

Modalizing the Multiverse

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Abstract: Multiverse hypotheses can be given modalized interpretations: that is, the different universes in that multiverse can be interpreted as alternative possibilities rather than as co-actualities. In David Lewis' modal realism, for instance, maximal spatiotemporally disconnected systems play the role of alternative logically possible worlds. Eras in eternal-recurrence models are often understood as representing different ways history could play out. Appeals to inflationary cosmology to explain fine-tuning often identify inflationary 'bubble universes' with different physical parameters as alternative physical possibilities. And I have previously argued that the many worlds of Everettian quantum theory should be regarded as alternative physical and metaphysical possibilities. So we should ask: which sorts of multiverses can properly sustain modal interpretations? I argue that there are distinctive features of the Everettian multiverse which are essential to legitimizing a modal reading. Multiverses without these features ought not to be modalized; instead such theories give us 'just more actuality'.

Keywords: multiverse, modality, possibility, objective probability, chance, recurrence, inflation, cosmology, Everett, many worlds

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1. Introduction

Some ways that things could be are actual. Some ways that things could be are possible yet non-actual. How do we draw the distinction between these two kinds of ways that things could be? One quite widespread thought is that the problem is trivial. We simply discover the complete and correct physical/cosmological theory describing our universe, and that represents the actual way that things could be. Then all other possible ways for things to be are non-actual. What could be simpler?

The problem is that this simple approach does not avoid the question of distinguishing between possible and actual. It instead offloads the problem onto the formulation of our theories in fundamental physics and cosmology. And the physicists who develop those theories are not particularly concerned with our distinction between the actual and the merely possible. They are primarily looking for theories with predictive power and mathematical depth, and for neither of these purposes is it particularly important to distinguish the actual from the possible. Ours is a philosophical question, though one which cannot be addressed in isolation from the relevant physics. In this chapter I shall attempt to answer it, in the particular context of multiverse theories.

Multiverse theories complicate the simple picture of physics as concerned with all and only actual things. In multiverse theories, physics describes an ensemble of universes, which differ from one another not in their underlying character but in the details of the events which play out in them. In that respect, individual universes in a multiverse are strongly reminiscent of the philosopher's conception of *possible worlds*, which dates back at least to Leibniz. The philosophical conception of possible worlds regards them as alternatives to each other – as rivals for the role of characterizing actual reality. It is similarly possible to regard the different universes in a physics-derived multiverse as alternative possibilities rather than as co-actualities. I shall refer to this interpretive move as giving a modalized interpretation of, or just *modalizing*, a candidate multiverse.

The mere availability of the modalizing move in the context of multiverse cosmologies indicates that the widespread thought described above – the thought that physics describes the actual way things could be – needs further support and arguments. These arguments will play out in different ways depending on the specific multiverse under consideration: the multiverses which are posited in physics in order to explain features of the observed universe are very varied, and all are different in character from the multiverses which emerge from a priori philosophical reasoning. Hence the core focus of the present chapter: which multiverses derived from physics should be given a modalized interpretation? Or, for short, which multiverses are modalizable?

My proposal connects the modalizability of a multiverse to the role of *objective chance* in that multiverse theory. The argument proceeds by investigating the most notorious modalized multiverse proposal in recent analytic philosophy – David Lewis’ modal realism – and scrutinizing the most prominent objections to it. Modal realism is often said, if true, to inevitably provide ‘just more actuality’ rather than providing genuine alternative possibilities. This *just more actuality objection* has much in common with the ‘Humphrey objection’ against counterpart theory. I criticise this style of objection, and I contrast it with a different objection which I take to be decisive against Lewisian modal realism: the *modal relevance objection*. The modal relevance objection challenges the modal realist to show that the other universes, once construed as possibilities, are then relevant to things we care about, in such a way as to make our practice of modalizing intelligible. This challenge will then provide a yardstick against which we can measure other proposed multiverse ontologies.

To foreshadow: in section 2, I develop criteria for when modalizing is apposite. In section 3, I motivate these criteria using the example of the possible worlds introduced by David Lewis as part of his modal realism. In section 4, I consider modalizing multiverses obtained through eternal recurrence – an idea common to numerous different physical and cosmological frameworks. Section 5 turns to a more contemporary cosmological framework – eternal inflation – which is a reasonably generic prediction of contemporary string-theoretic approaches to early-universe cosmology. In each of sections 3-5, I argue that the basis for modalizing each of these multiverses is inadequate (although there is a little-known variant of Lewisian modal realism, due to Robert Pargetter, in which the modalizing move has more plausibility). Section 6 then turns to the Everettian multiverse – the many worlds of many-worlds quantum theory – and looks at some features distinctive to this multiverse which centre around the metaphysics of objective probability. I argue that these features render the Everettian multiverse uniquely suited to a modalized reading. Section 7 is a conclusion.

2. Criteria for Modalizability

What makes a multiverse suitable for modalizing? My eventual suggestion will be that the universes in that multiverse need to stand in the right relationship with objective chance. But it will be helpful to approach that relationship by looking at objections to the modalizing move in a concrete case, to see what responses may be available. I shall argue in section 3 that modalizing any given multiverse faces a substantial obstacle, which I shall call the modal relevance objection. In order to rebut the objection, and justify modalizing a multiverse, one needs to demonstrate that the universes in such a multiverse play the right rational role for multiverse inhabitants. Those other universes should be relevant to them in the way in which alternative possibilities are relevant to us.

One way of demonstrating the relevance of a multiverse's universes, when construed as possibilities, would be for things in our universe to causally depend on things in other universes. However, that route is unpromising since events related as cause and effect are (I shall be assuming throughout) ipso facto part of the same universe. This enables an important simplification: we can narrow our focus only to multiverses where the universes are causally screened off from one another. Events in other universes, then, do not explain events in the actual universe.

