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God Acts in the Quantum World

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1. Introduction

Let's suppose, for the purposes of this paper, that God exists, as a personal, omnipotent being, and as the creator and sustainer of the physical universe. Let's also suppose, for the purposes of this paper, that the theologians who believe God would not *intervene* in the world are correct. Here "non-intervention" is to be understood in the technical sense that God would not violate the laws of nature that he created for the world, since that would involve God dealing in two different manners with his creation (McMullin, 1993). (The worry is: why would God create laws of nature that govern the world, and then violate them?) Even though these theologians believe that God doesn't violate the laws of nature, they do believe that God can *act* in the world, as long as God does so in ways that don't violate the laws. Nancey Murphy, Robert Russell, and Thomas Tracy are prominent theologians who give sympathetic discussions of this position, called "noninterventionist special divine action". (Murphy, 1995, Russell, 2002, and Tracy, 2002 are three essays which are representative of an extensive literature on this topic.)

So how could God act in the world without intervening? One way for God to do this is by acting at the indeterministic quantum level. For example, if there's some quantum process that has a 10 per cent chance of yielding outcome A, and a 90 per cent chance of yielding outcome B, God can, in a particular instance of this process, decide which outcome will result, without violating any laws.

It has sometimes been maintained that God's actions in the world are quite limited, if all he can do is act at the quantum level. My first goal is to show that, on some ways of understanding quantum mechanics, that is false; God's actions are almost unlimited. This gives God the almost unlimited freedom to bring about any effect in the physical world, including (for example) parting the sea, changing water into wine, resurrecting the dead, and producing fish and loaves of bread.

Moreover, it has sometimes been maintained that God's actions in the world, within this quantum-mechanical framework, are problematically *episodic*, in the sense that God can't continuously act in the world. I will show that, on some ways of understanding quantum mechanics, this too is false; God's actions can be continuous (though they need not be).

Quantum mechanics is probably a false theory—it can't accommodate the empirical evidence that supports general relativity, and that's one reason that physicists are working on a theory of quantum gravity, to supplant both quantum mechanics and general relativity. But still, this discussion presents a useful model of how it could be the case that God can have almost unlimited freedom to continuously act in the world, in a noninterventionist way.

2. Quantum Mechanics

A key part of my paper is about how to understand quantum mechanics, but I recognize that not all readers will want to deal with the details. So feel free to skip ahead to the next section, where I'll summarize the results of this section and then show that, on some ways of understanding quantum mechanics, even if all God can do is act at the quantum level, his actions in the world are almost unlimited. Those who read on will see that my discussion in this section is necessarily brief. There's a lot one could say about how to understand quantum mechanics; I'll just provide the highlights to situate my discussion of God's actions.

Let's start with a crucial point (to reward those readers who are sticking around). Some versions of quantum mechanics are indeterministic, while others are deterministic. The main deterministic version is David Bohm's pilot wave theory. According to this interpretation, particles always have definite positions, and outcomes of processes that look indeterministic are actually determined by the precise locations of the particles (locations which are only imprecisely accessible to us). If the laws of nature

are governing propositions established by God, and the laws of nature are Bohmian, then God won't be able to act in the world without contravening the laws he established.

The many worlds interpretation is another deterministic version of quantum mechanics. Not only does this involve the same restrictions on God's actions as Bohm's theory, it also allows different branches of the universe (colloquially called different "worlds") to go in many different ways, leading to the arguably theologically unhappy consequence that every possibility allowed by the initial conditions of the universe (and the laws of quantum mechanics) is actually instantiated in some branch. This arguably makes the problem of evil even more of a problem than one would have thought, since there will be branches of the universe where the branch is filled with evil events. (For related theological issues, see Monton, 2010.)

While there are deterministic versions of quantum mechanics, almost all physicists favor indeterministic versions. According to (one version of) the Copenhagen interpretation, quantum systems evolve deterministically, except when a measurement occurs, in which case the quantum state of the system collapses to a particular state, ensuring that the measurement has a definite outcome. Philosophers of physics nowadays universally reject this interpretation as at least being incomplete (and most likely false). The problem is that what counts as a measurement is not specified by the interpretation, and anyways, measurements probably aren't fundamentally different physical processes from all the other physical processes that occur.

