Evil and the Quantum Multiverse

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Abstract

Problems in moral philosophy and philosophy of religion can take on new forms in light of contemporary physical theories. Here we discuss how the problem of evil is transformed by the Everettian "Many-Worlds" theory of quantum mechanics. We first present an Everettian version of the problem and contrast it to the problem in single-universe physical theories such as Newtonian mechanics and Bohmian mechanics. We argue that, pace Turner (2016) and Zimmerman (2017), the Everettian problem of evil is no more extreme than the Bohmian one. The existence and multiplicity of (morally) terrible branches in the Everettian multiverse in contrast to the mere possibility of them in the Bohmian universe does not entail there is "more evil" in the former than in the latter. Low probability in the Bohmian case and low branch weight in the Everettian case should modulate how we respond to them in exactly the same way. We suggest that the same applies to the divine decision of creating an Everettian multiverse. For an empirically adequate Everettian quantum mechanics that justifies the Born rule, there is no special problem of evil. In order for there to be a special Everettian problem of evil, the Everettian interpretation must already have been exposed to decisive refutation. In the process, we hope to show how attention to the details of physical and metaphysical theories can and should impact the way we think about problems in moral philosophy and philosophy of religion.

Keywords: problem of evil, quantum mechanics, many-worlds interpretation, Bohmian mechanics, spontaneous collapse theories, decision theory, absolute prohibitions

Dedicated to the memory of Marilyn McCord Adams and Robert Merrihew Adams

1 Introduction

Physics aims to describe the world. Fundamental physics aims to describe the world at the fundamental physical level. It is rare for controversies in those fields to directly impact our theories of value. An interesting exception is found in quantum mechanics.[1]

[1]Another exception is the issue of determinism and its relevance to free will.

The many-worlds interpretation suggests that the world we live in is just one of many parallel worlds that emerge from the fundamental quantum state. Those parallel worlds are not spatiotemporally disconnected from us. In fact, they are in the same space-time as our world. Even though we share spatial-temporal locations, we (more or less) do not interact with the creatures in those branches.[2]

In this paper, we focus on the following question: how should we think of value aggregation in such a multiverse? This question is important in itself, but also relevant to a new version of the problem of evil against the existence of a loving God. The argument, which we shall call *the Everettian problem of evil*, adds a new twist to the old argument (see discussions in Dean Zimmerman (*Nautilus*, 2017) and Jason Turner (manuscript, 2016)).[3] Roughly speaking, according to the Everettian interpretation of quantum mechanics, physical reality consists in an ever-branching multiverse consisting of many distinct histories that are largely parallel to each other; if Everettian quantum mechanics is the true theory of the world, then there exist many worlds in which terrible and horrendous sufferings occur without end and without meeting any apparent purposes. These evil worlds are not merely possible but in fact as real as the branch we are in. The total amount of horrendous evil in the multiverse is just too much for traditional responses.

But that is not right. We argue that the inference from multiplicity of worlds to greater amount of evil fails. It is possible that the problem of evil in the Everettian multiverse is no harder than in single-world versions of quantum mechanics. To recover the empirical predictions of quantum mechanics, the Everettian interpretation requires some strategy to make sense of the probabilities of measurement outcomes assigned by quantum mechanics (in accord with the Born rule, which we explain in §2 and §4). For concreteness, we focus on the decision-theoretic strategy proposed by Deutsch (1999) and Wallace (2012). The strategy postulates certain "Savage-style (1954)" structural requirements on the agent's preferences over branches and recovers quantum probabilities together with utility assignments of those branches (via representation theorems). Since the probability and the utility come in one package in the Savage framework, the assignment of evil (disutility) to worlds is associated with certain probabilities. Hence, the empirical adequacy of Everettian interpretation requires us to consider other branches in proportion to their probabilities. Therefore, for rational deliberation, the total amount of evil that matters in the multiverse is greatly diminished: it is not the sum of evil in all branches, but a sum of evil weighted by the quantum probabilities. This is exactly the same as the probability-weighted (expected) utility in single-world versions of quantum mechanics. (We will explain these technical terms soon.) We call it the *parity thesis*.

Alternatively, if we compare the *expected* amount of evil in the Everettian multiverse with the *actual* amount of evil in a single-world version of quantum mechanics, the comparison is far less trivial and will depend sensitively on certain physical and moral considerations. For all we know, the comparison can go either way; it is possible that the former is less than the latter. Even in this case, the inference from multiplicity of

[2]This should follow from the appropriate dynamics and decoherence, which predicts that the interaction between different branches is negligible. We discuss this more in §2.

[3]For a review of the classical argument(s) of evil, see Tooley (2019) and the reference therein.

worlds to a greater amount of evil fails.

The case study is relevant not just for theists who take modern physics seriously. It is also relevant for agnostics who neither believe nor disbelieve the existence of a loving God and atheists who deny such an existence. Whether and how much the Everettian problem of evil differs from traditional problem of evil is relevant to the total epistemic case for and against the existence of God. Besides philosophy of religion, this case study also provides lessons that can be generalized to other issues about action and value in the quantum multiverse. We have tried to write the first few sections in an accessible way so that non-specialists can understand the background and the arguments.

2 The Everettian Problem of Evil

The Everettian or Many-Worlds interpretation of quantum mechanics was proposed by Everett (1957) in response to the quantum measurement problem.[4] The root of the problem lies in the wave function, which describes a multiplicity of outcomes and does not by itself select a definite one. The traditional textbook version of quantum mechanics says that the wave function obeys two different equations: one deterministic and smooth, called the Schrödinger equation that produces and keeps the multiplicity; the other probabilistic and non-smooth, called the collapse postulate, that reduces the multiplicity to one. But there is a conflict: if the wave function obeys the Schrödinger equation, how can it also obey the collapse postulate that contradicts the linearity of the Schrödinger equation? But if the wave function does not collapse, how can we obtain unique experimental outcomes? In short, we have the *quantum measurement problem*:

(P1) The wave function is the complete description of the physical system.

(P2) The wave function always obeys the Schrödinger equation.

(P3) Every experiment has a unique outcome.

