

3#- Alethic Modality & Everettian Quantum Mechanics

3.1 Introduction

The kind of modality at stake in this discussion is alethic modality, which should be carefully distinguished from epistemic modality. Roughly speaking, the former involves genuine contingency in nature; the latter involves the compatibility of a hypothesis with our knowledge. This distinction has other names: in the two-dimensionalist terminology of Davies and Humberstone (1981), alethic modality corresponds to alternative possibilities ‘considered as counterfactual’ and epistemic modality corresponds to those possibilities ‘considered as actual’. While I take it for granted that some such distinction is needed for a successful account of modal language¹, precisely how it is to be drawn is itself a metaphysical question, which will be addressed in the course of this chapter. From now on, unless the context demands it, I will drop the qualifier ‘alethic’ when discussing modality.

Why do we need a theory of alethic modality? One reason is that as metaphysicians we want a clear account of the metaphysical status of all true propositions, and we think there are true alethic modal propositions. As well as a metaphysical story, we also want an account of the epistemology of modal propositions, which meshes both with the metaphysical story and with the use that we make of these propositions in science and in everyday thought. So what grounds the truth of modal propositions, how are we to gain knowledge of them, and why do we care about them?

In addressing these questions, we immediately encounter many of the methodological problems discussed in Chapter 1. How are we to go about investigating modal reality? As Kripke famously quipped, possible worlds are not the kind of things we can inspect with a ‘powerful telescope.’ (Kripke (1980) p.44) But Kripke’s own view, that possible worlds are stipulated rather than discovered, faces methodological problems of its own. If conceivability is not luminous, how are we to know the possible from the impossible? If our intuitions are not necessarily reliable, how can we judge a theory of modality on whether or not it succeeds in recovering them? These questions have spawned a lively literature, but no consensus has been reached. Positions currently occupied span the whole range from realism about impossible worlds (Priest 2005), to denials of the existence of any possible worlds whatsoever (Chihara 1999). This wide variation in views is largely due to the lack of any common methodology in the area; the standards for a successful theory of modality vary amongst authors just as much as the theories themselves.

In line with the program of naturalization that is the subject of this thesis, I want to investigate to what extent our best scientific theories can speak to these thorny questions in the philosophy of modality. To this end, we will need to engage with quantum mechanics. Quantum mechanics is the framework within which virtually all micro-physics and molecular chemistry is done,

⁴ Li dq duj xp hqwlv qhhghg ir uvxfk d vldgdug yllhz / fr qvlghu vkh h{ dp sch ri I hup dñ OdvWkhr uhp 1Xqloyhu uhfhqw / lvz dv sr vledh lq vkh hs lvwlp lf vqvh vdwkch vkr uhp z dv idvhlKr z hyhu/ z h qrz nqrz vkwlvwlv lq idfwqhfhvvdud vkh lq vkh ddvklf vqvh=vlv ir or z viur p rxuuhfhqw Qglvfr yuhg surri ri lvZ lkr xwr p h glvqfvr q ehv hq ddvklf dqg hs lvwlp lf p rgddw/ z h fdqqr wp dnh vqvh ri rxulj qr udfh ri vr p h qhfhvvdud vkh p dkhv ddf dos ur sr vlv qvl

and it is especially salient in the context of modality as it is fundamental to our theory of objective chance in nature. Chance has long been a problem within the metaphysics of modality; Lewis referred to it as the 'big bad bug' in his Humean system (Lewis 1987), but those who are prepared to countenance chances which are not Humean-supervenient also have significant problems justifying the rational relevance of their posited chances (Hall 2004). As a bridge concept linking well-confirmed physics with outstanding problems in the metaphysics of modality, chance is an ideal candidate for a case study in naturalized metaphysics.

In this chapter I will focus exclusively on Everettian quantum mechanics (EQM), as opposed to other approaches to quantum mechanics. The reasons for this are twofold. Firstly, there is a growing consensus among many philosophers of physics that EQM provides a viable realist interpretation (rather than modification) of quantum mechanics, and furthermore that it is the only such interpretation. Secondly, I shall argue below that it provides us with a unique set of resources for the explanation of the semantics and epistemology of modality, including a naturalistic candidate for chance. If proponents of EQM are correct in their contention that it is the best way to make sense of quantum phenomena, then any metaphysical work it can do for us is a welcome bonus.