There are two popular indeterministic versions of quantum mechanics amongst philosophers of physics—modal interpretations and the GRW theory. According to modal interpretations, the quantum state of a system never collapses but, in addition to the quantum state, a system has a *value state*, which specifies which properties the system actually has. The quantum state evolves deterministically, but on most modal interpretations, the value state evolves indeterministically, and that's where the fundamental indeterminism arises in the world. There are many different versions of modal interpretations, corresponding to different specifications of which properties are determinate, and how the properties evolve. (For more see Bub, 1997.)

Unlike the modal interpretations, the GRW theory (named after its proponents, G. C. Ghirardi, A. Rimini, and T. Weber (1986)) is a collapse

theory, where the quantum state (also known as the wave function) of the system collapses down to a state that ensures that measurements have outcomes. (There have been various improvements made to the GRW theory; the resulting theories are collectively called Continuous Spontaneous Localization (CSL) theories. I'll stick with the GRW theory for simplicity, and because all the CSL theories have the same consequences for how to model God's actions.)

And those are all the major versions of quantum mechanics. Since we're interested in God's acts in an indeterministic quantum world, I'll focus on modal interpretations and the GRW theory. The results for God's acts would be the same on some versions of the modal interpretation as on the GRW theory, and modal interpretations are more complicated, so let's focus on the GRW theory.

According to the GRW theory, the wave function for a N -particle system always has a chance of spontaneously undergoing a collapse. A collapse (called a "GRW hit") on a particular particle has a 1 in 10^{15} chance of happening per second. What happens when a system undergoes a GRW hit is that the wave function is multiplied by a localized Gaussian (bell curve-shaped) function, with probability of the Gaussian being localized in any region being given by the value of the wave function in that region. (Technically, where the wave function is ψ , the probability of the Gaussian being localized is a function of $|\psi|^2$.) The GRW hit happens on the part of the wave function associated with a single particle but, for a typical macroscopic object, the positions of the particles are correlated to each other, so a GRW hit on one particle affects the state of the whole system. The net effect of a GRW hit is to localize the wave function for the N -particle system in the region where the GRW hit happened.

But on the GRW theory, wave functions are never completely localized—they always have tails that go to spatial infinity. (That wave functions have tails is true according to other versions of quantum mechanics, too. For example, on the Copenhagen interpretation, a wave function may be localized to a particular region when the measurement collapse happens, but by the standard dynamical equation of quantum mechanics, Schrödinger's equation, the wave function will only be localized at an instant; after that instant it will once again have tails that go to infinity.) By the dynamics of the GRW theory, the wave function can have value zero in some regions of space, but it has non-zero value in an unbounded region of space. Any place the wave function

has non-zero value, there's a non-zero probability that the GRW hit will happen in that region. This issue of the wave function having tails that go to infinity will be key for the discussion of God's acts below. (If one is having trouble mentally picturing the tails, it helps to think about a bell curve distribution—it's concentrated in one region, but there are tails that go to infinity.)

One complication I haven't yet introduced to the discussion is that the wave function is mathematically defined over $3N$ -dimensional space (where N is the number of particles in the system in question). Some philosophers of physics (such as Albert, 1996) have argued that the wave function, evolving in the high-dimensional space, is what's real, and the experience we have of living in a three-dimensional space is illusory. I maintain that this is an incorrect way to understand the ontology of quantum mechanics (for argument, see for example Monton, 2006 and Monton, 2013). There's no need for quantum mechanics to be that radically revisionary with respect to our common-sense understanding of the world as involving things evolving in three-dimensional space. And there is a way to make sense of that on the GRW theory. While there has been much debate about the ontology of the GRW theory, the standard view now is that the mass density ontology provides the (or at least a reasonable) way of understanding the ontology of the GRW theory. (See Monton, 2004 for the best defense of this ontology, and see also Ghirardi, 2011.) On the mass density ontology, the wave function for a particle represents how the mass of the particle is spread out throughout space. Since wave functions have tails, the mass is spread throughout an unbounded region of space, but the vast majority of it is sometimes concentrated in a small region of space; when the mass is concentrated in this way, the particle behaves more classically. Macroscopic objects will almost always be such that the vast majority of the masses of their particles are concentrated in small regions of space, since there are very likely to be frequent GRW hits on particles in the macroscopic object, and these GRW hits are very likely to happen where the wave function is already concentrated. Single particles, or few-particle systems, are very unlikely to undergo a GRW hit (recall that the chance of its happening, for a single particle, is just 1 in 10^{15} per second). This is how the GRW theory reproduces the results that we experience—we experience the world behaving classically at the macroscopic level, but quantum-mechanically at the microscopic level.