Each of these three propositions is, on its own, plausible. However, together they lead to a contradiction. To see the contradiction, let us apply them to Schrödinger (1935)'s famous thought experiment (see Figure 1):

> One can even set up quite ridiculous cases. A cat is penned up in a steel chamber, along with the following device (which must be secured against direct interference by the cat): in a Geiger counter, there is a tiny bit of radioactive substance, so small, that perhaps in the course of the hour one of the atoms decays, but also, with equal probability, perhaps none; if it happens, the counter tube discharges and through a relay releases a hammer that shatters a small flask of hydrocyanic acid. If one has left this entire system to itself for an hour, one would say that the cat still lives if meanwhile no atom has decayed. The first atomic decay would have poisoned it. The

[4] It is a family of interpretations with some variations. See Vaidman (2018) and references therein. Wallace (2012) presents one of the most comprehensive and updated discussion of the many-worlds approach. We mostly follow Wallace in this article.

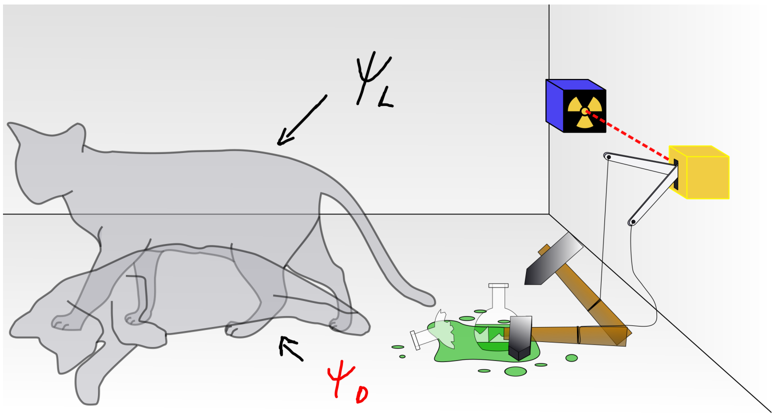

Figure 1: Schrödinger's cat thought experiment depicted in physical space. Picture adapted from Dhatfield, CC BY-SA 3.0 <https://creativecommons.org/licenses/by-sa/3.0>, via Wikimedia Commons.

> ψ-function of the entire system would express this by having in it the living and dead cat (pardon the expression) mixed or smeared out in equal parts. (Translated in Trimmer (1980))

At the end of the experiment, what do we find? First, we introduce some formalism. Let ψ_{cat} denote the quantum state of the entire system containing the cat, let ψ_L denote the quantum state of the system containing a living cat, and let ψ_D denote the quantum state of the system containing a dead cat. These quantum states are represented by *wave functions*.[5] They are mathematical gadgets that describe the physical states of the system. If it is the case that $\psi_{cat} = \psi_L$, then the cat is alive. If $\psi_{cat} = \psi_D$, then the cat is dead. The problem is that at the end of the experiment, if the Schrödinger equation is strictly obeyed, then ψ_{cat} is neither ψ_L nor ψ_D. If P1 is true, the cat-in-the-box system is completely described by the Schrödinger equation. After one hour, the wave function of the entire system deterministically evolve into a *superposition* of ψ_L and ψ_D with equal weights:

$$\psi_{cat} = \frac{1}{\sqrt{2}}\psi_L + \frac{1}{\sqrt{2}}\psi_D \tag{1}$$

Both ψ_L and ψ_D have weight $(\frac{1}{\sqrt{2}})^2 = 1/2$. This number, 1/2, is also called the branch weight of ψ_L and of ψ_D, for this setup. If P2 is true, the wave function never collapses into one of the definite states (ψ_L or ψ_D). It always remains in a superposition. If P3 is true, the cat is nonetheless in one of the definite states—either alive as described by ψ_L or dead as described by ψ_D.[6]

Since P1—P3 are inconsistent, at least one of them is false. Rejecting P1 or P2 requires developing alternative theories of quantum mechanics, since we would need to find additional objects not completely described by the wave function, or we would need to modify the Schrödinger equation. Rejecting P3 requires major revisions in

[5] For a brief introduction to the wave function and some related philosophical issues, see Chen (2019).

[6] For more thorough discussions about the quantum measurement problem, see Myrvold (2017), Albert (1992), and Bell (1990).

our assumptions about the world. There are three main "interpretations" of quantum mechanics that carry out such strategies.

The de Broglie-Bohm theory, or Bohmian mechanics (BM), rejects P1. According to BM, the wave function is not the *complete* description of the physical system. There are actual particles with precise positions in physical space. The cat, made out of such particles, is always in a definite state. The wave function still obeys the Schrödinger equation. But the wave function also determines the velocity of the particles via the *guidance equation*.

The Ghirardi-Rimini-Weber theories of spontaneous collapse (GRW) reject P2. According to GRW theories, the wave function does not *always* obey the Schrödinger equation. It undergoes spontaneous collapses into one of the definite states with a fixed rate per particle per unit time. In the cat experiment, given the vast number of particles in the system, it will quickly collapse into a definite state in which the cat is either alive or dead.

The many-worlds or Everettian quantum mechanics (EQM) reject P3.[7] According to EQM, there is no need to ensure that there is a *unique* outcome in the cat experiment. There are (at least) two branches of the wave function, one in which the cat is alive and the other in which the cat is dead. Both branches co-exist. Because of a property called *decoherence*, the branches do not interfere much with each other so that objects from different branches do not interact with each other. Because of decoherence, the branches are (almost) parallel to each other. The branches of the wave function are emergent worlds, the wave function is the complete and fundamental description of the "multiverse," and it always obeys the Schrödinger equation.

What is this notion of decoherence? And why is it important to EQM? These are important questions both to EQM and to our answer to the Everettian problem of evil. Interested readers are welcome to consult Wallace (2003, 2012) for more details. Here we present an informal discussion for non-specialists. As Schrödinger suggests in his thought experiment, the system's wave function contains "in it the living and dead cat (pardon the expression) mixed or smeared out in equal parts" as shown in Equation 1. On EQM, when the observer opens the box, the observer will also "split" into two, one observing a dead cat and the other a living cat.

But what makes it the case that the two "successors" of the observer never interact with each other and why don't they see a smeared-out cat that is half dead and half alive? We can see this in Figure 2. The total quantum state of the system is given by a superposition (of equal weights) of ψ_L and ψ_D, as represented by equation (1), corresponding to a weighted sum of the two wave functions. Even though ψ_L and ψ_D describe two states that overlap significantly in physical space, they do not have much overlap in *configuration space*, where each point represents the complete list of positions of all particles in the system. ψ_L is a function concentrated on the region L of the configuration space, where L is a macrostate corresponding to a set of microscopic configurations of "particles" that share a similar macroscopic profile—the cat is still alive. Similarly, ψ_D is a function concentrated on region D of the configuration space, where D is a macrostate corresponding to a set of microscopic configurations of "particles" that

[7] For arguments that Everett himself might endorse a single-world interpretation of quantum mechanics, see Conroy (2012).