Another way other universes might be relevant, however, would be if features of those other universes explain *what explains what* in the actual universe. Here objective chances enter the frame, as – without acting as direct explainers of events – chances can potentially still *mediate* causal explanations. That is, chances can potentially explain why one event (the cause) causes another event (the effect).¹ It then follows that one way – perhaps the only way – for other universes to be relevant to the actual universe is for events in them to form part of the grounding base for the chances operative in the actual universe. This is the hypothesis which I shall be developing.

What is it for chances to be operative in a universe? The chances have to attach to events in that universe: chances have to be chances *of* universe-bound outcomes: there has to be a chance of spin-up *as opposed to* spin-down. For this to be possible, chances must not attach only to alternative configurations of the entire multiverse. This gives us our first criterion for modalizability:

Chance Aboutness: Values of objective chances should attach to properties of specific universes, rather than only attaching to properties of entire multiverses.

Chance Aboutness, however, is by itself insufficient. If every universe in the multiverse had its own objective chance function, with all these functions independent, then there would be no relevance of the other universes to our universe's chance function – and hence no way for other universes to be relevant to what explains what in our own universe. So we have our second criterion:

Chance Dependence: Values of objective chances attaching to events in specific universes should depend on features of other universes in the multiverse of which that universe is a part.

Chance Dependence combines with Chance Aboutness to ensure that other universes in the multiverse are relevant to our interests in the way in which alternative possibilities are relevant.

¹ This can hold in indeterministic settings, with non-trivial chance values, as well as in deterministic settings where all chances take values of zero or one. See Hicks and Wilson (2023) for a full discussion of this explanatory role for objective chances.

If Chance Aboutness and Chance Dependence are satisfied, then knowing about the features of other universes becomes relevant and interesting information for an agent embedded within a universe in a larger multiverse. The agent can use this information to inform their knowledge of the chance distribution operative in their own universe, and thereby to inform their judgment of what explains what in their own universe. In turn this can have epistemic benefits in terms of prediction and understanding, given the deep connection between explanation and rational inference posited by explanationist epistemology. Overall, this general approach strikes me as the most promising style of response to the modal relevance objection. Thus we obtain my provisional proposal: a multiverse should only be modalized if both the Chance Aboutness and Chance Dependence criteria are satisfied. I shall take these two criteria to be jointly sufficient and – in the absence of other plausible sufficient criteria for modalizability – individually necessary.

Now that we have provisional criteria for modalizing a multiverse, we can begin to apply them to concrete proposals. That is my main goal in the remainder of this chapter.

3. Modalizing Lewis Worlds

The multiverse of Lewisian modal realism originates from explanatory projects in metaphysics, not in physics. Lewis was motivated to provide an account of our modal reasoning – about possibilities, necessities, and counterfactual dependencies, amongst others – which could help to assuage persistent philosophical doubts about these notions. (These doubts arose from logical positivist and logical empiricist critiques of metaphysics, and they persisted in moderated form in Quine’s scepticism about *de re* modality.) Accordingly, the worlds of the Lewisian ontology are not presented as the kind of thing which can be discovered by physics, but rather the kind of thing which can be hypothesized in order to help resolve distinctively philosophical problems.

Modal realism may be reconstructed via general principles which include the following:

O9: An individual x is a world iff any two parts of x are spatiotemporally related to each other, and anything spatiotemporally related to any part of x is itself a part of x .

O12: For any individuals $x_1, x_2, \dots, x_n$ there is a world containing any number of duplicates of each, if there is a spacetime big enough to hold them all, and such that for any spatiotemporal relation the duplicates in question stand in that relation.

P: It is possible that P iff there is a world according to which it is the case that P .
(Divers and Melia 2002: 16-17)

Principle O9 tells us what kind of thing a world is: it is a maximal system of spatio-temporally related individuals. Principle O12 tells us which worlds there are: there is a world for each assignment of intrinsic qualitative profiles to argument places in every spatiotemporal relation. Principle P tells us what worlds, thus defined, have to do with modality: the worlds captured by principles O8 and O12 correspond 1-1 with the complete alternative possibilities.

Numerous objections have been raised against Lewisian modal realism: indeed, it is quite remarkable how much philosophical attention it has received relative to the number of philosophers who have reflectively endorsed it. For our purposes, however, we shall need to consider two objections in particular: the *just more actuality* objection, and the *modal relevance* objection. Although the just more actuality objection is very widely offered as a reason for rejecting modal realism, I think that (at least as usually presented) it overgeneralizes, leading to a blanket veto of any revisionary reductive analysis of modality. That kind of *a priori* veto is not an approach which science-oriented metaphysicians can responsibly take. Instead, I shall argue that the modal relevance objection identifies the right reason for rejecting modal realism. This objection will then help to motivate a criterion against which multiverses motivated by theoretical considerations in natural science can be tested in later sections.

Begin with the just more actuality objection. As the name suggests, it is the charge that Lewis worlds – supposing they exist – should not be regarded as alternative possibilities but as additional parts of actuality. They are just more of the actual stuff, rather than merely possible stuff. Here is how Nathan Salmon puts the point:

“Lewis’s highly eccentric views concerning alternative universes, counterpart relations, and their alleged role in modal discourse have their ultimate source in a conceptual confusion between the modal proposition that *x* might have been such-and-such (where *x* is a possible individual) and the nonmodal proposition that *x* is in fact such-and-such (and is in some “world”).” (Salmon 1988: 239-240)

Thus, for example, if Lewis points to the existence of a world containing pink wombats as corresponding to the possibility that wombats be pink, Salmon replies that the pink wombats at that world (supposing they exist) are not modal alternatives to the actual world, but additions to the actual world – *just more actuality*. Versions of this objection have been explored by Lewis himself (Lewis 1986: 97-101) and most extensively by Michael Jubien (Jubien 2009: 74-77).

