an interpretational framework. Secondly, however, we shall urge that insofar as metaphysics is intended to be more than just a toolbox it needs to accommodate the implications of physics if many of its core claims are to be sustained. We shall illustrate this last point with a discussion of the nature of laws and modality in the context of modern physics.

Keywords: naturalism, modality, structuralism

1. Introduction

Dummett is not alone in highlighting the lack of engagement between metaphysics and science that has become so acute as to be detrimental to both disciplines. Without such engagement, metaphysics is seen to be divorced from 'the real world' and as inhabiting a domain of fantasy ontologies, baroque possibilities or, at best, 'toy models'. Equally, bereft of metaphysical interpretation, modern physics is rendered positivistic, with its theories reduced to mere algorithms for the production of experimental results. While there will always be those who do not see it to be the purpose of physics to extend beyond mere prediction and control, that *metaphysicians* are compliant with this situation is perplexing given that it is claimed that (a) 'rock-solid commitment to physicalism… is about as close to a bit of orthodoxy as one will find in contemporary philosophy,'(Hall 2010)[1] and that (b) it is the study of the *fundamental* that has been moving centre-stage within metaphysics in recent years (see Schaffer 2009). If all truths about the actual world are seen as determined by a

1 According to physicalism, "The world is as physics says it is, and there's no more to say." (Lewis 1999, 33–34).

fundamental physical basis, and it is the fundamental basis that is seen as the focus of metaphysical enquiry, the fact that so much metaphysics remains impervious to physics is bewildering to say the least.

Our intention in this paper is not to offer much by way of explanation of this lack of engagement but instead to make a double-edged claim concerning it. First of all, even if metaphysicians perpetuate this disengagement by developing theories that remain detached from modern physics, these theories may offer a set of resources that can be appropriated by philosophers of physics in order to set physics within an interpretational framework and may be valued for just that reason. Secondly, however, insofar as metaphysics is intended to be more than just a toolbox and to itself have some direct bearing on reality, the implications of physics need to be properly appreciated if many paradigmatically metaphysical claims are to stand up. In the absence of such appreciation, much of modern metaphysics remains 'fantasy metaphysics' even if, as we suggest, physically disinterested metaphysics in general may nonetheless offer resources that can be taken down off the shelf and put to work.

2. The Indispensibility of Metaphysics

It is this failure of metaphysicians to regard the engagement with physics as an essential feature of their practice that has in part led to the recent anti-metaphysical turn within the philosophy of physics. Reflecting on his early development, Carnap wrote that '[m]ost of the controversies in traditional metaphysics appeared to me sterile and useless' (Carnap 1963, 44-45) and in the eyes of many philosophers of physics the current situation appears to present little by way of improvement. In a recent collection in which metaphysicians apply the tools of their trade to their own field, Price writes,

> Metaphysics is actually as dead as Carnap left it, but – blinded, in part, by [certain] misinterpretations of Quine – contemporary philosophy has lost the ability to see it for what it is, to distinguish it from live and substantial intellectual pursuits. (Price 2009, 323)

Likewise, in the opening chapter of their defence of structural realism, Ladyman and Ross present an excoriating rejection of contemporary metaphysics, insisting that '[m]ainstream analytic metaphysics has … become almost entirely *a priori*' (Ladyman and Ross 2007, 24). Even that which pays lip-service to naturalism by referring to quarks, their colours and flavours and other accoutrements of modern physics is dismissed as 'really philosophy of A level chemistry' (ibid.). In their opinion, too many metaphysical positions are grounded in 'intuition' or reflection on 'everyday' objects and their properties, and attempts to import these into the context of modern physics typically prove disastrous. In consequence, according to Ladyman and Ross, analytic metaphysics ought to be 'discontinued'(p. vii).

This growing anti-metaphysical literature is well known (and we will soon be adding some of our own pet frustrations to the list). However, before we do so, we *do* feel that there is reason to draw back from sweeping claims to the effect that *a priori* metaphysics is without purpose or that it should be 'discontinued'; whatever exactly the problem with contemporary metaphysics is taken to be, we would caution that the appropriate *reaction* to it by philosophers of science has to be considered carefully. Our reasons for this claim are based on the suggestion, mentioned above, that the products of analytic metaphysics can be regarded as available for plundering by philosophers of science in order that we might exploit them for our own purposes. And that such plundering is in fact regularly engaged in is no more evident than in the structuralist philosophy of science that we ourselves endorse: ontic structural realism, after all, invokes such notions as 'modal structure', ontological dependence, fundamentality and the metaphysics of relations, and hence has had to deploy a great deal of involved metaphysical theory in order to articulate its core claims.[2] In our efforts to express the metaphysical revisions that physics forces upon us, we structuralists have found it immensely useful to call upon extant metaphysical packages on offer rather than have to develop the appropriate resources from scratch. The growing literature on ontological dependence, for example, is proving useful in expressing the core metaphysical claim of ontic structuralism, namely, that physical objects are ontologically secondary to structures (French, in preparation; McKenzie, in preparation). A form of truthmaker theory might also be deployed in order to articulate the eliminativism about objects that 'radical' ontic structural realism endorses (French op. cit.). Even the work of Lewis – a philosopher who is often pilloried for his lack of engagement with science – has been summoned in defense against the triviality objection to structuralism, in the work of Melia and Saatsi (2006).[3]