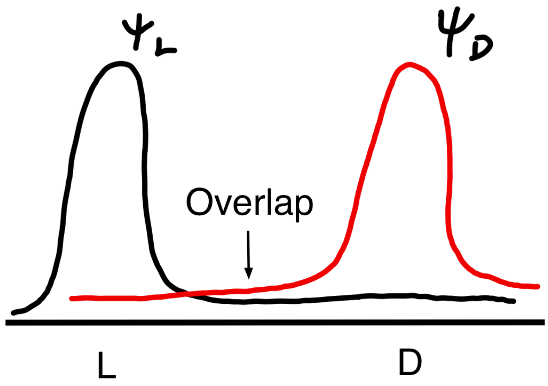

Figure 2: A schematic illustration of decoherence (in configuration space) that produces small overlap between the two wave functions. L and D correspond to the macrostates in which the cat is alive and the cat is dead, respectively.

share a similar macroscopic profile—the cat is dead. Decoherence is the phenomenon that wave functions such as ψ_L and ψ_D will quickly evolve to have very small (but non-zero) overlap in configuration space. The decohered wave functions will have little interaction with each other, and the interaction is so small that we do not notice them at all. Hence, the total wave function of the system ψ_{cat} will have two parts that (more or less) do not interact with each other. However, the usual justification to ignore the overlap between ψ_L and ψ_D is to invoke the idea that small weight (measured by $|\psi|^2$) corresponds to small probability, which is ultimately an appeal to the Born rule. We will return to this point.

It has been argued that the postulate of the multiverse leads to significant theological difficulties. On EQM, all branches of the wave function are equally real. Our branch is just one out of an infinity of real ones, many of them are good, but many others are terrible. As Zimmerman (2017) suggests, "The many-worlds interpretation of quantum physicist Hugh Everett III and the modal realism of cosmologist Max Tegmark include worlds that no sane, good God would ever tolerate. The theories are very different, but each predicts the existence of worlds filled with horror and misery. Still, many horrifying things happen with nothing seemingly gained from them. And, Everett's many-worlds and Tegmark's modal realism both seem to imply that there are huge numbers of horrific universes inhabited solely by such unfortunates. Someone like myself, who remains attracted to the traditional picture of God as loving creator, is bound to find such consequences shocking..."

In Zimmerman's view, the situation of the problem of evil is different in EQM compared to other quantum theories with a single universe, such as BM and GRW:

> "Old-fashioned quantum theory assigns a tiny likelihood to things going really badly in the future. It also implies that, from any point in our actual past, things could have gone much worse than they actually did. Since the many worlds interpretation takes these possibilities as actual occurrences, it predicts that there are branching universes in which things do go as awfully as possible."

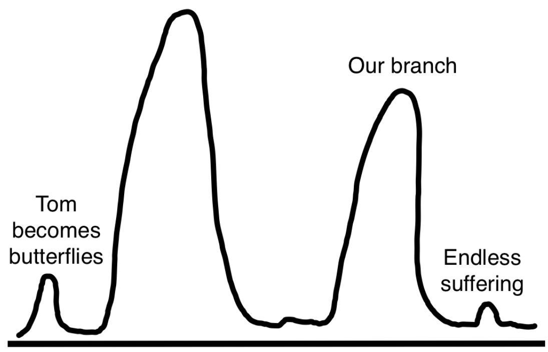

Figure 3: Branches of the universal wave function.

> "For example, whenever there is a minute chance of a catastrophe that leaves all human beings utterly miserable but just barely healthy enough to reproduce, there is a branch in the world-tree in which this sorry state of affairs actually happens, generation after generation. So there are worlds in which the emergence of the human race proves to be an unmitigated tragedy—or so it seems."

In other words, EQM reifies the merely possible histories (of single-world interpretations of quantum theory) into real histories that are in parallel developments.[8] Where BM and GRW assigns a non-zero chance, EQM admits it as a real event that happens in the actual history of the multiverse.

Why is that a more difficult problem than the traditional problem of evil? We can complete the arguments as follows. Compare, for example, the Bohmian problem of evil and the Everettian problem of evil. Suppose, for the sake of simplicity, the wave function contains only two branches: branch H_a that corresponds to the actual history in the Bohmian theory, and a branch that is filled with endless suffering and evil H_b. On the Bohmian theory, the problem of evil is just:

(A) How can an all-loving, all-knowing, and all-powerful God allow H_a, which is the actual history?

On the Everettian theory, the problem of evil becomes:

(B) How can an all-loving, all-knowing, and all-powerful God allow H_a and H_b, which are both real branches in the Everettian multiverse?

We can make it more realistic by adding more branches. (See Figure 3.) Typically, a wave function has an infinite number of branches. In general they have different branch weights. If Equation 1 describes the system of the cat in the box, then the branch that the cat is alive has the same branch weight as the branch that the cat is dead, and the

[8] There is a further interpretive question whether all the real histories should be called "actual." We return to this point in §4.3.

branch weight is $(1/\sqrt{2})^2 = 1/2$. However, if we set up the experiment differently, a different wave function may result:

$$\psi'_{cat} = \sqrt{\frac{1}{3}}\psi_L + \sqrt{\frac{2}{3}}\psi_D \qquad (2)$$

In this case, the branch that the cat is alive has lower weight (1/3) than the branch that the cat is dead (2/3). The Born rule, which we discuss in §4, stipulates that the probability that a branch is observed equals its branch weight.

It is *possible* that on balance, the amount of good is roughly on par with the amount of evil in the multiverse. However, it is also possible that some branches are just so awful that no amount of goodness will make the multiverse worth creating.[9] The problem of evil in the Everettian interpretation appears much more difficult because of the existence of many awful universes all of which are in reality.[10]

Before we proceed to our main argument, we will raise and answer a concern about the motivations of our project. Perhaps the problem can be dissolved by giving a principled theistic rejection of EQM. Taking the wave function as the complete description of the multiverse sits most comfortably with a materialist or physicalist metaphysics that is a distinctly minority view within theism. Is this sufficient to render the Everettian Problem of Evil uninteresting? We think not. First: the tradition of materialist metaphysics within theism can claim several prominent adherents, including Peter van Inwagen (1990) and Trenton Merricks (2001b). In fact, recent work has suggested that materialism sits comfortably within Abrahamic theism (Bailey 2021). Second: the project of reconciling theistic and more broadly religious views with materialism has intrinsic interest, as the growing literature on materialist theories of bodily resurrection shows.[11] And as we shall say again, those who already take themselves to possess good reasons to reject EQM may still find our parity thesis interesting. If we are right, then theists *need* not reject EQM in order to respond to the Everettian Problem of Evil.