To evaluate the just more actuality objection, it will help to compare it with the well-known *Humphrey objection* raised against counterpart theory by Kripke (1972). Kripke's core idea is that we should not analyse possibility for particular individuals in terms of counterpart individuals in other possible worlds, since actual individuals care about what might happen to them but 'could care less' (Kripke 1972: 344n.17) about what happens to otherworldly individuals. The connection with the Humphrey objection is unsurprising, since counterpart theory is a core element of modal realism (indeed, on some approaches to the semantics of modal theory, counterparts are involved in the correct analyses of all modal operators – see Dorr MS).² And since there is a fairly extensive literature on the Humphrey objection, it can help guide our thinking about the 'just more actuality' objection.

What's wrong with the Humphrey objection? I shall note two ways of responding to the objection: the charge that it misunderstands the counterpart-theoretic analysis, and the charge that it applies an implausibly strong methodological principle. The former kind of response succeeds only against versions of the Humphrey objection which are too weak to be serious candidates for what proponents of the objection have meant. The latter kind of response does plausibly address the intentions of those proponents, and I think it is successful against the objection as posed. However, reflection on why Humphrey-objection-proponents will still be unsatisfied will help point us towards a related, but much more serious, objection against Lewisian modal realism.

The first (less useful) kind of response accuses the Humphrey objector of failing to appreciate the distinction between having a modal property and grounding the having of a modal property. So, for example, Melia presents the Humphrey objection as suggesting that *only* our counterparts, and not ourselves, are relevant objects of our concern:

“If we say Humphrey might have won the election we are talking about something that might have happened to Humphrey, and we are not talking about what might have happened to someone else. Rather, it is in virtue of the fact that someone who resembled Humphrey has (not might have had) the property of winning, that our very own Humphrey might have won”. (Melia 2003: 107)

The problem with this response of Melia's, as De (2018) points out, is that it is implausible that opponents of counterpart theory are basing their entire objection on a simple misunderstanding of the counterpart-theoretic proposal, in light of the context of their objections. I agree, which is why I think the next type of response to the Humphrey objection is more interesting.

² See De (2018) for further discussion of the Humphrey objection and the extent to which it can be extended to target modal realism more generally.

The second kind of response to the Humphrey objection is that it applies too strong a constraint on possible analyses in metaphysics. If, in general, we want to analyse Bs in terms of As, then there is a clear sense in which our hypothesis entails that caring about the Bs is linked to caring about the As: what it is to care about Bs is – at least in part – to care about As. But – the response continues – it is not always transparent to the caring agent what one is caring about. For example, let us assume that the facts about temperature in a room are, in some more or less complicated way, reducible to the facts about molecular motion within the room. Then if I care about the temperature in this room, I thereby care about the patterns of molecular motion in this room. If I don't know about the underlying nature of heat, I may not realize that it matters to me what the patterns of molecular motion are like – but nonetheless, it does matter to me. If the molecules were to lose most of their kinetic energy, I would certainly notice; that change would make me extremely cold. All this can still hold true even in epistemic communities which have not yet contemplated the kinetic theory of heat. I take the lesson to be that an agent cannot always tell, even after extended reflection, whether something is in fact relevant to their practical interests. That thing's relevance to their interests may turn on theoretical matters which are simply beyond their ken.

If we take the line of reasoning involved in the Humphrey objection to its limits, we end up in the paradox of analysis. Analyses can never be surprising or revisionary if it is required of any analysis that our attitudes to the analysans and analysandum should coincide even in advance of knowing the analysis in question. Once we come to know that a reductive theory is correct – for example, once we come to know the truth of the kinetic theory of heat – then suitable reflection should put us in a position to know that we do in fact care about patterns of molecular motion. But it is inimical to any possible progress in the project of reductive analysis if match of prior attitudes to analysans and analysandum is taken as a precondition on the viability of any analysis.

If this second kind of response to the Humphrey objection is on the right track, then we can apply it to see clearly what is wrong with the 'just more actuality' objection to modal realism. Prior to empirically investigating thermal phenomena, we had different attitudes to the fact molecules are moving around rapidly and the fact that the room is warm. But once we acknowledge the explanatory power of the kinetic theory hypothesis, we should not continue to uncritically assume that this difference in attitudes is warranted. Likewise, prior to philosophizing, we had different attitudes to the existence of some spatiotemporally isolated world of some particular kind and the possibility of some particular kind of scenario obtaining. But once we notice the explanatory power of the modal realist hypothesis, we should not continue to take for granted that this difference in attitudes is warranted. Accordingly, we should not take for granted that Lewis worlds are not in fact relevant to our practical interests. That conclusion still requires further argument.

My suspicion is that proponents of the just more actuality objection see an important distinction between the ‘scientific’ hypothesis that heat is reducible to (previously unrecognized) molecular motion and the ‘philosophical’ hypothesis that alternative possibilities are reducible to (previously unrecognized) portions of reality. The distinction concerns the proper source of evidence bearing on the constitutions of heat and of modality. Evidence bearing on the nature of heat can be empirical, while evidence bearing on the nature of modality is supposed to be wholly non-empirical in character. In other words, I think that behind the just more actuality objection is a presupposition that theoretical postulates of our theory of modality should be knowable a priori – or at least, that the basic categorical structure of that theory should be knowable a priori. This is reflected in Salmon’s description of counterpart theory as a ‘conceptual confusion’, and more generally in mainstream metaphysics of modality where empirical considerations are almost entirely absent. (Exceptions here include Baron et al. (2025) and Wilson (2020).) Once we suspend the assumption that the metaphysics of modality must be approached a priori, the path is cleared for revisionary analyses of modality to be taken seriously and motivated by considerations drawn from our best scientific theories. That will be the project explored in sections 4-6.