In this chapter I will presuppose the correctness of Everettian quantum mechanics, and discuss to what extent it can play the role of a theory of modality. The plan will be as follows. In section 3.2, I will discuss desiderata for a theory of modality, and set some general conditions on any such theory. In section 3.3, I will look at physical modality in particular, and the dominant account of its metaphysics, which I call the restriction strategy. I will argue that the restriction strategy by itself does no explanatory work in an account of physical possibility, but rather shifts the explanatory burden to supplementary theories of laws of nature and of chance. In section 3.4, in accordance with the naturalistic approach of the thesis, I will apply Everettian quantum mechanics directly to the problem of physical possibility; this contrasts with the non-naturalistic general accounts of laws and chance that have previously been combined with the restriction strategy. In section 3.5 the Everettian approach is generalized to metaphysical modality; my claim is that it also provides a satisfying and reductive account of metaphysical modality, if we are prepared to bite the bullet of accepting the doctrine of strong nomic necessitarianism. In the final two sections, I provide sketches of a semantics and an epistemology for the resulting picture of alethic modality, which I call Everettian Modal Realism (EMR).

3.2# Desiderata for a theory of modality

I take it that a successful theory of possibility² should have the following features:

- a)# It should explain what it is for a proposition to be possible, and what distinguishes such a proposition from an impossible one.
- b)# It should explain the rational relevance of possibility, so conceived, to our actions and judgments.
- c)# It should explain how we attain knowledge of possibility, so conceived.

⁵ Vqf h qfhv w / sr veld d q lp sr veld d u l q u g h i l q d e d z l v k x v h r i q h j d v r q / z h f d q r i v q v l p s d i p d w h u e | v k l q n l q j l q v u p v r i d v k h r u r i s r v e l d w I I u r p v x f k d v k h r u / d q d f f r x q w r i q h f h v w d q g l p s r v e l d w z l o i r a z v w d j k w r u z d u g l

Fulfilment of criterion a) is both necessary and sufficient for being counted as a theory of possibility. Any theory which did not fulfil criterion a) would not be a theory of possibility at all. In stating condition a) for a theory of possibility more precisely, I will appeal to the terminology of truthmakers. A theory of possibility must comply with *truthmaker maximalism* for possible propositions; it must provide an appropriate truthmaker for each and every possible proposition. For more on truthmakers and truthmaker maximalism, see Armstrong (2004).

Criterion b) is motivated by the straightforward observation that we care about at least some modal claims, and constantly make use of them in our inferences. They are used to guide our actions and judgments; any theory must account for this. Similarly, condition c) requires that a theory do justice to our uncontroversial knowledge of many modal claims; a theory which entails that we have no modal knowledge at all would not be a theory about modality as we normally think of it. Fulfilment of criteria b) and c) comes in degrees; different theories may give better or worse explanations of the relevance and epistemic accessibility of possibility.

We might wonder whether criterion b) is independent of criterion c). If this were so, then we could face a situation where one theory scored higher on relevance but lower on epistemic accessibility; we should then have to balance the two criteria against each other in order to pick out one theory as preferable overall. I will argue that we do not face this problem, and that one particular account of possibility, based on Everettian quantum mechanics, does as well or better than any of its competitors at meeting both criteria. In fact, I do not think that the two criteria are fundamentally distinct; a good answer to one will invariably be a good answer to the other.

Williamson (2000) has influentially defended the claim that knowledge is the rational norm of belief, and of its occurrent form, judgement. On this view, we should rationally only assert or make judgments of the truth of claims that we know. And as Hawthorne and Stanley (forthcoming) argue in-depth, there are similar conceptual connections between knowledge and action; in particular, it seems very likely that something like their Reason-Knowledge Principle³ (that when one's choice is p-dependent, it is appropriate to treat the proposition that p as a reason for action iff you know that p) will have to be accepted.

If Williamson, Hawthorne and Stanley are right, then any proposition which can be rationally relevant to our judgments and actions must be knowable. And any knowable proposition p can also be the source of rational judgements (minimally, the known proposition p is a reason to judge that p) and of rational action (where the choice is p-dependent). These connections represent an important interdependence between knowability and rational relevance. This interdependence should be captured by a good theory of modality; the accounts we give of the knowability and rational relevance of possibility ought to fit with the conceptual connections between knowledge and action and between knowledge and judgment.

We might worry that our three conditions a) - c) leave something out. A common requirement on theories of possibility, particularly in the context of metaphysical possibility, is known as Plenitude (see Lewis 1986 §1.8). Lewis states the condition as a combination of abundance and completeness: there should be enough worlds to account for all genuine possibilities, and no worlds which represent any genuine impossibility. However, he faces a problem in stating the

⁶ Vhh Kdz vkr uqh dqg Vvdqh| -ir ukfr p lqj , s <1

condition of Plenitude without making it trivially true. The problem (originally pointed out by van Inwagen) is as follows: once Lewis identifies possibility with occurrence in some world, then it trivially follows that every world represents a genuine possibility, and no world represents any genuine impossibility. Condition a) then loses any bite.