3 The Metaphysics of Diminishing Value

Our dissolution of the Everettian problem of evil *begins* with a very general phenomenon: certain operators modulate the way we should respond to the sentences under their scope. The type of modulation varies widely by operator. Sometimes, our ontological commitments are changed. Sometimes, our appropriate normative stance is changed. Sometimes both are. This provides the key to our approach. In the next section, we will

[9] Here we assume some additive principle of value aggregation. But it is not strictly necessary. We can allow non-additive value aggregation and the following arguments can be adapted. See footnote #16.

[10] Another way to develop Zimmerman's argument is that the mere existence of H_b makes it more difficult to believe in the existence of a loving creator. That is how Turner develops the argument. Understood this way, the problem is not about value aggregation but the mere existence of some horrible history in EQM. However, what we say below also provides a response to this line of argument. For a related argument, see Qureshi-Hurst (2022).

[11] See, for example, Van Inwagen (1978), Zimmerman (1999), Merricks (2001a), Baker (2007b) and Mooney (2018).

contend that branch-weights in EQM inherit the normative-stance-modulating role of probability operators, so that the correct assessment of the evil in a Everett's quantum multiverses is a sum of the existing evils weighted by their branch weights. We will begin our discussion of how these operators work with the following sentence:

MASSACRE: There is a massacre where 100 people die

Upon learning MASSACRE, the proper response is some combination of sorrow, indignation, anger, and a need to do something to stop the massacre. We now know that a terrible thing exists, the massacre, and there is a morally mandated response we should have. Morally functioning agents do not like massacres and try to stop them when able. However, if we place MASSACRE under the scope of some kind of operator, this proper response can be modulated. For example, a tense operator:

P-MASSACRE: In the past, there is a massacre in which 100 people die.

Upon learning *P*-MASSACRE, our proper response is different. Some combination of sorrow, indignation, and anger is still appropriate, though perhaps the proportions should be different. However, given the temporal asymmetries in our world, it would be quixotic to try and prevent the massacre. From a presentist perspective, what we have learned is not that a terrible thing exists, which warrants action if we are able. We have learned that a terrible thing did exist. Because of the tense operator, we are not committed to the existence of the massacre, and this has an effect on the proper response to what we have learned.

Consider now another example, this time involving a modal operator:

$\diamond$-MASSACRE: Possibly, there is a massacre where 100 people die.

The proper response to learning $\diamond$-MASSACRE is very different from that of learning MASSACRE. A merely possible massacre is not nearly the occasion of sorrow and anger as the genuine artifact, and is not an occasion of urgent intervention. A morally functioning agent may be somewhat disappointed in logical space for containing merely possible massacres, but there is no call for a serious emotional response while the massacre remains a mere possibility.

These judgments seem intuitive from the perspectives of presentism and actualism. It is part of the role of past tense and possibility operators that they eliminate ontological commitment, and this elimination modulates the proper moral response to the sentences under their scope. An occasion for action becomes an occasion for remembrance under the scope of a past operator, and something perhaps to fear or avoid under the scope of a possibility operator. An operator would not be a past tense or possibility operator if it did not block ontological commitment and modulate moral response in the right way. This establishes the basic point: prefixing a sentence with the right operator can have a major effect on the proper response to learning it.[12]

[12]We should clarify that views about God's relationship to time will make a difference to which true sentences can be formed by attaching an operator to a sentence. For example, if God is timeless, perhaps

When we are weighing how its consequences contribute to the moral status of an action, the standard rule is to use its expected utility. The expected utility of an action is an average of the value of its possible consequences weighted by their probability of occurring if the action is taken. This reveals another family of operators that modulate the proper moral response to a sentence: probability operators. For example, compare two different probability operators:

PR-0.5-MASSACRE: the probability of a massacre in which 100 people die is 0.5.

PR-0.1-MASSACRE: the probability of a massacre in which 100 people die is 0.1.

Upon learning that two acts we are considering could result in a massacre, but one of them gives a 50% chance of it happening while the other has only a 10% chance, the badness of the massacre weighs differently in the correct evaluation of the value or disvalue of these courses of action. In neither case do we regard the act as leading to a massacre. The fact that the massacre comes with a probability diminishes how it impacts our deliberation. And different probabilities modulate the impact differently. The massacre contributes less of its disvalue to the expected utility of the act where it is modulated by the probability-0.1 operator. Just like the past tense and possibility operators, the probability operator has as part of its functional role that it diminishes the badness of learning sentences under its scope, and of how that badness is reckoned in accounting for the consequences of an act. An operator would not be a probability operator if it did not diminish the axiological valence of learning the sentence under its scope, and the contribution it makes to reckoning the (dis)value of an act's potential consequences.

This brings us back around to our response to the Everettian problem of evil. As we explain in the next section, the branch-weight-n operators must have the same functional role as the probability-n operators, on pain of the entire empirical case for Everrett collapsing. One of the characteristic functions of a probability operator is to modulate the proper moral response to learning the sentence under its scope, and to change how it contributes (dis)value to the consequences of an act that may make it true. Any operator that does not fulfill these functions is not a probability operator.

4 Probabilities and Diminishing Expected Value

In this section, we provide a concrete response to the Everettian problem of evil as an instance of the general strategy outlined in §3. We argue that the argument from Everettian problem of evil fails to present additional challenge to traditional theism beyond the standard problem of evil. EQM, on pain of being empirically inadequate, must recognize that the "evil branches" outside the branch we find ourselves in are no more horrible than the probability-weighted merely possible branches on BM or GRW.

no sentences prefaced with a tense operator (such as "in the past") are true of God. However, for examples like MASSACRE and its variants, we do not mean for them to apply specifically to God. At this point, we are instead using them to illustrate the *general* point about how different operators modulate the appropriate response.