The moral of the story is that it would be premature to reject Lewisian modal realism on the basis of the just more actuality objection. Does modal realism ultimately succeed in providing a plausible revisionary theory of modality? I think that it does not; but the reason it fails is not attributable to the general shape of the account (as just more actuality objectors would have it) but instead comes down to the details of the worlds which Lewis posits. The real problem is that these worlds are the wrong sort of thing to be relevant to our interests. This notion of relevance to our interests – intentionally reminiscent of the ‘caring about’ relation Kripke talks about – may then lead us towards a better way of developing a Humphrey-like objection against Lewisian modal realism.

The better kind of objection I have in mind is one I have elsewhere called the ‘modal relevance’ objection (Wilson 2020: 9-11). Lewis worlds are spatiotemporally and causally isolated from one another – in particular, from our own Lewis world – and this renders it distinctively hard to see how features of any such worlds could be relevant to our interests. Here it doesn’t help to say – as Lewis says (Lewis 1986: 97-101) – that Lewis worlds are relevant because they are the referents (or truthmakers, or grounds, or whatever notion is preferred) of our modal discourse. This just pushes back the question one stage, to the question of why we have adopted and continue to incessantly use the elements of modal vocabulary in question. Perhaps it may be built into the semantics for our actual counterfactual construction that other Lewis-worlds are involved in the truth-conditions of counterfactual claims; the question remains why we use that kind of counterfactual construction in the first place. (See Wilson 2013a for additional discussion of this methodological point.)

The modal relevance problem is entangled with a problem which I have called the modal knowability problem (Wilson 2020: 9-11). This is the problem of explaining how, if there are indeed Lewis worlds, it is possible for us to have any knowledge of them – or even to have justified true beliefs about them. While modal relevance challenges the possibility of explaining how it is that the facts about Lewis worlds have any bearing on the experience of worldbound agents, modal knowability challenges the possibility of explaining how the experience of worldbound agents has any bearing on the facts about Lewis worlds. The problem, again, derives from the mutual isolation of the different Lewis worlds – what goes on at one does not bear in any non-trivial way on the probability of what goes on at any other.

In the introduction I suggested a strategy for recovering the value of knowing about the features of other universes: even if features of other universes are causally isolated from our own, so that they do not causally explain any actual events, features of other universes might still be relevant to actual events by bearing on what explains what within the actual universe. This gave us a criterion for the explanatory relevance of other universes in the form of two principles I called Chance Aboutness and Chance Dependence. Taken together, these principles say that values of objective chances attaching to properties of specific universes depend on properties of other universes in the multiverse of which that universe is a part. Accordingly we should ask whether Chance Aboutness and Chance Dependence hold in Lewisian modal realism.

The problem with this prospective solution to the modal relevance problem is that Lewisian modal realism, while it satisfies Chance Aboutness (by construction, via Lewis's Humean theory of laws and chances³), does not satisfy Chance Dependence. There is no mechanism or analogous explanatory connection by which chance values at a Lewis world might be explained in terms of the features of other Lewis worlds. Any explanation of objective chances in the actual world in terms of Lewis worlds would have to be in some sense constitutive – it would need to identify some law of metaphysics, or similar principle, determining that when there are Lewis worlds of a certain type then there are objective chances of some specific values in some specific Lewis world. Then we could potentially infer, via an inference to the best constitutive explanation of known objective chance values in our actual world, that there are indeed other Lewis worlds. But what could such an explanation be like? Nothing of the sort that Lewis can accommodate. Any constitutive explanation of the values of particular objective chances in terms of features of other Lewis worlds would contradict Lewis's Humean approach to laws and chances, as wholly supervening on (i.e. fixed by) the world that they are the laws and chances of.

³ See Schaffer (2007) for an accessible introduction to Humeanism about laws and chances.

The closest thing to a mechanism which generates Lewis worlds is the principle of recombination – Divers and Melia’s principle O12 above, which specifies that there are worlds corresponding to every spatiotemporal configuration of individuals. Recombination is a central principle of modal realism. But Lewis does not understand it as a generative principle: rather, it is put forward as a compact statement about the extension of worlds which fills out the specific details of the Lewisian modal vision. For example, it can be used to “settle – or, as opponents might say, beg” (Lewis 1986: 91) questions about the modal status of the laws of nature. Accordingly, recombination by itself does not explain the existence of any particular Lewis worlds, so it cannot help to explain values of objective chances in a world in terms of the features of other worlds.

There is the prospect of a version of modal realism which rejects Lewis-style Humeanism, and regards chance instead as a distributional feature which spans multiple worlds. In the version of modal realism suggested by Robert Pargetter (Pargetter 1984), objective chance is a measure over a space of Lewis-style worlds rather than a measure defined separately at each world; this approach traces back to earlier work by John Bigelow (Bigelow 1976). Call a theory of this kind *probabilistic modal realism*. In such a theory, chances at the actual world do after all depend on the existence of non-actual worlds – since actual chances are identified with a metaphysically privileged measure over a large space of worlds, these chances being well-defined relies on the existence of that space of worlds. Given the plausible further assumption that the existence of the space of worlds is partially explained by the existence of each world in that space, we have the desired kind of explanation which supports appropriately explanatory counterfactuals. So Chance Aboutness and Chance Dependence are satisfied.