In various ways, then, structuralist philosophy of science has benefitted enormously from the existence of a body of metaphysics ready to be taken off the shelf when the moment arrived. But since the afore-mentioned metaphysical packages were by and large developed independently of any consideration of contemporary physical theory, we would argue that it would be counterproductive to insist that the sort of analytic metaphysics that 'floats entirely free of science' should be 'discontinued'. Thus while we share many of the misgivings about metaphysics that Ladyman and Ross express, we believe that were this particular piece of advice to be heeded then genuinely naturalistic philosophy of science would undoubtedly suffer in consequence.

In fact, the relationship between philosophy of science and metaphysics might be usefully compared to that between physics and pure mathematics. Just as it was useful to Einstein that the theory of non-Euclidean geometry was there for the taking when the moment arose, so it is useful to eliminative structuralists that there has been developed a theory of dependence compatible with the elimination of the dependent entity. And just as it was useful to the development of particle physics that the theory of Lie groups was largely completed by the time the appropriately high-energy regimes could be probed, so it is beneficial to the defender of the Everett interpretation that a theory of personal identity that makes decision-making make sense in branching universes was already on the market[4].

2 Standard – object oriented – realism may appear to avoid a similar deployment but only because it unreflectively incorporates the above intuitions and everyday reflections.

3 Note that what is required of Lewis' notion of 'elite' properties to block this objection is far less than is required for the 'Best System' analysis, to be discussed below.

4 Of course, this is not to say that the relevant mathematics was developed entirely independently from the physical context (see Bueno and French forthcoming).

And just as it was fortuitous that the theory of imaginary numbers was fit for use at the advent of the quantum revolution, so it has proved useful that various metaphysical packages were in place to provide possible frameworks for its interpretation, including haecceities and, more recently, a form of Leibniz's Principle of Identity of Indiscernibles, revamped *a la* Quine (French and Krause 2006; Saunders 2003). This is of course not to discourage the development of 'made to order' frameworks that engage (more or less) directly with the physics, such as the metaphysics of non-individuals and the associated formalism of quasi-set theory (French and Krause op. cit.); but nonetheless, given that scholastic or 17th century rationalist metaphysics can be usefully appropriated by the philosopher of quantum physics, it seems folly to try to predict in advance what will or will not prove useful to us in the course of time – a stance that should also be taken, of course, with regard to mathematical structures and entities (such as imaginary numbers) and their role in natural science.

It is these sorts of historical considerations that suggest one reason we, as naturalistic philosophers, have to *value* scientifically disinterested metaphysics is that its constructions might prove to be useful in the philosophy of future science, *regardless* of how great the portions of metaphysics that turn out to be surplus to requirements. And once *that* is conceded, it becomes very difficult to oppose scientifically disinterested metaphysics *tout court*.

3. *Why* the Disinterested Nature of Metaphysics?

Nevertheless, whilst the above observations partially mitigate a physically disinterested approach to metaphysics – at least with respect to the ends and purposes of philosophy of physics – they don't explain *why* metaphysicians habitually ignore a field that seems quite clearly central to their own discipline, nor does it entirely excuse it. Metaphysicians, after all, presumably hold that there is value to their discipline beyond it serving as a production line for constructions that might eventually be used and abused by philosophers of physics. Furthermore, it seems that philosophers of physics can rightly hold that it is one thing for metaphysicians to come up with constructions that are *entirely independent* of contemporary physics – as with the above examples - and quite another for them to confect theories that both claim to employ physical entities *and* willfully ignore or misrepresent the relevant physics when it suits their purposes to do so.[5] So why *is* metaphysics so decoupled from physics?

A plausible answer would probably cite the fact that philosophy has increasingly grown to conceive of itself as 'the science of the possible'.[6] Callender (2011) nicely charts the recent developments that have led to the widespread embrace of this conception, beginning with the work of Kripke that made modality respectable again and tracing it through to its present state - a state in which many metaphysicians would agree that,

> … whereas scientists excavate dusty field sites and mix potions in

5 Indeed, in our opinion, it is that the latter 'lip-service' is so often practiced that constitutes the truly alarming take-home message of Ladyman and Ross' book; a list of examples can be found on p18.

6 For an early statement of this conception see Russell (1919).

> laboratories to tell us which states of affairs are actual, metaphysicians are concerned with what is and isn't metaphysically possible. (Callender 2011, 36)

This contemporary perspective on the scope and purpose of metaphysics is reflected in Lowe when he states that '[e]mpirical science at most tells us what is the case, not what *must* or *may be*… Metaphysics deals in *possibilities,*' and similar sentiments pepper the contemporary literature (Lowe 1998, 11).