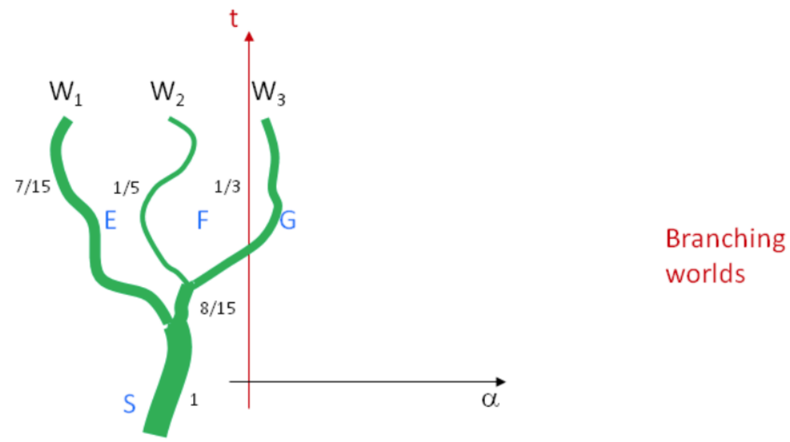

Figure 4: Branches of the wave function with unequal weights. All the branches are in reality. What does it mean to say that branch W1 has a 7/15 probability of happening when W2 and W3 are also real? The picture is from Saunders (2010).

This is because their valuation will be diminished by branch weights–probabilities in the Everettian universe.

A major conceptual problem for the Everettian interpretation is the problem of probabilities. In textbook quantum mechanics and in single-universe quantum theories, out of many possible events only one happens, and it happens according to a precise probability. The probability is assigned by the Born rule. The wave function provides a branch weight (modulus square of the wave function) to each branch. The Born rule says that the probability that any branch is observed is given by its branch weight. Let us illustrate with some examples. If Equation (1) describes the system of the cat in the box, then the probability that the cat is alive is the same as the probability that the cat is dead, and it equals $(1/\sqrt{2})^2 = 1/2$. However, if Equation (2) describes the system of the cat in the box, then on single-universe quantum theories, the cat will have a higher probability of being dead (2/3) than being alive (1/3). Now, since in the Everettian interpretation all the branches are real, what do the probabilities such as 1/3 and 2/3 mean? It is not to be identified with mere frequencies, as that would give us 1/2 and 1/2 on the naive counting: out of the two cats in the two branches, exactly one is alive and exactly one is dead. (See Figure 4 for a schematic illustration of a branching wave function with unequal weights on different branches.)

4.1 The Dual Emergence of Probability and Value

To solve this problem, Everettians have suggested that we understand branch weights as the kind of things agents should adopt as their credences . There have been several proposals. One of the most influential ones is the decision-theoretic approach suggested by David Deutsch (1999) and developed by David Wallace (2012). Key to their approach is the Savage-style representation theorem framework, in which we extract probabilities and utilities from preferences. In order for the probabilities and utilities to be somewhat objective, the assumptions or the axioms for the preferences are treated as rational requirements. Wallace (2012) explains the technical details. Structurally, the agents have preferences over acts, which are definable features of the state space.[13] If their preferences obey certain richness and rationality axioms, we can prove that there exists a probability function (P) and utility function (U) pair such that the expected utility of multiplying the probability and utility is a faithful representation of the agents' preferences.

In Savage's framework, there are neither probabilities nor utilities to start out with. We begin with preferences. A representation theorem is then a bit of mathematics that says, "if preferences witness the following axioms, then there exists a probability function P and a utility function U such that that if X is preferred to Y, then P(X) multiplied by U(X) is greater than P(Y) multiplied by U(Y)." The axioms include structural requirements such as that the preference has to be a total ordering (transitive, asymmetric, and naturally inducing an equivalence relation). If the preferences satisfy the axioms then there is a way to represent them as belonging to an expected-utility maximizer. Importantly, however, this representation is only unique up to a point. The utility function is unique up to a linear transformation.[14]

There are some important things to note here. First, while the usual Savage representation theorem shows that the agent's preferences are represented by some probability function, the quantum representation theorem proved by Wallace tells us exactly what the probability function has to be—the one assigning probability in accordance to the branch weight (in agreement with the Born rule). Second, what we get out of the decision-theoretic strategy is not simply a unique probability function, but a probability-utility pair. They emerge together from the structure of rational preferences agents have over branches. Hence, this interpretation of probability in Everett makes probability inseparable from value, and makes value an emergent property just like probability.

Let us now think about the relation between value and branches. The preference ordering presupposes the existence of branches. Mathematically, from the preference ordering we recover probability, and with probability we can recover utility by treating agents as expected utility maximizers.

There is a deeper sense in which the emergence of value depends on probability, and this is related to the emergence of the branching structure. At the fundamental level of reality, there is just the quantum state described by a wave function in superposition. It is not clear if there are any definite outcomes of experiments or even any observers with definite experiences. After all, even observers and measurement instruments are in superpositions! However, due to decoherence (§2), the wave function gives rise to branches that are stable and do not interact much with each other. The branches help us make sense of the existence of definite records and people with definite experiences. However, decoherence is justified by an appeal to probability. In single-worlds theories of quantum mechanics, decoherence works because under the normal dynamics of the wave function and the force laws of this world (and a low-entropy initial condition

[13]In the context of EQM, the state space is the Hilbert space used in quantum mechanics. Following Wallace (201), the acts are defined to be certain unitary transformations on the Hilbert space.

[14]That is, U and $aU + b$, where $a > 0$, represent the same utility preferences. For example, if a utility function is the constant function $U(x) = x$ that maps dollars to the dollar amount in utils (in some unit), then $U'(x) = 2x + 3$ is a linear transformation of $U(x)$. And they represent the same utility preferences.