It will help to give a simple example of probabilistic modal realism’s other-world-to-chance explanatory structure. A fair die is rolled twice, giving a space of 36 different possibilities – each corresponding to a different ordered outcome pair. The actual result, for concreteness, is 2 followed by 5. The chance that a double would be obtained is $1/6$ – corresponding to the disjunction of the six different same-number worlds 1-1, 2-2, 3-3, 4-4, 5-5, 6-6. Now consider some explanatory claims and their associated dependence counterfactuals:

1. The existence of non-actual worlds (partly) explains why there is an objective probability of a double being rolled. *If there had been no non-actual worlds, then there would have been no probability measure defined over them.*
2. The existence of the six same-number worlds (partly) explains why there was a non-zero objective probability of a double being rolled. *If there had been no same-number possibilities, then the probability of a double being rolled would have been zero.*

3. The existence of the six same-number worlds (partly) explains why the probability of a double being rolled was $1/6$. *If there had been a different number of same-number worlds, then the probability of a double being rolled would have been different.*

In each of these cases, the explanation is only partial – for example, the number of different-number worlds plausibly also contributes alongside the number of same-number worlds to the probability of a double. But still, by holding fixed the appropriate variables we can evaluate (and, I hope, find plausible) the associated dependence counterfactuals.⁴

It is time to sum up our discussion of Lewisian modal realism. This theory is the classic instance of a multiverse being assigned a modalized interpretation. I have argued that the distinctive features of Lewis’ system – particularly his Humeanism about chance and his non-generative approach to the principle of recombination – render the other worlds explanatorily irrelevant to features of the actual world, and hence they preclude other Lewis worlds from playing the rational role of alternative possibilities. This failure of modal relevance – rather than the ‘just more actuality’ objection which has been most prominent in the literature – presents to my mind the strongest reason for rejecting a modalized interpretation of the Lewisian ontology. However, we have also seen a probabilistic variant of modal realism which looks to be in a better position to vindicate the explanatory relevance of facts about other worlds; this variant accordingly seems better able to support a modalized reading. We shall return to this probabilistic multiverse model in section 6.

4. Modalizing Eternal Recurrence

Our next case to consider is that of multiverses associated with eternal recurrence hypotheses. The kinds of eternal recurrence multiverses I have in mind are those which include a segment which is recognisably like ours, but in which – on the largest timescales – involve cycles of repetition. We may contemplate both ‘linear’ recurrence, in which an infinite sequence of duplicate history-segments stands in some objective temporal ordering, and ‘circular’ recurrence, in which a single history is ‘travelled around’ infinitely many times. The latter only makes sense in the context of a dynamic view of time – presentism, or a moving spotlight view – whereas the former approach does not depend on any particular metaphysics of time. In the simplest models, all the alternative eras are qualitatively identical: so, even if we modalize their eras, we obtain no alternative possibilities differing from actuality. But in general, the events which occur in distinct loopings may vary.

⁴ For more discussion of the sort of counterpossible evaluation I have in mind here, see Wilson (2018) and Baron et al. (2020).

Recurrence multiverses of various kinds have been posited in physics. The original models were associated with classical mechanics and classical statistical mechanics. In such models we have perfect recurrence if the whole universe returns exactly to a point in its own state space which it previously occupied. Moreover, the Poincaré recurrence theorem shows that many classical systems will return arbitrarily close to such a point in finite time. More recently, we find this idea in the *conformal cyclic cosmology* (CCC) theory put forward by Roger Penrose in a series of works over the last three decades (Penrose 2006, 2021). According to CCC, the very hot dense initial state of the universe is actually identical to the cold dilute end state; these states are related by a conformal rescaling, a transformation in physical size (holding shape fixed) which is regarded as a symmetry of the underlying theory and hence as not corresponding to any objective difference in reality.

It makes *prima facie* sense to consider a modalized interpretation of an eternal recurrence multiverse. We can identify individual eras – individual runs of the recurring history segment – although it should be noted that there need be no event distinguished as the ‘start’ or ‘end’ point, hence the possibility of no objectively preferred way of dividing history into different eras. We can then regard the individual eras as alternative possibilities: to say that we could have lived in a different era is to say that there are counterparts of us in the other eras, in which case we would have non-trivial alternative possibilities.

David Lewis was in a certain sense open to modalizing different eras in a recurrence multiverse. He allows that individuals can have distinct counterparts within a single Lewis world – so, for example, he acknowledges a clear sense in which I could have been you and you could have been me (Lewis 1986). It would have been natural for Lewis to think, accordingly, that we both could have lived in a different era of the very same recurrence timeline. He doesn’t discuss modalizing of a more holistic kind – consideration of counterparts of whole eras, or of whole recurrence timelines – but I don’t see any reason why his approach to actual-world counterparts shouldn’t be extended here also. Then we would have possibilities like the switching of two eras – our era and the subsequent era could have occurred in a different order, and this possibility would be grounded only in the actual recurrence history – without the need for any other possible worlds at all. Perhaps even the entire timeline could have occurred one era later than it in fact did.

How does the proposal to modalize an eternal recurrence multiverse fare relative to the criteria set out in section 2? I suggested that Chance Aboutness and Chance Dependence are necessary conditions on modalizing a multiverse: values of objective chances must attach to events in specific universes and they must constitutively depend on features of other universes in the broader multiverse. How does this criterion play out in the case of recurrence multiverses?

The first point to note is that any multiverse in which there are traces left across the transition points between eras will not meet the condition. In particular, in Penrose’s CCC, information is not completely eliminated at the conformal rescaling: objects have continuous spacetime trajectories across this point, and Penrose has in fact looked for traces of past eras in astrophysical observational data. So we can immediately set aside recurrence multiverses relevant like CCC as poor candidates for modalizing: the causal dependencies between events in different universes renders each sequence of universes a different way for a complete causal chain to play out, and so we are committed to regarding such complete causal chains as representing individual possibilities.