The consequences of this evolution in metaphysicians' concept of their discipline for the role of physics within it are twofold. First of all, since it is primarily *conceivability* that is taken to map out possibility space, the ontology of physics is dwarfed by the remaining merely possible ontology that metaphysics has a duty to study.[7] Secondly, since on this conception it is the question of the *possibilities* available to this ontology that constitutes the central question of metaphysical interest concerning it, and these possibilities are again primarily staked out in terms of conceivability, it follows that *even with regard* to the subset of physical ontology, physics cannot suffice to settle the important metaphysical questions. Thus the relevance of physics is twice diminished: once because it fails to furnish metaphysics with anything but a tiny slice of the objects and properties falling within its proper domain of study, and again because it cannot adequately address the important metaphysical questions about even that thin slice.

The feeling that physics has at best peripheral significance is made explicit in Conee and Sider when they write

> Metaphysics is about *the most explanatory basic necessities and possibilities.* Metaphysics is about *what could be* and *what must be*. *Except incidentally*, metaphysics is not about explanatorily ultimate aspects of reality that are actual… (Conee and Sider 2005, 203; latter italics ours)

Here we will not take issue with the idea that possibility is a (perhaps the) central question in metaphysics, nor with the idea that it is an emphasis on the possible that is in some sense distinctive of metaphysical enquiry. What we *do* wish to dispute, however, is the idea that physics has only an 'incidental' or marginalized role within metaphysics *even if* we buy into this conception of metaphysics (cf. Callender op. cit., 43-44). Although philosophy is replete with examples of how the history of science has *expanded* our conceptions of the possible, we will here emphasize how science *circumscribes* it and moreover does so in a way that reinstates physics as the proper point of departure for modal questions concerning the actual. Granted that this issue too has received some attention (see, again, Callender op. cit.), we will try to flesh out some of the details by emphasizing just how *fruitless* modal discussions concerning

7 As Yablo puts it, "If there is a serious alternative basis [to conceivability] for possibility theses, philosophers have not discovered it." (Yablo, 1993).

physical ontology are if taken to be divorced from actual physics.[8] In doing so, we hope to show that the idea that the emphasis on the modal entails that the philosophy of physics does not have a central (expository and regulatory) role to play within the discipline as a whole is entirely misguided.

We will frame our discussion around what is perhaps the most basic question in modal metaphysics, namely that of whether modality is ontologically primitive or rather such that modal claims may be expressed without remainder in terms of the inherently non-modal. Our approach to this question will focus on the arguments surrounding the modal status of laws of nature – that is, surrounding *nomological* necessity – and the issue of whether something primitively modal is needed in addition to the ´non-nomic base' in order to account for natural laws.

4. Laws, Modality and the Non-Nomic Base

Broadly speaking, there are two main approaches to the theorizing about the modality attached to laws: (i) *reductive* accounts, in which the laws are taken to supervene on a `basis of non-nomic facts' – that is, on a basis of states of affairs constituted wholly by categorical properties and relations, and (ii) *non-reductive* accounts, in which the laws are regarded as an 'additional ingredient' in the inventory of a world. Thus while each account postulates worlds, that laws hold in these worlds, and a categorical or non-nomic basis to each, they differ over whether the laws constitute *additional* items in the inventory of the worlds over and above their categorical bases. Let us take Lewis as the leading representative of the first position (see Sider 2003), Lange as our proponent of the second, and begin with a discussion of the latter.

4a. Anti-Reductionist Accounts of Nomological Necessity

Lange's sophisticated and subtle account of laws is markedly different from the nomic necessitation account of Dretske, Tooley and Armstrong (DTA) but bears similarity to it in its commitment to primitive modality.[9] For Lange, as for them, the laws are independent of and ontologically additional to the categorical basis – in Lange's words, they are like 'powdered sugar sprinkled over the doughy surface of the non-nomic facts.' (Lange 2000, 51). Lange argues for the non-reductive aspect of his view by motivating the idea that a world with a lone proton could be governed by a number of different laws. Hence the reductive 'Humean supervenience' account, according to which laws are determined by the non-nomic basis, must be false.[10] Arguments for a similar conclusion have been mounted by defenders of the DTA analysis, perhaps most notably Carroll (1994). Carroll presents us with two worlds, identical with respect to all particular matters of fact and hence containing the same regularities but which

8 And of course, if modal debates concerning actual fundamental ontology are fruitless when detached from physics, their fruitfulness when they concern putative ontology we are not epistemically acquainted with in even the indirect sense that we are with physics can only be subject to further doubt.

9 Here we are primarily taking Lange (2009) as representative of his view.

10 Here and throughout we understand Lewis' 'Humean supervenience' account to be stripped of its problematic locality assumptions (which are irrelevant for our purposes).

are stipulated to have different laws. However, as Beebee has pointed out, the very *plausibility* of the stipulated scenarios assumes a 'governing' conception of laws that defenders of the reductive account reject from the outset (Beebee 2000). Thus, it is claimed, this and similar arguments simply beg the question as a result.