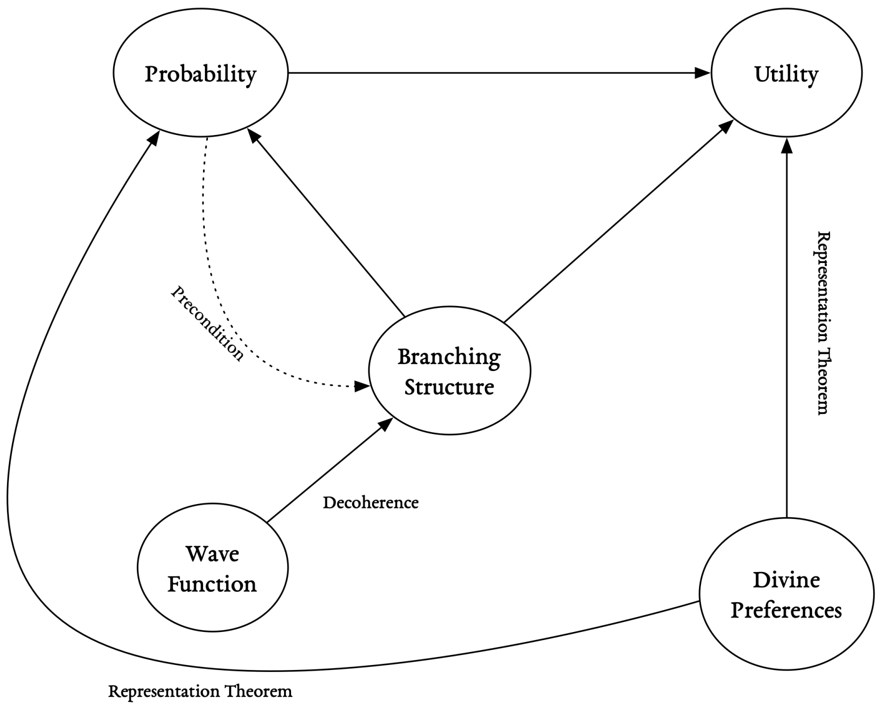

Figure 5: A directed diagram of the dependence relations. Note that it is in the branching structure that one finds the image of ordinary objects and their features.

that Albert (2000) calls the *Past Hypothesis*) the overlap between the relevant wave functions tend to become very small very quickly. (See Figure 2.) And the smallness of the overlap indicates that the overlap (or interference) has small weight (measured by the modulus square of the wave function). By the Born rule, the small weight indicates that there is a low probability of interference between the relevant parts of the wave function. This means that the branches are emergent only when we understand the modulus square of the wave function probabilistically in accordance with the Born rule. Hence, if the emergence of values in the multiverse depends on the emergence of definite experiences, and if the latter depends on the emergence of branches, which ultimately depends on notions of probability, then the emergence of value depends on probability.

But if that is right, we have a circularity in the Everettian justification of Born-rule probability (see Figure 5). The quantum representation theorem starts with certain assumptions about preferences. The preferences presuppose a branching structure, and from those preferences we recover Born-rule probabilities.[15] The conclusion is

[15] In the literature, those preferences are taken to be *human* preferences. Such preferences are dispositional, and not just preferences over what actually happens (Wallace 2012: 164). In our dialectical context they can be taken as preferences in the mind of *God*. For the purpose of our argument, we take God's preferences to be also dispositional preferences: if God were in such and such situations in an Everettian multiverse, what God would have preferred to do. For God to have such preferences, God need not be actually doing such things in the multiverse (accepting bets and trying to make money), and God need not be presented with such decisions. God simply needs to be aware of God's dispositional preferences in order to assign values and probabilities to the emergent branches.In fact, according to the axioms of Savage-style representation theorems, God/a rational agent is required to have preferences over situations that could not possibly be an option in a decision problem they face (e.g. the so-called constant acts that take every state of the world to the same outcome). Buchak (2013: 91-92) offers a discussion

the Born rule, but it is also assumed in the premises. In order to make sense of the preferences over branches, we need a branching structure. To justify the emergence of a branching structure, we need to treat the small-weight interference terms as negligible for rational decision. And for that, we need the Born rule according to which small weights correspond to small probabilities. Hence, the Deutsch-Wallace strategy (and similarly the strategy using self-locating probabilities discussed in Sebens and Carroll (2016)) involves a circle. Its explanation for the emergence of probability or chance in the Everettian multiverse already presupposes the Born rule from the start. This point has been emphasized in the literature by Baker (2007a) and Kent (2010). At best, those formal mathematical proofs are just a self-consistency check; Kent writes (p.338), "Wallace's argument should rather be understood as attempting to show something weaker: that the Born rule [probability] re-emerges as output (albeit, to be fair, in an interesting and non-obvious way) if assumed as input."

We accept the Baker-Kent argument. However, it is not our goal to criticize EQM here. After all, there is no special problem of evil if EQM fails to be empirically adequate (that is, if the Born rule is unjustifiable in EQM). To take the Everettian problem of evil seriously, we assume that EQM can be made to work, and the most promising strategy is that of Deutsch-Wallace. So it is a precondition to appreciate the Everettian problem of evil that we grant the justification of probability in this framework. At this stage of the dialectic, we should say that the it is not a vicious circle but a virtuous one.

Hence, we suggest that it is a precondition for the existence of the branching structure and the empirical adequacy of Everettian interpretation that the branch weights are treated probabilistically. This is the deeper sense for which the emergence of value depends on probability. If that is the correct way to think about the emergence of probability and value, then the precondition seems to also apply to God's reasoning at creation. God cannot bypass the decision-theoretic strategy and cannot set aside probabilities to assign values to different branches of the quantum multiverse. Let us emphasize this:

Precondition For God to assign values to different branches in the quantum multiverse, God has to recognize that there are branches emerging from the quantum state, and in order to do that God has to regard branch weights *probabilistically*.

We pause and clarify the importance of this principle in the dialectical context. The empirical confirmation of quantum theory consists in observing that the empirical statistics during experiments conform to the Born rule statistics. Hence, a theory that cannot recover Born-rule probability cannot explain the empirical observations. If some people think that the above-mentioned circle is a vicious one, then they do not think there is justification for Born-rule probability in EQM and they do not think that EQM has been empirically confirmed. They may even think that it's empirically disconfirmed. Hence, they should not be troubled to learn about any problem of evil that depends on EQM. That is, if our argument below is right, then either there is no Everettian problem

and defense of the intelligibility of this feature of Savage's theorem. So assigning these dispositional preferences to God is not asking for something different in kind from what Savage asks of every rational agent.

of evil because the physical theory is not even empirically adequate or the Everettian problem of evil is not as extreme as suggested.

4.2 The Problem Revisited

Because probability and value emerge in EQM together and only in the effort to impose the rational requirement of expected-utility maximization, the relationship between expected utility and actual utility in EQM is different than it is in a single-world quantum theory. Normally, we think of expected utility as a stand-in for actual utility. What's out there in the world are actual values. But we don't know those, so we accommodate our ignorance by reckoning value by expected utility. In fact, one of the more common justifications of the expected utility rule just is that it best approximates actual utility in the long run (Feller 1968).