Consider then the most promising kind of recurrence multiverse for modalizing: a multiverse comprising an infinite sequence of eras, where events may play out differently in different eras, and where each loop starts and ends in a distinctive ‘reset’ state at which all records of the previous loop are wiped. (We would then also need indeterministic fundamental laws if all eras are not to match precisely.) In such a recurrence multiverse, a modalized reading makes room for non-trivial physical contingency. Since the indeterministic laws will (or at least can) play out differently on each era, then there will be qualitative differences in the events which occur within each era.

Does this scenario satisfy Chance Aboutness? The answer will depend on whether the reset state also resets the identity of the chance function. Do we have different probability distributions over each era, or is there a single probability distribution which covers all eras taken together? This, I think, will come down to mathematical features of the laws which are associated with the relevant chance distribution. In particular, if the laws are Markovian⁵ – if information about the current state of the universe makes irrelevant (screens off) any physical significance of information about past states – then the probabilities associated with them cannot vary from one reset state to another reset state. (This is the case for the classical statistical mechanical recurrence multiverses I mentioned at the outset.) In such a case, it is open to interpret the chances associated with each era as corresponding to a different objective chance function. But if they are non-Markovian, this prospect is closed off: we will then need a probability distribution which spans the whole sequence of eras.

We now need to turn to consider the Chance Dependence condition: that values of the chances in the actual era need to constitutively depend on events in other eras. And here the situation is reversed from the previous condition: Markovian laws rule out any such constitutive dependence, while non-Markovian laws might in principle allow it.

⁵ For an accessible philosophical introduction to the question of whether the laws are Markovian, see Builes and Odisseas Impagnatiello (2025).

Given Markovian laws, the chances within a given era are dependent only on the reset state, the subsequent events in that era, and the chancy laws operative within the era in question. Different ways in which the whole series of eras could play out will not differ with respect to the chances in some given era: the chances in a era supervene only on the events within that era and the laws which govern it. In other words, the other eras are invisible: ours would play out in the same way, with the same chances, even if the other eras played out differently – or, for that matter, even if the other eras did not play out at all.

I conclude that there is no way for a recurrence multiverse to satisfy Chance Aboutness and Chance Dependence Simultaneously. Accordingly, I conclude that the prospects for modalizing an eternal-recurrence multiverse are poor. However, this conclusion is of fairly limited significance. Eternal recurrence hypotheses – especially of the kind which are candidates for modalizing – remain highly controversial and speculative. In the next section, I'll turn to a multiverse theory which is much more widely endorsed within cosmology: the multiverse of eternal inflation.

5. Modalizing Eternal Inflation

Inflation is a physical process, hypothesized to have occurred only a fraction of a second after the big bang, in which space expands very rapidly. It is incorporated into the highly successful Λ -CDM model of the large-scale structure of our universe, and it is taken to solve two key problems about the observable universe: the horizon problem and the flatness problem.

The horizon problem is the problem of explaining the uniform character of the physical universe as viewed in different directions from Earth. Given the constraints imposed by relativistic causality, regions which are at the limits of the observable universe in different directions would never (absent any inflation) have been in causal contact with one another. Yet radiation visible from these regions is at the same temperature: these regions are at thermal equilibrium. Our usual understanding of thermal equilibrium is that it is only achieved when two systems have been in causal contact with one another, as for example when a bottle of juice is placed inside a refrigerator. How then can we explain the thermal equilibrium of these very different regions? Inflation answers: there is a time in the distant past where these regions were able to interact directly in the usual ways, through direct exchange of radiation. This led to an equilibrium state which was subsequently massively expanded through the process of inflation; and this process occurred uniformly enough to leave the relative thermal properties of the now spatially distant regions strongly correlated.

The flatness problem is the problem of explaining the extreme proximity to perfect flatness of the large-scale structure of the spacetime we observe. Given the expansion of the universe subsequent to the Big Bang, any deviation from flatness of the spacetime metric would tend to increase in magnitude. Accordingly, given the current closeness to spatial flatness that is observed, the original degree of spatial flatness of the early universe appears to need to have been preposterously high. This very precise requirement on the initial state gives rise to a suspicion of fine-tuning. But this suspicion is allayed if the process of inflation takes hold; inflation is capable of operating on an initial state which departs from flatness by some considerable degree and ‘flattening’ or ‘smoothing’ this state out in the expansion – flattening it enough to explain why a very high degree of flatness still persists today.

Inflation is widely endorsed within cosmology essentially on the basis of these two arguments, and it is incorporated into our best simulation models of the universe – models which have achieved remarkable accord with observational data. So inflation is generally seen as having strong empirical credentials (although see Ijjas et al. (2013) for dissenting voices). But while apparently empirically successful, inflation raises a difficult theoretical complication: space is very reluctant to stop inflating. In most contemporary models of the inflation process (which posit the existence of a quantum inflaton field, which decays to a lower energy state through rapid spacetime expansion), inflation doesn’t end uniformly. Instead, inflation may be re-initialized in some regions of the expanding universe, leading to the ‘nucleation’ of a new ‘bubble universe’ – in which a new process of inflation is subsequently initiated. The relative rates of expansion and bubble nucleation determine whether inflation ceases at the global level, or whether it continues forever in a runaway fashion with new bubbles nucleating inside bubbles. This latter scenario is known as *eternal inflation*.