Lange, however, attempts to avert this objection by doing more than simply appeal to the intuition that it is possible for the laws to differ in two worlds with the same non-nomic basis: he goes further by *motivating* that thought by appealing to the more neutral intuition that many facts about the world could have been different without the laws being so (Lange 2000). The key idea is that laws can be distinguished from accidents in virtue of possessing 'counterfactual stability', where this is to be understood in terms of the lawlike generalisations remaining true under logically independent counterfactual circumstances that are accidental. Taking those propositions that do not contain the phrase 'it is a law that' or any modal operator to be 'sub-nomic', the set of such sub-nomic propositions can be defined as stable if the members of the set remain true under every sub-nomic supposition consistent with the set. A generalisation is then regarded as lawful if and only if it belongs to the largest non-maximal stable set of true propositions; thus, '…necessity involves a kind of maximal persistence under counterfactual suppositions.' (Lange 2007, 472)

His intuition that the laws remain fixed under 'counterfactual perturbations' is a plausible one to which the Humean will be sympathetic - at least to some degree. By following this intuition through to (what he takes to be) its natural conclusion, Lange motivates the claim that the laws of the actual world would remain the laws of a world in which there is nothing but a lone proton. Since it is held that one can imagine another world where protons obey very different laws than ours do, and given that from *that* world one could arrive at a lone proton world holding *those* laws invariant just as *we* obtained a categorically similar world while holding *our* laws invariant, we see that two worlds that contain the same non-nomic facts can differ with regard to their laws. It is this invariance of laws across such radical changes of non-nomic facts that leads Lange to conclude that the laws cannot be constrained by these facts in the way the reductive account maintains.

Lange's argument thus represents a distinctive and novel twist on arguments in defence of irreducible modality. Lonely worlds are in fact a staple of nomological arguments issuing from both ends of the spectrum, presumably since they provide a simple setting in which questions about the relationship of categorical bases to the nomic superstructure in question can be systematically addressed (cf Haufe and Slater 2009, 266). It may easily be seen, however, that the method through which these 'lonely' possible worlds are generated is actually crucial to the success of Lange's argument. Reflection on this both offers a way out for the proponent of the reductive account and – more relevantly for our purposes – is indicative of the concerns that arise when metaphysics is allowed to float free from physics. Let us go through how this works.

Two modes of lonely-world generation can be discerned in metaphysical discussions (the following is taken from Haufe and Slater 2009): '*impoverishment*' and '*building* *from scratch*'. In the case of the former, we start with 'our' world and then depopulate it over time to arrive at (say) the lone proton world. In the case of the latter, by contrast, we 'build from the ground up', as it were, a permanently sparse world containing only one proton (Haufe and Slater ibid., 269-270). This latter is a world in which 'all God had to do' was create a single proton in order to create the non-nomic basis of this world.

Lange himself adopts the impoverishment strategy (op. cit., 87) and on the basis of the intuition that the laws would remain as they are even through radical non-nomic changes he concludes that this would hold even when such changes include severe depopulation. Likewise, if we were to start with other worlds where the laws are different we could impoverish *these* to arrive at a one-proton world. As mentioned above, the claim is then that since the same apparent regularity – one proton scooting about – can support very different laws, the reductive account is gravely undermined. However, there are clearly concerns one should have about the soundness of this argument.

First of all, it is not at all straightforward to claim that merely by obtaining a given lonely world via impoverishment from very different 'starting' worlds one has thereby obtained a world with the same regularity in each case (a claim clearly crucial for the above conclusion to go through). For if the regularity in play here includes the relevant history of the lone proton, say, then it will *not* in general be the case that the same regularity is obtained. And since 'impoverishment' is explicitly understood as leaving the history of the world intact up to some point, the lone-proton world obtained from *this* world can be said to be very different from the lone-proton world generated from the world with very different laws since the two 'starting' worlds have different histories (Haufe and Slater op. cit., 269). It therefore follows that the two lone-proton worlds will contain very different regularities and hence we do not have a case of 'same regularities, different laws' that would undermine the reductive account.

Furthermore, and quite apart from the failure of the impoverishment strategy to generate worlds with different laws but identical regularities, one should have serious doubts about the crucial intuition that the laws remain invariant under successive impoverishments of the categorical base. That the laws remain stable under removal of (at least some) 'everyday' objects seems uncontentious: it seems hard to find any grounds at all for claiming that in a world like ours in all respects except that it is missing the Eiffel tower, Newton's laws would not have held (ibid., 270-271). But one does not have to move beyond the everyday to stretch the intuition: what about a world in which everything *but* the Eiffel tower has been removed? What history consistent with the relevant laws could produce such an outcome? Likewise – and turning now to the objects of the microworld – is it possible for the laws of the Standard Model to produce a solution in which there is just one proton? It should be obvious that even if this question receives a positive answer (which to us appears unlikely), it is a non-trivial matter to establish that it does.[11] At such extremes our intuitions seem stretched to breaking point and it is certainly no longer the case that one can just blithely maintain that the laws would remain the same as they were following such depletions.