Matters are different in EQM. Wallace's axioms require agents, on pain of irrationality, to be expected utility maximizers whose credences match the Born rule. This is what grounds the status of the branch weights as probabilities, and allows decoherence to clear the way for the emergence of branches. Since actual utilities will, in general, attach to the denizens of branches (people, experiences, apples, etc), the facts about actual utilities will be metaphysically downstream from the facts about expected utilities. This inverts the order we find in single universe theories. Thus, the most basic value facts in EQM are facts about expected utility. We cannot, as in single universe theories, bypass expected utility considerations as products of ignorance and count only the actual utility in the multiverse. Since the most basic value facts are facts about expected utility, our most fundamental normative attitudes toward the happenings in Everett's multiverse must be modulated by the branch weights.

Before the beginning of the universe, God faces a decision problem. What would be a good world to create? If God creates a Bohmian universe, there is only one history, but many possible ones weighted by probabilities. If God creates an Everettian multiverse, there are many parallel histories coexisting, but they are also weighted by the same probabilities as those in BM. The expected values of the two worlds given the same wave function are exactly the same, supporting the parity thesis. If God draws on the expected value considerations, then the existence of multiple branches in an Everettian universe should not make a difference to God's decision. That is, whether or not the other branches of the wave function exist in reality or in mere possibility should not make a difference to their probabilities or their expected values.

This is because God must reckon value and expected value differently in EQM and BM. In the Bohmian universe, God can look at the various possible histories, assay them for value, which attaches directly to its objects independent of considerations about probability, then examine the objective probabilities of each possible history and take a weighted average to get the expected value of the universe. While Bohmian mechanics is deterministic, it still requires an initial probability distribution. The initial probability distribution is called the *quantum equilibrium distribution*, which is crucial for proving that Bohmian mechanics makes exactly the same probabilistic predictions as textbook quantum mechanics does. (This was proven in the influential paper by Dürr et al. (1992).) If the initial probability distribution in Bohmian mechanics were entirely subjective, the empirical adequacy of Bohmian mechanics would be subjective too.

In the Everettian multiverse, however, this approach is not available to God. Value-facts are not fixed until objectively rational preferences are fixed, and they are not independent of probability-facts. Instead, if God is to find any value in the Everettian universe, God must first consult God's preference ordering and find a probability/utility pair that represents them as maximizing expected utility. Only then will God have probability-facts corresponding to the branch-weights and value facts along with them. Unlike in the Bohmian universe, God is much more involved in the metaphysics of value in the Everettian multiverse.[16]

What about the perspective that God stands outside of time? Perhaps God has a bird's-eye view of the history of all the events in space-time. If BM is true, then the history of events on space-time is described by the events of a single branch. If EQM is true, then the history consists in the history of events in an infinite number of branches. Perhaps we should calculate the actual value in the Bohmian universe and the expected value in the Everettian multiverse and compare the two. In that case, it is not clear how the comparison ends. It could very well be that the expected value in the Everettian case is less than the actual value in the Bohmian universe, and it could be the other way around (it is unlikely that they are exactly equal). The comparison of value is sensitive to the physical state of the Everettian multiverse, the probability weights of those branches, and the the state of the actual history in the Bohmian universe. There is no straightforward argument that the Everettian problem of evil is easier or harder than the Bohmian one. The inference from multiplicity of worlds to a greater amount of evil fails.[17]

4.3 Replies to Objections

Objection 1. The classical multiverse vs. the quantum multiverse.

Suppose the universe was fully classical, but oddly shaped. There are no wave functions or other quantum weirdness. Just good old particles in the void, but with spacetime taking a treelike structure so that there is no difference in the manifest image of our branching classical world and our branching Everettian one. Let us assume that the classical physical laws can be made consistent with such a treelike branching structure. Then it seems like our arguments do not go through. Probability, after all, is now unrelated to the branching structure, and value emerges from the properties and relations of ordinary objects. But this classical universe seems similar to an Everettian universe. What about the Everettian universe allows us to discount the things and events on the branches according to their branch weight, while it would be incorrect to do so in the classical multiverse?

Reply: The difference is best illustrated. In Figure 6, we show a directed graph of the

[16] As discussed in footnote #13, the theistic Everettian can go further here. They can take the divine preferences to be the standard of rational preferences, providing an objective anchor of the basic postulates of the Deutsch-Wallace project.

[17] Here we set aside the problems of infinities, which will make the comparison even harder and not easier. See Nover and Hájek (2004) and Chen and Rubio (2020) for some discussions of infinite state spaces and infinite values.

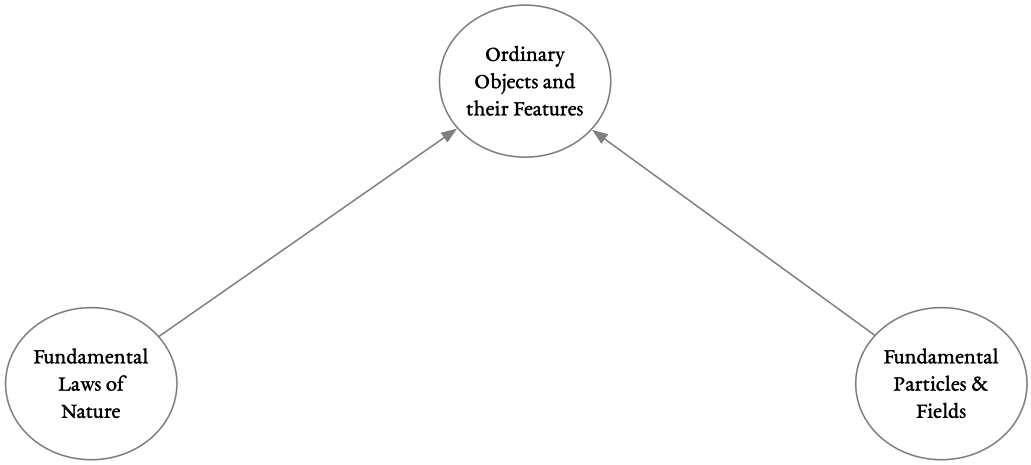

Figure 6: A directed diagram of the classical dependence relations. Note that probability and value do not appear in the grounding structure of ordinary objects and their features.

grounding structure of a classical world.[18] As we can see, this is very different from the graph of the situation in Everett. In particular, probability and value are not essential in the grounding structure and play no role in the move from the fundamental to the derivative. That is why the ethics of a classical branching universe are so different from an Everettian one. Normatively critical things like probability and value do not appear in the grounding structure. This difference explains why a classical branching universe that is superficially similar to an Everettian one is, in fact, axiologically much different.

Objection 2. There is no circularity in the Everettian account of probability.