Eternal inflation generates a multiverse – of different ‘bubble universes’ which has been widely discussed in the foundations of cosmology. It has been suggested that these bubble universes might have a role to play in explaining the apparent fine-tuning of a variety of cosmological parameters; if there is a mechanism to implement different values of some parameter in different bubbles, then it will be unsurprising that any bubble we observe ourselves to inhabit is a bubble with a life-permitting value of that parameter. Candidate mechanisms which could implement different values of relevant parameters include the compactification of dimensions in M-theory, in which some subset of the prior 11-dimensional spacetime retain their physical significance while others become tightly curled up, and lose direct physical salience. This compactification process can play out in dazzlingly many different ways – this is the so-called ‘landscape’ of string theory. (See Susskind 2005 for an introduction.)

The universes in the eternal inflation multiverse may have different parameter values, but they have other important things in common. They are all located in one single background spacetime – so, in principle they remain spatiotemporally connected. They also share an underlying production mechanism – bubble nucleation – which is an essentially quantum-mechanical process.

How do the universes in an eternal inflation multiverse fare according to the criteria I have proposed? We need to evaluate whether the existence and features of the other inflationary bubbles ends up making any difference to the values of the chances in this bubble.

The problem of assigning different probabilities to different bubbles of the eternal inflation multiverse is one of the most difficult problems facing eternal inflation theory. While combinatorial reasoning provides us with a route to establishing which kinds of bubbles are possible – i.e. which compactifications of the background dimensions of M-theory are permitted – this kind of reasoning does not by itself constrain what probabilities should attach to one compactification over another, or how these play out into the large-scale distribution of universes with different parameters in the overall inflationary multiverse. (The potential infinity of this multiverse makes the probabilities involved particularly intractable.) This difficulty with assigning probabilities to bubbles is known as the *measure problem*, and it is a major source of uncertainty in current formulations of eternal inflation. For a detailed discussion of the measure problem, see Friederich (2021).

For present purposes, we can observe that while the value of these bubble probabilities are not easily derivable from the background framework, the general nature of these probabilities is well understood. Because inflation is a quantum-mechanical process – the decay of the inflaton field is studied with the tools of quantum field theory, and the indeterminism of bubble formation is understood as quantum-mechanical indeterminism – the probabilities associated with the formation of a particular bubble will be exactly the quantum probabilities associated with the quantum process of formation of that particular bubble. So measure probabilities are just quantum probabilities. What the nature of these measure probabilities is then depends on the interpretation of quantum mechanics that is adopted.

While the exact interpretation of quantum chance is of course disputed, it is not disputed that inflation (in particular eternal inflation) is a quantum-mechanical process which has some varying quantum chance of producing this set of bubbles or that set of bubbles. So, we can use this point of broad consensus to evaluate how our criteria of Chance Aboutness and Chance Dependence apply to the eternal inflation multiverse setting.

The first criterion to check is Chance Aboutness: are quantum chances defined at the level of individual bubbles or at the level of complete sets of bubbles? The answer is that quantum chances, in the eternal inflation setting, attach to complete sets of bubbles – complete eternally inflating multiverse. Any further chances are a matter of self-location within that set of bubbles – within one quantum-mechanical history – and so they are not a matter of quantum chance. Thus the eternal inflationary multiverse fails the first part of the Chance Dependence test for modalizability.

The eternal inflationary multiverse also fails the second part of the Chance Dependence test: the values of probabilities in our bubble do not depend constitutively on goings-on outside the bubble. In some models, in which bubble collisions may leave traces in our bubble (for example in the cosmic microwave background radiation), we have causal relations between events in different bubbles; this already undermines the idea that there is an objective chance distribution which spans across the different bubbles, reinforcing the point made in the previous paragraph. But even if we appeal to a model where inflating bubbles, once formed, are causally isolated from the rest of the universe, we still don't have the right kind of constitutive dependence of chance values in the actual bubble on events going on in other bubbles. The chances of events within a bubble are fixed by the quantum state of the inflating region at the point of bubble nucleation. So again, the other bubbles are irrelevant to the chances of events within our own bubble, and the inflationary multiverse fails to satisfy Chance Dependence condition.

I conclude that the multiverse of eternal inflationary cosmology is not suitable for modalizing: it fails to satisfy both of our criteria.

We have one more kind of multiverse to consider in the next section: the multiverse of the many worlds of Everettian quantum mechanics.

6. Modalizing Everettian Quantum Mechanics

Everettian quantum mechanics is a theory of a quantum multiverse, a multiverse which incorporates a universe (an *Everett world*, or *branch*) for every permissible outcome of a quantum-mechanical chance process. The theory has many features of philosophical interest, including raising intriguing questions about emergent ontology and approximation (Wallace 2012, ch.2). But for our purposes, it is the theory's distinctive account of quantum probabilities which is central.

Everettian quantum mechanics was initially put forward as a non-probabilistic theory – its initial proponent, Hugh Everett III, titled a long version of his PhD thesis ‘Wave Mechanics without Probability’. But the quantities associated with probability in other interpretations of quantum theory – the squared-amplitudes of the wavefunction, as featured in the Born rule – nevertheless play a central role in the Everett interpretation. Contemporary Everettians (Papineau (2010), Saunders (2010), Wallace (2012), Wilson (2013b, 2020)) often argue that these quantities should in fact be interpreted directly as objective physical probabilities.

The Born rule probabilities are uniquely interesting when it comes to our criterion of Chance Aboutness. There are no (non-trivial) probabilities for the entire multiverse – the theory is deterministic at the zoomed-out level, so the only probabilities that could be associated with this multiverse or that multiverse are zero or one. Instead, the quantum probabilities (sometimes called branch weights) attach to individual Everett worlds. If the chance of spin-up is 90% and the chance of spin-down is 10%, then the combined weights of the spin-up worlds add to 90% and the combined weights of the spin-down world add to 10%. This is to say that the probabilities are defined over a space of Everett worlds – they attach to features of individual Everett worlds, rather than of entire Everett multiverses.⁶ For this reason, the Everettian setting satisfies the Chance Aboutness criterion: that objective chances should attach to individual universes in the multiverse.