In any case, given that 'contamination' from histories annuls the ambitions of the impoverishment strategy, if Lange is to create situations in which he can claim that there is a single regularity and yet a variety of possible laws it must be via 'building from scratch'. Yet things are no better if one generates such worlds by this second strategy (Haufe and Slater ibid., 269-270). In this case the regularities are unambiguous since the history of the world that depopulation starts from is not problematically carried over into the world under consideration (since there *is* no depopulation), but by relinquishing depopulation methods we lose whatever grounds – however thin – that we may have had previously for maintaining the intuition that the laws will remain invariant. Some other means of ascertaining the laws that hold in a 'built from scratch' world must be found; but while the regularities in such a world may be regarded as settled (or at least as settled as the stipulated categorical base), it seems to us that we simply *have no idea* of what the laws appropriate to this world are if they are taken to transcend the regularities.

For consider yet again the lone proton world. The only theory we know of that (we think) correctly describes the proton is the Standard Model of particle physics; but that the Standard Model's laws could apply in this world is (to say the least) far from clear. Think of the questions that a physicist would have to address in an attempt to ascertain whether this was indeed the case. Could the lone-world proton – defined by a certain set of determinate fundamental properties – have (all the) mass that it is actually taken to have, in the absence of the Higgs? Could the proton be properly said to be charged in the absence of photons that mediate the electromagnetic interaction?[12] Could the symmetries of the actual laws – say matter - anti-matter symmetry – be said to hold in a world permanently devoid of antimatter? Similarly, given that actual protons are related to other types of hadrons via global SU(3) symmetry, could *this* symmetry be said to hold in a world in which there are no tokens of these other hadron types?[13] And is it possible for a world to contain just a single quantum particle throughout its entire history given that quantum mechanics gives a finite probability for all particles to decay to a particle of another type (although here the proton is perhaps a special case)? It can quickly be seen that layer upon layer of questions – questions with non-trivial answers – must be addressed if we are to progress with this issue. We once again see that although the assumed categorical basis is certainly 'simple', the defense of the claim

11 Lange himself on the other hand seems very confident about this: he writes (Lange 2000, 85) that 'When we contemplate the closest lone-proton world… we imagine taking the actual world and setting its initial conditions so that a lone proton is the result generated by the actual laws. Cosmologists might run their computer simulation for these rather boring initial conditions – perhaps as a test of their program'. It is not clear that this corresponds to anything cosmologists would, or indeed, *could*, do. In particular, if the laws are related to the relevant symmetries, as they must be if they are to be deemed 'actual', then there are deep problems; technical obstacles may further impede the generation of such lonely scenarios. (We'd like to thank Erik Curiel for providing further details on these obstacles.)

12 This point will be returned to below.

13 There are obvious paradigmatically metaphysical worries here too: if, for example, one were to adopt an Armstrongian view of properties (in which they must be instantiated in any given world to be nomically related in that world), the possibilities described here would be ruled out.

that that basis represents a solution of actual laws is certainly not; and furthermore, if the defense of the claim that the lone-proton world represents a solution of the actual laws is highly non-trivial (if indeed it can be defended at all), what hope have we of defending the idea that it is a solution of realistic natural laws – i.e. laws of similar complexity to those of actual physics – *when we don't even have any idea what those laws are supposed to look like*?

The claim that there are a variety of laws that could hold in such a world now appears very hasty indeed: it is not clear that we can establish that even the *actual* laws hold in a world containing this basis, let alone a variety of laws unbeknownst to us. The proponent of reductionism, on the other hand, can of course turn all this to their advantage: they will simply insist that the laws of lonely worlds generated this way correspond to whatever the regularities in such worlds are and – unlike any alleged laws that go beyond these regularities – these may be regarded as unambiguous. At the very least, the burden of argument has most certainly shifted away from her (ibid., 270).

We thus see that if the simple worlds these anti-reductionist arguments trade in are generated via impoverishment, the actual laws continue to infect the world in a way that undermines the argument against the reductive account. If, on the other hand, we try to build such a world from scratch, it seems at worst implausible and at best highly non-trivial that the actual laws could be said to hold in a lone-proton world devoid of the electrons, anti-protons, gauge bosons, etc., to which actual protons are nomologically connected - let alone whether some as yet unspecified laws do. Moreover, given that our only *theory* of the proton is one in which it is governed by actual laws, and given that – as Haufe and Slater point out – our *intuitions* about what would happen in lone proton worlds must remain 'radically unclear' (ibid. 270), there does not appear to be any resources whatsoever available with which to settle this issue. As such, it appears that there is simply nothing we can bring to the table with regard to defending Lange.