(For the cognoscenti: in addition to the wave function and mass density ontologies, the other main ontology for the GRW theory is the flash ontology. I find that ontology to be implausible (given that an individual particle is only in existence for an occasional instant of time), but none of the claims below about God's actions hinge on whether the flash ontology or the mass density ontology is the correct ontology for the theory (though the presentation would be quite different on the different ontologies).)

3. How God Can Act Without Intervening

Recall that we're following the strictures of the proponents of noninterventionist special divine action: God doesn't intervene in the world (in that God doesn't violate the laws of nature), but God can act in the world (by, for example, determining the results of indeterministic physical processes). On the GRW theory, and some modal interpretations, God has an effective, wide-ranging means of doing this. I'll focus my argument on the GRW theory.

For those who skipped the previous section: the GRW theory is an indeterministic version of quantum mechanics that allows for indeterministic "GRW hits" to happen on the wave function of a particle, thus localizing the wave function. On my preferred understanding of the GRW theory, having a wave function of a particle localized means that a majority of the mass density of the particle is in a small region of space, but the wave function has tails that go to infinity, so the mass of the particle is also spread out throughout this infinite region of space. The GRW hit can happen anywhere that the wave function is non-zero, so the GRW hits can happen most anywhere in space, concentrating most of the mass density for the particle in that region where the GRW hit happened.

Now we come to the crucial argumentative move of my paper. Within the constraints of the laws of the GRW theory, God can make a GRW hit happen anywhere, on any particle, or collection of particles. This gives God the power to move particles around anywhere in the universe. And moreover, God can do so arbitrarily quickly, just by making the GRW hits happen in an arbitrarily small amount of time.

(One slightly technical point: what if the wave function for a particle is zero in a particular region of the universe (for example, because another

particle is localized there)? In that situation, God could do a GRW hit on the blocking particle to move it out of the way, thus changing the wave function of the particle God wants to move, and then God can do a GRW hit on the particle God wants to move, to get it in the desired location. That's how God can move particles anywhere.)

The standard (purported) miracles of God can all be accounted for in this way, or so I'll now argue. Let's start with an easy case: God parting the sea. Here, particles in the sea just need to shift a fixed distance to a new location. God could do this by simultaneously executing a GRW hit on the wave function for each of the particles, with the GRW hits all centered where God wants the sea to be. (It may take multiple GRW hits per particle, but God could cause those to happen arbitrarily quickly.) Note that the sea parting is allowed by the laws of the GRW theory; it's just incredibly improbable that that would happen. (It's akin to the (empirically well-demonstrated) quantum tunneling phenomenon, where a particle suddenly appears in a new location, except instead of the single particle tunneling, every particle in the relevant portion of the sea does so.) If we were to witness the sea part in this way, we should recognize that no laws of nature need have been violated. (Whether such a sea-parting event would nevertheless provide evidence for the existence of God is an epistemological question outside the scope of this paper.)

Let's turn to more difficult cases of how God might act without intervening. Alvin Plantinga talked with people who are knowledgeable about quantum mechanics, and on that basis wrote the following about God's miracles:

According to the expert opinion to which I have had access, some of these (parting the Red Sea, miraculous healings) are pretty unproblematically compatible with QM. On other miracles, however—for example, raising someone from the dead, and transmutation, as with changing water into wine—there seems to be substantial difference of opinion among the experts. Little analysis of these kinds of cases has been published; but some of the experts I've talked with (Katherine Brading, Craig Lent, Bas van Fraassen) think it implausible that QM be compatible with these miracles. Others, for example John Earman and Bradley Monton, think QM is compatible with them. (Plantinga, 2008, 382; Plantinga, 2011, 94–5)

I'll now argue that Earman and I are correct. Plantinga goes on to cite personal correspondence with me, discussing the case of changing water into wine:

you've got a bunch of individual particles (electrons, protons, etc.) that are composing the water, and they can all have GRW hits such that their positions are redistributed to the locations that would be appropriate for them to compose wine. (Monton, from Plantinga, 2008, 382; Plantinga, 2011, 94–5)

Why would Brading, Lent, and van Fraassen think otherwise? Plantinga doesn't say, but the worry, as I understand it, is that the appropriate bonds so that the particles that make up the water actually form bonds into the chemical molecules that make up wine wouldn't be able to be established. I'll now argue that this worry is unfounded.