Our second criterion, Chance Dependence, requires that the values of chances attaching to events in individual universes should be constitutively dependent on other universes within the multiverse. This too is a feature possessed by Everettian quantum theory: the chances of an event in an individual Everett world depend on the whole distribution of branch weights across all the Everett worlds. So chances attach to individual worlds, but they are grounded in features of the entire multiverse.

Satisfying both of our criteria provides a powerful way for Everettians to respond to the modal relevance objection. The other Everett worlds are relevant because they are part of the dependence base for the values of the actual chances, and these actual chances in turn help to account for what explains what in the actual world. So insofar as we are interested in explaining and predicting events in the actual Everett world reliably, we should be interested in mapping out wider facts about the whole space of Everett worlds.

⁶ I have elsewhere called this principle Individualism, and have argued that it is the only way to make coherent sense of objective probability in the Everettian setting. See Wilson (2013b, 2020).

What distinctive features of the Everett multiverse contribute to its modalizability? I think three features are particularly significant:

- i. the universality of the squared-amplitudes (being a new physical quantity, distinctive to quantum theory, which is well-defined for every Everett world),
- ii. the distinctive character of this new quantity as not directly measurable (unlike other physical quantities such as position or momentum), and
- iii. the unitarity of quantum theory, which ensures a coherent probabilistic interpretation of the squared amplitudes of components of the quantum state (via its guaranteeing conservation of objective probability, independently of the details of the dynamics).

For a detailed technical discussion of these features of quantum chance, see Saunders (2010). What they collectively ensure is that there exists a probability distribution with exactly the features needed to satisfy our criteria of Chance Aboutness and Chance Dependence. There is a probability distribution, which comprises a measure over Everett worlds and hence is partially constituted by the other Everett worlds, but which plays the rational role of chance at the actual Everett world.

We can usefully compare Everettian quantum theory with the probabilistic variant of Lewisian modal realism offered by Pargetter (1984). There are significant commonalities: both theories posit a space of possible worlds with a single objective probability distribution defined over them all. They accordingly both satisfy Chance Dependence and Chance Aboutness, which I have argued are minimal sufficient criteria for multiverses to be given a modalized interpretation. However, the overall account of objective probability offered by Everettian quantum theory is significantly richer and deeper than that of Pargetter's probabilistic modal realism.

In Pargetter's theory, the probabilistic interpretation of the objective probability measure is imposed by philosophical fiat and is not integrated with any detailed physical theory. There is nothing in probabilistic modal realism itself which accounts for the rational role of its probabilities in terms of their connection with rational prediction and explanation. By contrast, in the Everettian setting there are detailed bodies of work connecting the quantum squared amplitudes with rational cognitive states of agents in Everett worlds: for a sample of this work, see Saunders (2010), Wallace (2012), Sebens and Carroll (2018), and Wilhelm (2022).

Accordingly, while there is a legitimate case for modalizing Pargetter's probabilistic modal realism, the resulting combined account of modality and probability remains significantly less compelling than Everettian quantum theory.

7. Conclusion

Most multiverses have the wrong features to support a modalized interpretation. I have diagnosed this failure of modalizability in terms of violations of Chance Aboutness and/or Chance Dependence: these multiverses do not render features of the other universes constitutively relevant to any of the chances attaching to individual features of our own universe.

The Lewisian multiverse satisfies Chance Aboutness but violates Chance Dependence, because chances are determined in the Lewisian framework as a wholly in-world matter. There is no sense in which the existence or the features other Lewisian worlds constitutively explain the values of chances in the actual world. There is a variant on Lewisian modal realism – Pargetter’s probabilistic modal realism – which satisfies both Chance Aboutness and Chance Dependence; however, this theory has been almost entirely neglected in the literature on the metaphysics of modality.

Eternal recurrence multiverses violate either Chance Aboutness or Chance Dependence. Either they violate Chance Aboutness because – in a theory where traces can be left by previous eras – events in different eras are causally relevant to one another, so that chances are defined over whole sequences of eras, or they violate Chance Dependence because – in a theory where eras are suitably isolated – the chances in an era are wholly determined by features intrinsic to that era. In either case, there is no constitutive explanation of the values of chances attaching to events within an era in terms of features of any other eras.

Eternal inflation multiverses violate both Chance Aboutness and Chance Dependence. Bubble nucleation is naturally viewed as a causal process, so that quantum chances are defined over whole systems of nucleating bubbles, violating Chance Aboutness. And, the (quantum) chances for (quantum) processes within a bubble are wholly determined by the (quantum) state of that bubble, violating Chance Dependence. So again, there is no constitutive explanation of the values of chances within a bubble on features of any other bubble.

The Everettian multiverse, solely amongst the physically-motivated options considered here, has features which support modalizability. The branching process is not suitable to be viewed as a causal process: causation is best thought of by Everettians as a wholly in-world phenomenon. Chances are then attached to individual Everett worlds, satisfying Chance Aboutness. And quantum chances in an Everett world are constitutively dependent on the other worlds in the Everettian multiverse, since they derive from a probability distribution – the Born rule branch weights – which is defined over the whole space of Everett worlds. This satisfies Chance Dependence.

The main upshot of this discussion is that multiverses should be modalized if and only if they support a suitable probability interpretation, such that the distribution of facts across the whole multiverse helps to metaphysically explain the facts about individual chances which attach to features of a single universe. From this point of view, we can see the applicability of objective modality as just a shadow cast by the applicability of objective probability. A universe inherits its status as an alternative possibility from its status as a bearer of chances where the chance distribution in question spans the whole multiverse. In this sense, objective probability precedes objective possibility.

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Biography

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