In the light of this triviality problem, Lewis adopts a more substantive version of the Plenitude condition; he asserts that any satisfactory theory of possibility should recover the truth of our intuitive judgments about possibility. These he takes to be successfully encoded by a principle of recombination: as he vaguely puts it 'anything can coexist with anything else, at least provided they occupy different spatio-temporal positions'⁴ (Lewis *ibid.* p.88). The details of this principle are not relevant at this stage: the point is that Lewis relies on the truth of our intuitive modal judgments in the course of arguing that his account satisfies condition a). Lewis' stipulation of plenitude thus amounts to these two claims: that a possible sequence of events is a sequence of events which we intuitively judge to be possible, and that an impossible sequence of events is one which we intuitively judge not to be possible.

We see from this that Plenitude is not a further condition on an acceptable theory of possibility, but rather is a (controversial) methodological principle restricting acceptable ways to satisfy condition a). Lewis' discussion of Plenitude reveals his commitment to the conservativeness of a theory of modality with respect to our ordinary modal judgments; but this commitment will not be universally shared. Lewis' appeal to common sense is not the only ground we could have for thinking that a particular theory satisfies condition a): if a conception of possibility characterized by a particular way of meeting condition a) is epistemologically accessible and plays the correct role in rationally guiding our actions and beliefs, then this by itself seems enough to ensure that it is well-motivated.

This becomes apparent when we turn to consider Lewis' way of justifying the epistemological accessibility and rational relevance of his concrete possible worlds. He argues that we find out about the contents of other concrete worlds through our modal intuitions combined with the identification of concrete worlds with ways things could have been; and he likewise argues that the nature of these concrete worlds is relevant to us precisely because our intuitive beliefs about what could have happened are relevant to us. His arguments that conditions b) and c) are met are thus exactly equivalent to the justification he gives for the claim that his account satisfies condition a). I conjecture that this will be the case for all plausible theories of modality.

If the foregoing is correct, then Plenitude need not be taken as an independent condition on a theory of modality; it is already captured by a), b), and c). With these general conditions on a theory of modality in place, I now turn to the specific case of physical modality. I will argue that the orthodox account of physical modality merely transfers the burden of meeting these conditions to whichever accounts of laws of nature and of chance accompany them.

⁷ *[Illegible text]*

3.3# Physical possibility and the restriction strategy

Probably the most orthodox account of physical possibility is given in terms of a restricted set of metaphysically possible worlds. Lewis (1986) makes this account explicit when expounding the theoretical virtues of his genuine modal realism:

“More often than not, modality is *restricted* quantification; and restricted from the standpoint of a given world, perhaps ours, by means of so-called ‘accessibility’ relations. Thus it is nomologically necessary, though not unrestrictedly necessary, that friction produces heat: at every world that obeys the laws of our world, friction produces heat. It is contingent which world is ours; hence what are the laws of our world; hence which worlds are nomologically ‘accessible’ from ours; hence what is true throughout these worlds, i.e. what is nomologically necessary.”

(Lewis 1986, p.7)

Here Lewis offers an analysis of physical possibility in terms of metaphysical possibility and of laws of nature. It should be noted that this analysis does not depend on Lewis’ genuine realism about possible worlds: it can equally well be adapted to any view upon which quantification over worlds is in any way legitimate, such as modal fictionalism. The key feature of Lewis’ proposed analysis is that it places physically possible worlds and metaphysically possible worlds in the same ontological category. Call this the *restriction strategy* for analysing physical possibility.

I have two central objections to the idea that the restriction strategy can play the role of a theory of physical possibility. The first is that it is not clear that metaphysical possibility should be taken to be conceptually prior to physical possibility. I postpone discussion of this objection to section 3.5. The second objection, which is the one I will focus on in this section, is that the restriction strategy is not by itself a complete theory of physical possibility⁵; it cannot meet conditions b) and c) without supplementation by a theory of laws of nature. The restriction strategy by itself does no explanatory work.

This needs unpacking. For the sake of argument, assume that the set of metaphysically possible worlds is given unproblematically, and consider the question of why we should be interested in restricting our talk to physically-possible worlds, as defined according to the restriction strategy. There are many possible restrictions on the space of metaphysical necessity which lead to restricted forms of necessity, most of which are philosophically uninteresting. Alexander Bird presses this point as follows:

“Nor does it add to the kinds of possibility and necessity that one may define new modal terms along the lines of: p is nomologically necessary iff $(p \wedge \text{the laws of nature})$ is metaphysically possible, and p is nomologically possible iff $(\text{the laws of nature} \rightarrow p)$ is metaphysically necessary. But that is clearly a constructed kind, and the trick of construction can be pulled for anything whatsoever, e.g. ‘feline necessity’, where something is felinely necessary if it is true in all possible worlds which contain cats. Neither nomological necessity nor feline necessity name a distinct and genuine kind of necessity.”