Imagine that we start with a glass of water, which is fundamentally composed of various particles of a few different types: electrons, quarks, and so on. Imagine that a large number of GRW hits occur on the wave function of the water system, in such a way that the particles are moved into a particular configuration of positions that they would be in if they constituted wine. (More precisely, the masses for the particles are highly localized in this configuration of positions.) Would this rearrangement of positions be enough for the liquid in the glass to be wine? The answer is "yes": once the particles are in the appropriate positions, they will automatically have the appropriate bonds such that they have the chemical structure of wine. Here's why.

As we currently understand it, there are four forces in nature, gravity, the electromagnetic force, and the weak and strong nuclear forces. The force of gravity acts between every particle with mass, so once the particles are in the positions they would be in if they constituted wine, the force of gravity will act between the particles just as if it had been a glass of wine from the start. The electromagnetic force is the same way; it is based on the positions of the particles. For example, an electron and a proton that are a certain distance apart from one another will experience a certain attractive force, even if the electron and proton spontaneously appeared in those positions a short time before (taking into account the fact that this attractive electromagnetic force travels at the speed of light).

What about the strong and weak nuclear forces? The strong nuclear force (responsible for binding in the atomic nucleus) has a very short range—its effects aren't experienced when particles are more than 10^{-15} meters apart. The range of the weak nuclear force is even shorter—about 1/1000th the diameter of a proton. Thus, for both these forces, particles must be close together to feel its effects. But once particles are put close

together, the effects will be felt. God's actions in the form of GRW hits will be enough to get the particles in the appropriate positions, and the fundamental forces (as governed by the laws of physics) then automatically come into play.

Thus, God can act by causing GRW hits in such a way that water is turned into wine. Raising someone from the dead is similar—the GRW hits move the particles around into the configuration of a living person, and as a result, the appropriate forces come into play to establish the appropriate chemical and atomic bonds. (With regard to the personal identity question, of whether this amount of physical and psychological connectedness is enough for the resurrected person to count as the same person as the person who died, my opinion is that it would be the same person, but to argue for that would take us too far afield.)

What about, starting from a few loaves of bread and a few fish, producing enough to feed five thousand people? This is an interestingly different case than the water-into-wine and resurrection cases, because it seemingly involves more particles coming into play than one started with. Indeed, Peter Hodgson (2000, 514) claims that “the feeding of the five thousand is contrary to the law of the conservation of matter.” Where could the extra particles come from? A limitation of my view of how God can act in the quantum world is that God can't create new particles *ex nihilo*—that isn't allowed by the laws of the GRW theory. But, nothing stops God from bringing in other particles from far away, and using those particles to make fish and bread. For example, God could take particles making up nitrogen high up in the atmosphere, or particles making up rocks on Mars, and do GRW hits on them in such a way that those particles become bread and wine here on the surface of the Earth. Nothing in the Biblical story of the fish and loaves of bread rules out God acting in that way.

I could give more examples, but you get the picture. All the standard purported miracles can be accounted for by God acting in the world via GRW hits, without violating the laws of nature. (The one obvious exception is a miracle that essentially involves a divine element, such as the incarnation of God in the form of Jesus.)

Moreover, the GRW theory isn't the only version of quantum mechanics that yields these happy results of God being able to perform miracles in a noninterventionist way. Some modal interpretations, such as Bas van Fraassen's (1991) Copenhagen Variant of the Modal Interpretation, have

a highly stochastic dynamics for the value states. Given such a version of quantum mechanics, God could pick a dynamics for the value states that is compatible with the laws, in such a way that that dynamics yields the miracle God desires. (Note that when I say “is compatible with the laws”, that can be interpreted to mean “is allowed by a model of the theory”; van Fraassen famously does not believe in laws of nature (see for example van Fraassen, 1989).)

4. God’s Actions Need Not Be Episodic

After Plantinga quotes the personal correspondence with me, regarding the case of changing water into wine, he writes: “Monton is speaking of the GRW approach to quantum mechanics; presumably a similar point would apply to the classical Copenhagen interpretation” (Plantinga, 2008, 382; Plantinga, 2011, 96).