4b. Reductionist Accounts of Nomological Necessity

As we have just seen, the failure of the anti-reductionist to mount a challenge against the regularity theorist consists largely in the lack of resources with which they might defend the idea that a variety of laws can pertain to a given non-nomic basis. Since the reductionist does not posit anything over and above that determined by the basis and that basis is regarded as unambiguously specified, futile trips to other worlds do not appear to be required for *them* to settle questions about what laws correspond to given basis – something that should by now be clear is a definite advantage. Popular consensus has it that Lewis' 'sophisticated regularity account' is the most promising representative of the reductionist views and it is this that we will take as our example of the Humean end of the spectrum (Lewis 1983). On this account, only those regularities that are theorems of the best systematization of the non-nomic basis deserve the title of laws. The 'best system' in turn is understood as the axiomatization of the basis that achieves the best balance of simplicity and strength. Thus, laws conform to (what we might call) the familiar 'regularities plus' picture but here the extra factor does not involve any primitive modality: the laws that hold in a world remain fully determined by the basis, though in a more involved fashion than would be the case in a cruder account.

As already noted, since the best system is held to be determined by features intrinsic to the categorical basis it looks as though, in contrast to the previous account, the laws associated with a given basis can be established without recourse to trips to other possible worlds. However – when the best system is understood *a la* Lewis at least - this independence from other-worldly considerations in fact turns out to be spurious, for it transpires that we *do* have to consider the other-worldly behaviour of actual kinds to specify the best system for any given basis. This is because – as Lewis acknowledges – the 'simplicity' requirement on the best system is vacuous unless supplemented with the requirement that the axiomatization be performed in a specified language (Lewis ibid., 367). As is well known, and in keeping with his metaphysical framework as a whole, Lewis takes this language to be that whose predicates pick out the *perfectly natural properties*. These perfectly natural properties are then taken to coincide with the *fundamental* properties (since it is ultimately these that suffice to specify worlds).

It is indisputably essential to Lewis' reductive ambitions in general that all the perfectly natural properties are *intrinsic*, for otherwise they cannot be subject to the 'principle of free recombination' that lies at the heart of his modal system. Furthermore, the inclusion of the predicate of 'perfectly natural' as an ideological primitive is motivated by the theoretical benefits of doing so; since it is the suitability of these properties to analyze duplication that grounds the majority of these benefits, and since their ability to analyze duplication requires that they be intrinsic, unless these properties *are* intrinsic then the motivation for including this primitive is seriously undercut. Now, for Lewis (as for others) a property is intrinsic only if it could be had by a lone object (which of course is to say in the Lewisian framework that there *is* a world in which a lone object has it; cf. Langton and Lewis 1998). Furthermore, it is clear that the only 'perfectly natural' and hence fundamental properties that *we* – as this-worldly agents – may be said to have any epistemic acquaintance with are, by physicalism, the properties of *fundamental physics*. These Lewis lists as 'the charges and masses of particles, also their so-called "spins" and "colours" and "flavours", and maybe a few more that have yet to be discovered.' (1986, 60). Hence if we want to *verify* the crucial claim that all the perfectly natural properties are intrinsic – as all Lewisians surely should – then all we can reasonably hope to do is to check that *these* properties are intrinsic. But how are we to do this?

There seem to be just two places (to our knowledge) where Lewis considers the issue. In one, he writes that 'On my analysis, all of the perfectly natural properties come out as intrinsic. That seems right.' (1983, 16). In the other, he asserts that 'It can plausibly be said that all the perfectly natural properties are intrinsic' (1986, 61). Unfortunately for Lewisians, however, it is not at all obvious that these properties *are* intrinsic: there are in fact good reasons to say that they are either simply *not* intrinsic or at best such that their intrinsicality must remain forever unbeknownst to us.

The most expedient argument that one can marshal against the claim that all the fundamental physics properties are intrinsic is perhaps that which exploits the fact that the (current best candidates for) the fundamental laws of physics are formulated as *local gauge theories*. The basic idea underpinning such theories is that the equations governing particle interactions should be generated from the interaction-free equations by demanding that those equations are invariant under a local gauge (or 'local phase') transformation. Thus, in order to generate the properties of particles through which they undergo fundamental interactions (such as the colours of quarks and the charges of electrons), one must apply the appropriate gauge transformation to their interaction-free equation (in both cases the Dirac Lagrangian, which describes the free motion of spin-1/2 particles). This is in fact now viewed as the fundamental guiding principle of particle physics (though the underlying reason for this is a matter of dispute). But the essential point for our purposes is that these local gauge transformations applied to the free-particle equations imply the existence of at least one new particle, since the implementation of the procedure inevitably introduces what is called a *gauge boson*. In the case of electrodynamics, for example, this particle is the photon; in the case of the strong interaction we introduce the gluons, and similarly in the case of the weak interaction we obtain the W and Z bosons. Thus if we understand the properties through which the fundamental constituents of matter interact in terms of gauge transformations, and these bring in their wake the appropriate gauge bosons, then it looks as if we *have no choice* but to say that the properties such as charge and colour are not the sort of properties that lone objects can have, and hence that these properties are not after all intrinsic.