One might say, in response to our claim about Precondition, that one can explain the decoherence mechanism without appealing to probability. For example we can appeal to the naturalness of the Hilbert space norm (the natural inner product measure that grounds the Born rule). Perhaps we can use counterfactuals to ground why that norm is natural: the norm is natural because it supports stable counterfactuals. So Precondition is false. Hence, the arguments in this paper do not work.

Reply: More needs to be said to make such an objection work. For example, the proposed explanations of the naturalness of the Hilbert space norm in terms of stable counterfactuals do not work. Counterfactuals in the quantum mechanical framework require probabilities in the antecedents or the consequents. This already requires a notion of probabilities that makes sense. In arguing for Precondition, we are not arguing that the Everettian justification of probabilities does not make sense. We are merely arguing that it already presupposes a notion of probability. If we have to justify why a certain norm is privileged only by appealing to another probabilistic notion, then that again supports our argument.

Objection 3. Absolute prohibitions.

Another objection: haven't we gone over entirely to the consequentialist dark side in making our reply? Perhaps if the primary problem with Everettian universes was

[18]Some people may disagree with incidental features of this graph, such as the position of the Laws of Nature. We have opted for something like one would get from a devoted Newtonian, but moving the laws into a more Humean-friendly position would not change the basic point.

the *volume* or *quantity* of evil, modulating it with probability would be a solution. But the problem is more qualitative than that. Even the evilest sequence of events we have experienced could have taken a darker turn. And so in some branch of the Everettian universe, it *does* take that darker turn. And in some of those branches, that is where things end. No further, redeeming things or events stand ready to do the work of theodicy for the denizens of that branch. Branches like this might be absolutely wrong to create. If they are, then it doesn't matter that they have low probability. According to a strict deontology, allowing a low probability of violating an absolute prohibition is absolutely prohibited. Absolutely prohibited actions are so bad that no decision plan that gives them some probability of occurring is permissible. The question is not one of quantity.

Reply: We emphasize that we are defending the parity thesis. It is not our aim to provide a theodicy. Our goal, instead, is to show that Everettian and other realist theories of quantum mechanics are on a par with regards to the problem of evil. What in an Everettian world amounts to a bad branch amounts to a remote but real possibility in a non-Everettian world. According to our strict deontologist, allowing this risk in a Bohmian world is just as bad as allowing it on a low weight branch in the Everettian world. The extent to which its remote possibility insulates the creator from a deontic violation in the Bohmian world is exactly the extent to which its inclusion on a low weight branch insulates the creator in an Everettian world. Perhaps the creator is convicted in both. Perhaps not. Either way, our parity thesis stands.[19]

On a more technical note, how to integrate absolute prohibitions into the decision-theoretic framework the Everettian relies on is an open question. Traditionally this is done with the inclusion of side-constraints. Jackson and Smith (2006) survey a number of other options for squaring absolute prohibitions with uncertainty, but none of them fares any better than the simple rule that risking the violation of an absolute prohibition is absolutely prohibited.

Objection 4. An Adams-Style Objection.

The final worry appeals to an analogy of Adams's moral objection (1974) to Lewis's modal realism (1973, 1986). According to Lewis, every possibility is as real as actuality is. The difference between a merely possible world and the actual world is not that actuality has some special status that the mere possibilities lack, but that it is the world the speaker inhabits. Adams noted that the goods and evils of unrestricted existence are settled. Adams argued that the ability to change the balance of good and evil in reality is an ineliminable goal of morality, and that Lewis's modal metaphysics made this impossible. Like Lewis's pluriverse's contents, Everett's multiverse's total contents are fixed. Like Lewis's worlds, Everett's branches cannot be eliminated. Does the Everettian multiverse nullify morality for inhabitants of the branches? If so, this may create the long-elusive asymmetry between single-universe and Everettian quantum theories.

[19]Here we address the worry (raised in footnote #8) that our arguments in this paper rely on the principle that value aggregation is additive. The principle is in fact not necessary. Suppose for the sake of argument that in a Bohmian universe there is a "right" aggregation principle for *risks* that is non-additive. Then we can just as well apply the same principle to aggregate the *values* from the branches in the Everettian multiverse. The parity thesis stands.

Reply: Lewis responded to Adams by invoking the intrinsically egocentric element of all actions. For Lewis, while the goods and evils of mere possibilities are no less good or bad for being merely possible, they are irrelevant to the question of right action. Moral deliberation should focus on the actual world. A similar response can be given in the Everettian context. As for moral deliberation, the Everettian agent ought to be concerned about evils and goods that go on in the actual branch, for other branches are effectively causally isolated from the actual one, as a consequence of decoherence. To justify the response, one needs a theory of actuality and causation in an Everettian multiverse. Wilson (2020) provides such a theory. Wilson's quantum modal realism combines an Everettian ontology with a Lewisian modal theory, regarding branches in the multiverse as diverging worlds that are effectively causally isolated. He responds to the Adams-style objection with a similar answer (pp. 69-72). Adopting an indexical theory of actuality so that the actual world is the branch of the speaker, Wilson argues that the principles of moral theory should be formulated in terms of actuality rather than in terms of reality *tout court*. For instance, he formulates 'actuality-consequentialism' as follows (p.71): "The right act to perform is the act with the best consequences for the actual world." Thus, the Everettian need not think that morality is nullified.

5 Conclusion

Once we recognize the role that a branch-weight operator must have, the Everettian problem of evil becomes less extreme. Learning of those terrible branches full of suffering has no more effect on the proper response of a functioning moral agent than learning, in a Bohmian world, of the corresponding possible histories. Low probability in the Bohmian case and low branch weight in the Everettian case modulates the response in exactly the same way. Likewise, when God is deliberating how to set up the fundamental physics of a world, the low branch-weight of those histories offsets their contribution to the world's value in exactly the same way that low probability offsets their contribution. For an empirically adequate Everettian quantum mechanics, one that includes a satisfactory account of probability, there is no special problem of evil. In order for there to be a special Everettian problem of evil, EQM must already have been exposed to decisive refutation. And if we compare the expected values of the Everettian multiverse with the actual values of the Bohmian universe, there is no straightforward argument that the Everettian problem of evil is more challenging.

One general lesson we may draw from this case study discussion is that value judgments can sometimes depend on the underlying physics and metaphysics. In exotic situations such as the Everettian quantum multiverse, our initial intuitions may lead us astray. The metaphysics of physics in such a world is dramatically different from that of an ordinary world. It is then not surprising that their differences can have normative implications.

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