Plantinga is mistaken here. On the Copenhagen interpretation, a quantum system evolves deterministically until a measurement process occurs; only then is there a stochastic process in which God can act without violating the laws. Hence, my argument for the compatibility of these miracles with noninterventionist special divine action would not go through under the assumption that the Copenhagen interpretation is true. Proponents of quantum special divine action typically present their theory using the Copenhagen interpretation, and from that standpoint God can only act when a quantum measurement occurs.

This leads John Polkinghorne to raise the following important criticism of the standard, Copenhagen interpretation-based, view of quantum special divine action.

There is a particular difficulty in using quantum indeterminacy to describe divine action Occasions of measurement only occur from time to time and a God who acted through being their determinator would also only be acting from time to time. Such an episodic account of providential agency does not seem altogether satisfactory theologically. (Polkinghorne, 1995, 152)

Polkinghorne holds that it is not satisfactory for God to be able to act only when measurements occur. But why is this not satisfactory? The answer I would give is, because then God does not have the freedom to generate a miracle whenever he wants (at least, he does not have that freedom, given that he does not want to deal in two different manners

with his creation). But Polkinghorne gives a different answer. He writes, regarding measurement events: “their strictly episodic nature does not obviously fit them to describe agency, which must surely be assumed to have a more free-flowing character” (Polkinghorne 2002, 188–189).

Polkinghorne doesn’t give an argument here, nevertheless I have some sympathies with his position. But first: what is his position? As I’ll now explain, there are three plausible interpretations of his view. This is worth going into, not just for the sake of Polkinghorne’s exegesis, but because it will help us to explore to what extent my versions of quantum special divine action are better than the standard Copenhagen one.

First, Polkinghorne could mean that God’s actions must take place over intervals of time. This view strikes me as implausible—presumably God is capable of acting instantaneously. But perhaps there are situations where God *wants* to act over an interval of time. This leads to the second interpretation: Polkinghorne could mean that God should be free to act over an interval of time; God’s agency shouldn’t be constrained to instants. And finally, the third interpretation is to take “free-flowing” seriously: it’s not just that God’s actions should take place over an interval of time, but there should be some sort of tight connection between the actions at instants within that interval.

On the first interpretation, both the standard Copenhagen view of special divine action and the GRW version fall prey to Polkinghorne’s critique: the collapse of the wave function as a result of measurement happens at an instant, as do GRW hits. But on the second interpretation, that God should be free to act over an interval of time, Polkinghorne’s critique only impacts the Copenhagen view. On the Copenhagen view, God’s actions are limited to the instants where wave function collapse occurs as a result of measurement. But on my view, God can act at every instant in an interval of time, by causing GRW hits at each of those instants. (Or, under the assumption that a modal interpretation like van Fraassen’s is true, God could pick a dynamics for the value states over some interval of time that is compatible with the quantum-mechanical laws, in such a way that that dynamics yields the result God desires.)

It’s unclear to me exactly how to spell out the third interpretation, that there should be a tight connection between God’s actions at instants within the interval, but I see that there is something to it. On the third interpretation, the standard Copenhagen view of special divine action is

definitely maligned, because on the Copenhagen view God just acts at an instant. On the view that God acts via GRW hits, I see the concern that each GRW hit is its own event, without there being a free-flowing connection between the different GRW hits. Nevertheless, if the different GRW hits over some interval of time are all for some cohesive end (turning water into wine, for example), then what is free-flowing is the process of the water gradually turning into wine, as the GRW hits happen. (Given modal interpretations like van Fraassen's, God's actions could be more free-flowing in a natural way, by having God control the dynamics for the value states over some interval of time.)

In sum, Polkinghorne's critique is open to interpretation, but regardless of how one interprets it, the standard Copenhagen view of quantum divine action falls prey to the critique, while on some reasonable interpretations my versions of quantum special divine action do not.

Robert Russell attempts to argue that, in fact, his Copenhagen view of quantum divine action does not fall prey to Polkinghorne's critique. If Russell is right about this, then that removes an important reason to favor my versions of quantum special divine action over Russell's. But as I'll now show, Russell is not right about this.