If this conclusion is correct, it represents a very bad result for Lewisians. In light of it, we can envisage Lewisians defending themselves by means of one of the following two strategies. The first strategy is to accept that these properties are indeed extrinsic but to take this as a signal that they are not after all fundamental; rather, what *is* fundamental is a previously unacknowledged *external relation*.[14] The claim is thus that we should reconceive of charge, colour and other properties involved with gauge transformations in terms of relations that do not supervene on properties of their relata (presumably in this case principally fermions and gauge bosons). The details of this would certainly have to be worked out, though there are at least two worries that we have about this general approach. First of all, such a strategy sits uncomfortably with the supposedly 'physicalistic' claim of Lewis that it is up to *physics* to provide an inventory of the this-worldly fundamental properties and relations, given that physicists apparently *do* count these properties as fundamental and do *not* appear to ever make reference to the alleged external relation – whatever it is – that is (hypothetically) being appealed to here. And secondly, even if such an external relation can be cooked up, we do not see how any such relation could hope to be specified without making reference to gauge symmetry; since this symmetry is a feature of *laws*, presumably no such relation could be taken as a denizen of the 'non-nomic base' Lewisians take to determine laws.

A more plausible strategy would be that of holding that even though *as far as actual*

14 See Darby (2009) for an example of extending the inventory of external relations as a Lewisian response to quantum physics.

physics is concerned these properties are conceptually entwined with the implementation of local gauge transformations, and *even though* these transformations bring in their wake the corresponding gauge bosons, these bosons are nevertheless only *contingently* associated with these properties. This would of course amount to a denial of a certain form of nomological essentialism that would need to be argued for in the specific case at hand, though we should note that Lewis' *general* argument against nomological essentialism rests upon the principle of recombination – a principle whose validity turns on precisely that which is currently in question (see Lewis 1986, 162-3).

In any case, if the gauge-theoretic argument against intrinsicality is sound, then if Lewisians want to maintain that charge is nevertheless intrinsic they must establish that there is a possible world in which the laws are consistent with a lone charged particle – a lone proton, say. By the above argument, such a world of course cannot be a world in which the actual laws hold. In having to ascertain whether such a world is possible, we therefore find ourselves once again having to contemplate lone-proton worlds wholly bereft of the resources with which to analyze them, namely, the *theories* of protons and of electric charge that physicists have painstakingly constructed and provided us with. Without anything with which we can meaningfully establish that lone objects can have these properties, then, if we want to continue to claim that all the perfectly natural properties are intrinsic then we must either simply stipulate it or remain agnostic on the issue. But either way this is a bad result. Not only is intrinsicality required for their free recombination, the inclusion of perfectly natural properties within Lewis' system is motivated principally by their theoretical fecundity and, as mentioned above, that fecundity is overwhelmingly dependent on their intrinsicality. Hence *without any good reason* to believe any longer that all the fundamental properties are intrinsic, we should be hesitant about continuing to appeal to them at all. And that is no less the case when it comes to appealing to them to solve the 'simplicity' problem that – if left unchecked – ruins the best system analysis.

Now, we are of course not pretending to have done a full survey of all the Humean analyses one could deploy in this situation, nor of all the possible get-out clauses that defenders of the one account we did look at might exploit. But we do hope to have shown that there is a significant lacuna in this most familiar of modal analyses from a naturalistic point of view. A defence of Lewis' analysis, as with the rival anti-reductionist account, inevitably requires us to consider actual fundamental properties in worlds in which the actual laws of physics do not hold. But once again, since everything that we *know* about these properties is tied to our theories and hence to the laws that actually hold, we find in each case that there is simply nothing useful that we can say in such scenarios.

4c. Moving on from mere assertion

That there is nowhere for the kind of reasoning engaged in above to go is something that we feel we all must ultimately accept. Extracting ourselves from the debate between supporters and critics of the various modal accounts of laws, the lesson we can draw with regard to the theme of this essay is that these methods of imaginary world-building utilizing the properties of fundamental physics are deeply problematic and hence the modal theories that depend on them equally so. In a sense this reaffirms Hacking's admonishment to possible world builders that 'mere assertion' about such worlds is not enough – not enough in that case to eliminate Leibniz's Principle of Identity of Indiscernibles as necessary on the basis of the 'mere assertion' of Blackian 'two globe' worlds, but more generally, not enough to illuminate features of relevance to *this* world (Hacking 1975). Our inability to say anything with content about physical properties and entities without a working physical theory shows us that, so long as metaphysicians are concerned with the fundamental and inhabit the actual world, to think that physics is assigned a peripheral role in metaphysics on the grounds that it primarily concerns the modal is to fancy ourselves as having cognitive powers that we simply do not have. This simple epistemic point clearly places tight constraints on the kind of modal theorizing that we can and hence should indulge in. Of course, it might be objected that one can still meaningfully engage in modal talk outwith such constraints but we regard such talk as fantastical in the sense that what is involved is fantasy modality – or to appropriate Leibniz's term, 'chimerical' – built merely on alleged 'conceivability' and not 'genuine' possibilities in the sense of being grounded in anything that resembles science. Although, as noted earlier, empirically detached metaphysics may yield resources that the philosopher of science can appropriate in interpreting physics, any such appropriation will in turn be sensitive to that physics; metaphysical constructions purporting to involve physical particles and properties ripped out of the theories through which we know them are unlikely to illuminate much – either about physics or anything else.