(Bird 2007 p.48)

The natural response from a friend of the restriction strategy would be that the laws of nature are more significant than the proposition that cats exist, and that a restriction to possible

⁵ Z h p l j kwdor z r u u | v k d w d v z h o d v e h l q j l q v x i i l f l h q w d v d q d f f r x q w r i s k | v l f d o s r v l e l d w / v k h u h v l f v r q v u d v j | v p x j j d v l q x q n v v i l h g v x e v d q v y h d v x p s v r q v u l s d u l f x o d u / v k h d v x p s v r q v k d w k h o z v r i q d v u h d u h p h w s k | v l f d o j f r q v l q j h q v

worlds which share our laws is correspondingly more significant than a restriction to possible worlds including cats. This response, however, shifts the explanatory burden to the laws themselves; it becomes incumbent on a defender of the restriction strategy to give an account of laws of nature which vindicates their application in the analysis of physical possibility. In particular, it must be shown that the theory we give of laws will ensure that the restriction strategy meets conditions b) and c). That is, we must be able to show that the laws in question are such that we can know what they are, and we must be able to show that knowledge of them will be relevant to our rational actions and beliefs.

A related argument against the restriction strategy is due to Kit Fine (2002, p.266), who presents it in the context of arguing that natural, metaphysical, and normative necessity are *sui generis* and irreducible to each other. Consider the modal status of the laws of nature themselves. We want to say they are themselves physically necessary, since they are true in all physically possible worlds. But if we take physical necessity as necessity relative to the laws of nature, then the condition is trivial. Physical necessity, according to the restriction strategy, is necessity relative to the laws of nature, and physical possibility is possibility relative to the laws of nature. But the necessity of a proposition relative to itself is a trivial condition, as is the possibility of a proposition relative to itself. Fine argues that this presents a problem for the restriction strategy:

“The general problem is that a definition of natural necessity as a form of relative necessity will tend to make the necessity of the propositions with respect to which the necessity is relative a trivial or insubstantial matter; yet we tend to think that the necessity attaching to the laws and the like is not of this trivial sort. Any true proposition whatever can be seen as necessary under the adoption of a suitable definition of relative necessity. Any proposition that I truly believe, for example, will be necessary relative to the conjunction of my true beliefs, and any proposition concerning the future will be necessary relative to the conjunction of all future truths. The problem therefore is to explain why the necessity that issues from the definition of natural necessity is not of this cheap and trivial sort; and I doubt, in the case of any otherwise reasonable definition that might be proposed, that this can be done.”

Fine, in Gendler and Hawthorne 2002, p.266

What consequence does Fine’s argument have for the restriction strategy? It highlights the fact that the restriction strategy involves a conceptual connection between necessity relative to the laws of nature and physical necessity; Fine talks of this conceptual connection as making the necessity of the laws of nature themselves trivial. But I think this charge is unfair. For any given proposition P, it is of course trivial that P implies itself. But the 'restriction strategy' doesn't say that the natural necessity of P consists in P's implying itself: this would certainly be a trivial form of necessity. It says that the natural necessity of P consists in P being implied by the conjunction of the laws. The latter form of necessity is not trivial, even if P happens to be a law, as Fine in fact recognises:

Where the proposition P is a law, its being a natural necessity, according to the definition, will consist in: (a) its being entailed by the various laws, including P itself; and (b) its being a law. But (a), which is merely a matter of self-entailment, can hardly contribute to the given proposition’s being a natural necessity; and it will be hard to see, in any given case of (b), how the defining feature of a ‘law’ might constitute an adequate account of the *necessity* of the given proposition.

Fine, in Gendler and Hawthorne 2002, p.265

The response I suggest on behalf of the restriction strategist is to follow Fine's option (b), and to ground the natural necessity of a proposition directly in that proposition's being a law. Fine argues that it is 'hard to see' how the lawhood of a proposition might constitute an adequate account of its necessity; but I contend that this is only because we have no successful account of the lawhood of a proposition. Were we able to give an account of laws which grounded their knowability and rational relevance, it would become much more plausible that playing the law-role could be constitutive of being naturally necessary.