Sometimes, Russell concedes the point, to an extent at least. For example, he writes, "It is... true that indeterminism arises only during an irreversible interaction with more complex objects" (Russell, 2003, 362). I hold that this is already granting Polkinghorne's critique: God cannot act at any time he wants, but only when there is an "irreversible" (more on that below) interaction with, not just any object, but a more complex object. But after the above quoted sentence, Russell goes on to say:

My point, however, is that these interactions are not limited to physical measurements in the lab; instead they occur throughout the universe wherever elementary particles are irreversibly absorbed by objects ranging from complex molecules and interstellar dust to those of the ordinary macroscopic world. To me this suggests a God who acts throughout innumerable occasions in the universe, and thus a much more comprehensive view of divine action than the term "episodic" suggests. (Russell, 2003, 362)

I'm not convinced by Russell's defense of "nonepisodicness" here. For a measurement to occur, there has to be the sort of interaction Russell specifies, where an object interacts with a more complex object. When such an interaction does not occur, God cannot act in the world (subject to the assumption we're making, regarding God's not wanting to violate

the laws). This strikes me as a clear limitation on God's actions. Moreover, this is a limitation that the GRW version of quantum special divine action doesn't share: a GRW hit can happen at any time, anywhere that the wave function is non-zero, so God is always free to cause a GRW hit to occur.

Russell puts the point in a slightly different way in another essay. He writes:

What about the "episodic" nature of such interactions? In fact, such interactions can occur at any time and place in the universe where the deterministic time-development of the quantum phenomena governed by the Schrödinger equation is disrupted by an irreversible interaction (measurement)... (Russell, 2002, 310; Russell, 2009, 375)

There's an ambiguity here that I want to resolve. One might think that the laws of quantum mechanics determine which interactions are irreversible, but that's not the case. In principle, all interactions could be governed by the Schrödinger equation, and as long as that's the case, all interactions are reversible. The problem with the view that all interactions are governed by the Schrödinger equation is that, on that view, measurements typically don't have results, so something about quantum mechanics needs to be modified, to ensure that quantum mechanics captures our experiences of measurements having results. This is why the Copenhagen interpretation specifies that, when a measurement happens, the wave function collapses—this collapse process is irreversible. The main problem with the Copenhagen interpretation is that it doesn't give a physical specification of what it takes for a measurement process to happen. Russell is giving a partial characterization of what it takes for a measurement to happen (in terms of interaction with a more complex system), but ideally one would want a more precise characterization (and I'm confident that Russell would agree). The key point is that, according to Russell's Copenhagen version of special divine action, God can only act when this measurement process occurs—and, as Russell points out, such measurement processes occur only when an object interacts with a more complex object. Absenting such an interaction, God cannot act. I conclude that God's actions on Russell's view are episodic, and thus fall prey to Polkinghorne's critique. God's actions according to my versions of quantum special divine action need not be episodic, and this is an important reason to prefer my versions over Russell's.

5. Saunders' Critiques

But are there other reasons to be unhappy with my versions of quantum special divine action? As far as I can tell, modal interpretations have never been discussed in this literature on quantum special divine action, so no critiques of those interpretations have been raised in this context. The GRW theory, though, has been discussed in this context, and Nicholas Saunders (2002, 156–9) has argued against the GRW theory as a way of understanding quantum special divine action. I'll now show that Saunders' critiques are ill-founded.

The first of Saunders' arguments against the GRW theory which I'll focus on is that the GRW theory

appears basically contrived: for a microscopic quantum system with a small number of particles N , the multiplication of the Gaussian [i.e. the GRW hit] becomes so infrequent as to be practically undetectable; moreover the width of the Gaussian appears to be chosen to be sufficiently big to ensure that any energy conservation violations which arise as a result of its multiplication would be very small and are thus experimentally undetectable. (Saunders, 2002, 158–9)

It's true that the two new fundamental constants of the GRW theory (the probability of a GRW hit happening, and the width of the Gaussian) have been picked to fit the extant data, but there's nothing wrong with that. It's a typical process in science that sometimes one uses empirical evidence to determine how to *formulate* one's theory; if the process of theory-formation didn't rely on empirical evidence there would be something horribly misguided about the process. So I wouldn't call the GRW theory "contrived"; it was formulated under empirical constraints, which is a standard practice of science.

It is true that the GRW theory violates the principle that energy is conserved, but that principle isn't sacrosanct; according to the GRW theory, that principle is simply false. (For those who think giving up that principle is egregious, note that it's not even clear how to formulate the principle of conservation of energy in the context of general relativity. It's not at all clear that this is a true principle of physics.)