5. Towards a Structuralist Account of Laws and Modality

If we adhere to the view that metaphysics is primarily about the modal, the above considerations may be felt to lead to a rather demoralizing conclusion, namely, that there is little for metaphysics to do beyond redescribing science. But rather than simply sitting around helpless in the face of the difficulties outlined above we suggest that we try to adopt a more positive stance. In our view, the reason for the impasse that has been reached in both the reductionist and anti-reductionist cases is precisely the shared presupposition: *that there is such a thing as a non-nomic base*.[15] We have seen that it makes no sense from a naturalistic point of view to consider the objects and properties in isolation from the theories in which they are introduced, so what is the purpose of regarding the objects and properties in this base as 'non-nomic'? Any defense of this idea would doubtlessly take us back to considering the sort of artificial worlds that we already have, and once again to no effect.

We therefore suggest that we cease to view even the 'base' of a world as non-nomic and instead understand fundamental objects and their properties in terms of the structuralist

15 Indeed, we would argue that the usual understandings of 'categorical' properties are adapted to a wholly classical (i.e. 'functional) account of law; as far as we can tell, not one of the usual ways of characterizing categorical properties applies to fundamental kind properties once interactions are understood in terms of the operator equations through which quantum laws are expressed.

tradition in philosophy of physics (cf. Black 2000). According to this view, objects and their properties are 'law constituted' in various ways. In the context of classical physics, Newton's laws plus the Law of Universal Gravitation may be taken to yield the relevant kind-properties, so that the kinds that a theory as a whole concerns are encoded within the shared structure of the models of the theory (Brading 2011). With respect to physics post the quantum revolution, structuralists have pressed that since it has been characteristic of the practice of twentieth century physics to conceptualize fundamental particles in terms of the Lie groups encoding the symmetries of the laws those particles partake in, naturalism enjoins us to unravel the natures of those particles in these terms as well. Maintaining maximal continuity with physics and *identifying* particles in terms of the symmetries of laws means that fundamental particles can no longer be considered to constitute a non-nomic base.[16] As such, the fundamental presupposition of both the above approaches disappears, and with it the above impasses.

Conceiving of particles in this way is not, however, *ipso facto* to imply that there are no interesting modal questions one can ask about the laws such particles satisfy and, in particular, whether they can satisfy laws different from those they do. Identifying particles in terms of symmetries does not interfere with the relative coupling strengths of the various interactions, for example, so that one can still enquire into counterlegals such as what the actual world with its inventory of particles would be like if, say, the relative strength of the electromagnetic force was ten times stronger at a distance of a femtometer (so that the electromagnetic repulsion between protons is beginning to impinge on their strong nuclear attraction, threatening the cohesion of matter; cf. Lange 2002, 78). Similarly, one can make sense of the questions physicists ask of what the world would be like if there was no Higgs mechanism (cf. Quigg 2007, section 5). Speaking more generally, the question of the extent to which the laws that particles feature in are uniquely determined once we identify those particles in terms of nomic symmetries evolves into the question of the extent to which symmetry structure determines the laws uniquely – something that it in general does not, although this claim is sometimes made for local gauge symmetries. Questions concerning nomological essentialism consequently turn on the status of the gauge principle in fundamental physics and the status of frequent claims to the effect that this principle 'dictates' the dynamics.[17] All things considered, then, the sorts of questions that Lange *et al.* raise for whether particles of a given type can satisfy alternative laws may therefore still arise when we identify particles in terms of (this aspect of) nomic structure; the difference in this case is that what is required to meaningfully *answer* these questions is better defined and – most gratifyingly of all – the task of actually doing so blends continuously into tasks that occupy that area of enquiry most revered by the majority of contemporary philosophers: that is, fundamental physics.

In conclusion, if metaphysicians want to be more than purveyors of fancy goods for philosophers of science to appropriate, and *even if* metaphysics regards itself as the study of the possible, given the central *methodological* role of the actual in systematic

16 See (for example) Cei and French [forthcoming]; Castellani (1998); Livanios (2010).
17 Both of these questions are discussed in Martin (2003).

modal theorizing and physics' privileged role within it, metaphysicians *cannot but* engage with the philosophy of physics. We hope to have shown that a structuralist account of that physics opens up more fruitful avenues of metaphysical discussion than those predicated on a myth of a `non-nomic base' that knows no place in science.

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