Fine's case against (b) is not limited to the claim that it is hard to see how lawhood could constitute natural necessity. He asks us to consider the proposition that K1, K2... are the only kinds there are, where K1, K2... is an inventory of all the kinds that there are. He then goes on to make the following claims about this proposition:

The 'law' here is the proposition that K1, K2... are the only kinds that there are, and its being a 'law' essentially consists in its being true. But we are inclined to think that, insofar as it is a natural necessity that there are no other kinds, it is because there is something in the nature of the world that prevents there being other kinds; and the mere fact that there *are* no other kinds can hardly be taken to constitute an adequate account of what this force, or form of necessity, might be.
Fine, in Gendler and Hawthorne 2002, p.266

It is quite open to the restriction strategist to simply deny both that the proposition in question is a law, and that it is a natural necessity. This move may be unavailable to those defending particular views of laws, such as the Mill-Ramsey-Lewis 'regularity theory' defended by Lewis; so much the worse for these views of laws. I think it is perfectly coherent for a defender of the restriction strategy to allow that, if things had gone differently in the early universe, there might have been more or fewer natural kinds than there actually are; and this would not require any change in the laws of nature. If this move is available, then Fine's arguments against the restriction strategy are inconclusive.

Despite these responses to Bird and Fine, I do think that there is a problem with the restriction strategy lurking, which Bird and Fine have not quite pinned down. The problem is that the kind of conceptual connection between lawhood and natural necessity postulated by the restriction strategy does not *by itself* explain why physical necessity is an interesting form of necessity. Here I am in full agreement. The restriction strategy is not explanatory, and hence not a complete account of physical modality, unless it is supplemented by an explanatory account of laws of nature; in which case, the restriction strategy does none of the explanatory work. However, if some genuinely explanatory account of laws could be given which explained their knowability and relevance, this could combine with the restriction strategy to produce a genuinely explanatory theory of physical possibility.

My conclusion is that the friend of the restriction strategy must pin his defence of the knowability and rational relevance of his version of physical possibility on the knowability and rational relevance of the laws of nature themselves. These requirements on theories of laws of nature correspond to what van Fraassen (1989) calls the *identification problem* and the *inference problem*. Van Fraassen argues that no extant theory of lawhood can solve both the identification problem and the inference problem. However, I do not wish to argue in support of his claim here.

Rather, my point is that the restriction strategy does not deliver a theory of physical possibility without supplementation by a theory of laws of nature.

The restriction strategy also leaves open the question of the metaphysical status of chance. If our world is chancy, as current best physics indicates, then accounting for the relevance and knowability of claims about chance is an indispensable part of accounting for physical modality. Even if our world is deterministic, it has been argued that a theory of chance can still be given⁶; and any theory of deterministic chance will likewise have to account for its rational relevance and knowability. This explanatory work will have to be completely independent of the restriction strategy, which by itself puts no constraints whatsoever on our theory of chance.

The restriction strategy cannot be the whole story when it comes to the analysis of physical possibility. If we are to retain the restriction strategy, we need theories of laws of nature and of chance in order to give an account of physical possibility. And if we want a naturalistic account of physical possibility, then we will need to look at a realistic theoretical framework for natural laws and for chance. That is the plan for the next section.

3.4# Naturalizing physical possibility

3.4.1#Example – Classical statistical mechanics

To begin with, take classical statistical mechanics. The theory is a simple one, and comparatively well-understood by philosophers; it also provides an appropriate foil for the more sophisticated account which will follow it. Classical statistical mechanics postulates a state space for a given system (where each point in the space corresponds to a particular microscopic state, or microstate, of the system) and a set of trajectories through the state space (which correspond to the allowed time-evolutions of the microstate of the system.)

To use CSM in conjunction with the restriction strategy to give an account of physical possibility, we will need to consider the state space of the whole universe, and in particular the allowed trajectories through that space. It is natural to identify the trajectories with the possible worlds allowed by CSM – the ‘possible worlds of the theory’. The definitions of alethic modal concepts which result are as follows:

A proposition is physically necessary iff it is made true by all trajectories through the state space of the universe.

A proposition is physically impossible iff it is made true by no trajectory through the state space of the universe.

A proposition is physically possible iff it is made true by some trajectory through the state space of the universe.

A proposition is physically contingent iff it is made true by some but not all trajectories through the state space of the universe.

How does this account measure up to our three criteria for a theory of physical possibility? Condition

⁶ Vhh/ ir uh{ dp s dh/ Or hz hu/ E1^5334‘=öGhvwup lqlvp dqg Fkdqfhñ Vwglhv lq Klhwu/ dqg Sklãvrsk/ ri Prghuq Sk/vlfv/ 65/ ss193<μ531