The second argument of Saunders against the GRW theory (and other Continuous Spontaneous Localization theories) is that they "bypass rather than fully address the problem of measurement in quantum mechanics," because "the highly localized state which results from

Gaussian multiplication is *not the same as a completely localized state*.” Saunders goes on to explain the problem of wave function tails—that wave functions aren’t highly localized; they go out to infinity. But it’s this feature of the GRW theory that I’m exploiting to explain how God is so free to act in the quantum world: God can do GRW hits to move particles anywhere. Moreover, there’s now a well-worked-out and agreed-upon ontology for the GRW theory which accommodates these wave function tails, the mass density ontology (Monton, 2004, Ghirardi, 2011).

Saunders’ third and final argument focuses on God’s actions given the ontology of the GRW theory. But the argument is only plausible because Saunders has a different view of how God would act than I do. Saunders writes:

under this connection between quantum special divine action and the [GRW] approach to measurement, God still does no more than determine when interventionistically to “toss the quantum dice” and get a probabilistic result. The theologian is still left with the burden of describing how it is that God might obtain a purposive result under this scheme. . . . (Saunders, 2002, 159)

As I interpret him, Saunders is saying that on the GRW-based account of quantum special divine action, God determines *when* a GRW hit happens, but not *where* it happens. If that were the account, then indeed, God wouldn’t be able to control the evolutions of systems, and hence God wouldn’t be able to get purposive results. But as a result, that account is a non-starter. On my GRW-based account of quantum special divine action, God determines when *and where* GRW hits happen, and that is how God has the almost unlimited freedom to bring about any effect in the physical world.

6. Two Concluding Thoughts

I’ll close with two concluding thoughts. First, this ability of God to act in the physical world, via quantum effects, comes with a price. Specifically, God *has* to act in the world, or at least be ready to act in the world, to ensure that it does not go vastly awry. God cannot be a hands-off God who starts the universe in motion but then no longer intervenes—or at least, God can’t ensure from the start that he will be such a God, under the assumptions that God is unwilling to let the world go certain horrible ways, and

that God does not determine the outcomes of indeterministic processes at the moment of creation. Why? Because, for example, it's possible that, if nature is left to its own devices, in the next second GRW hits happen in such a way that all humans cease to exist. This is incredibly unlikely, but it's compatible with the GRW theory that that happens (because the GRW hits could happen in such a way that each human's particles are scattered as if there were an explosion, leading to at least the physical death of that human). God presumably wouldn't want that to happen, and that's why he has to be ready to act. (Note that I haven't taken up the debate over whether God is the cause of all quantum indeterministic events or just some; my point here is that God has to be willing to be the cause of at least some.)

Here's my second concluding thought. I have for the most part been talking as if the GRW theory could be a true theory of the world, but in fact it (like every other version of quantum mechanics) is probably a false theory. As I noted at the start, quantum mechanics cannot accommodate the evidence that supports general relativity, and that is one reason physicists are searching for a theory of quantum gravity, which will supplant both quantum mechanics and general relativity. It could turn out that some theory of quantum gravity is the true theory of the world, or it could turn out that after coming up with that theory, we will realize that we still have further to go. What I've defended in this paper is a model for how non-interventionist special divine action could work. I've defended the details of the GRW-based model, not to argue for the truth of the GRW theory, but to show that there is a plausible extant model for how noninterventionist special divine action could happen. (I've also suggested that some modal interpretations provide another plausible model.) We will have to see whether future theories of physics have the level of indeterminism built in to them such that my model for noninterventionist special divine action still applies. Given the current state of physics, we just don't know, and it's hard to even make a well-informed guess.

Polkinghorne makes a similar point:

In our present state of knowledge, no proposal relating to the conceivable causal joint of divine providential interaction can be more than what the physicists would call a "zero-order approximation," a crude starting point from which one may hope that better developments might eventually spring. (Polkinghorne, 2002, 190)

Philosophers sometimes aren't happy with such inconclusive results, and there has been a trend of metaphysicians appealing to physics as if physics is giving us conclusive answers regarding the nature of the world. (For a critique of such metaphysicians, see Monton, 2011.) If I wanted to be such a metaphysician, I would present the GRW theory as if it were a plausibly true theory of the world, and conclude that the problem of noninterventionist special divine action has been solved. But our current physics is far from conclusive, and, as a result, our physics-based hypotheses regarding how God could act in the world must be far from conclusive as well.¹

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