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Miracles: metaphysics, physics, and physicalism

KIRK MCDERMID

Department of Philosophy and Religion, Montclair State University, Montclair, NJ 07403

Abstract: **Debates about the metaphysical compatibility between miracles and natural laws often appear to prejudge the issue by either adopting or rejecting a strong physicalist thesis (the idea that the physical is all that exists). The operative component of physicalism is a causal closure principle: that every caused event is a physically caused event. If physicalism and this strong causal closure principle are accepted, then supernatural interventions are ruled out *tout court*, while rejecting physicalism gives miracles metaphysical carte blanche. This paper argues for a more moderate version of physicalism that respects important physicalist intuitions about causal closure while allowing for miracles' logical possibility. A recent proposal for a specific mechanism for the production of miracles (Larmer (1996d)) is criticized and rejected. In its place, two separate mechanisms (suitable for deterministic and indeterministic worlds, respectively) are proposed that do conform to a more moderate physicalism, and their potential and limitations are explored.**

Introduction

Many writers assert that miracles are law-violating instances (Swinburne (1970), Odegard (1982), Collier (1996), MacGill (1996)), but respondents claim that this idea is variously incoherent (McKinnon (1967), Flew (1967)), or false (Basinger (1984), Larmer (1996a)). The incoherence charge only applies to a strictly Humean view of laws as merely accounts of what actually happened (McKinnon (1967)), not to more robust views of laws as representing some variety of physical necessity or causal power. Likewise, many criticisms of the position that miracles violate laws are also excessively epistemological in orientation; e.g. Flew (1967) argues that true counter-instances (miracles) will lead us to revise our (knowledge of) laws to conform (or vice versa), therefore no true violation occurs (because the 'law' that was broken was not a true law – it was merely a fallible epistemological summary of experience.) This paper addresses the conflict between laws and miracles on the metaphysical, rather than epistemological level: are natural laws and miraculous events metaphysically compatible?

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Before we start, though, some brief remarks about why this might be worth discussion. It has been suggested to me that classical theists in particular would see this worry as either unimportant, or threatening to their theology. It's unimportant, because clearly God's power transcends the natural, and He can, of course, freely act without concerning Himself with what natural law ordinarily proscribes. Natural laws may metaphysically constrain the physical, but not the supernatural, so they seem a side issue at best. But, if raising the question of metaphysical compatibility is taken another way – as exploring substantive restrictions on divine action, then most theists would fiercely reject this line of questioning as ill-founded from the start.

But there are many reasons to prefer an approach that attempts to reconcile the metaphysics of natural law with miraculous action. First, a philosophical motive: is it *possible* to reconcile them? Are miracles *necessarily* law-violators? Exploring this issue might help us understand both miracles and laws, whether or not they are ultimately reconciled. This is (at least for some) an academically interesting issue regardless of theological implications (or the lack thereof.)

But, I do not think this issue is theologically idle: it seems important to ask this question, because the answer can give us some significant information about the relationship of the divine to the natural. Are they necessarily antagonistic, as a law-violating account might require, and as some classical theists might assume? What implications might this have, if one's conception of the divine is as the creator (and/or sustainer) of the natural order? Even if one wishes to preserve God's interventional capacities, it would be illuminating to know what such a capacity metaphysically entails, in terms of the universality and necessity of natural law.

Finally, I reject the idea that this threatens God's power: we need not take this enquiry as presuming any metaphysical restrictions on God's action. Instead, we can explore this as a self-limitation of God's power. If we were to find ways to intervene without violating natural law, we have merely demonstrated that there is a *physical* possibility for the miraculous that the divine can exploit, if He so chooses. God can (I suppose) still reserve the right to do the physically impossible, and violate natural laws if He so desires. (But, again: why would He, if he could accomplish the same ends more elegantly, in accordance with the laws He presumably laid down to govern the natural world?) Exploring the idea of non-violating miracles as a self-limitation of the divine respects the intuition that God would not cavalierly override Himself, or do things (e.g. establish laws) that He would know He would need to undo at some point. This seems an interesting enough view that we should expend some effort to either vindicate or refute it.

Two ways to circumvent natural law

Both Basinger & Basinger (1986) and Larmer (1996a, 1996d) present arguments to the effect that (metaphysically-efficacious) laws need not be violated by

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miracles, in the same general vein: these laws are circumvented, rather than violated, by supernatural activity. For Basinger & Basinger, natural laws, as a matter of course, have *ceteris paribus* clauses that exempt supernatural activity. That is, the argument is made (in various ways) that supernatural activity falls outside the scope of the law. We will call this method of circumvention the 'exemption' tactic. The idea is simple: because natural laws predict 'what will or will not occur under certain *natural* conditions' (Basinger & Basinger (1986), 13 [my emphasis]), they simply fail to apply in cases of supernatural activity.

Larmer uses a similar loophole when he argues that the supernatural could influence the 'material conditions to which the laws of nature apply' (Larmer (1996a), 42) without interfering in the operation of the laws themselves. In this case, the idea is to make use of an already explicit *ceteris paribus* clause in the conservation laws of a physical system. By denying that the universe is a closed system to which conservation laws properly apply, we open the way for miracles. Call this the 'open-systems' tactic. On this view, all miraculous activity is accomplished through creation and annihilation of physical material. No dynamical laws are violated or circumvented as in the 'exemption' tactic – even at the moment of the miracle. All the newly created material obeys all of the dynamical laws, as usual. As an example (which we shall return to throughout the paper as a paradigm example), the transmutation of water into wine can be accomplished simply by annihilating (some) of the water and creating all the molecules (alcohol, tannins, etc.) that comprise a nice Merlot.

Physicalism and causal closure

Though both tactics successfully reconcile laws and miracles, they do not satisfy many critics.[1] The problem, says Larmer: the doctrine of physicalism. Physicalism is a spectrum of positions that, generally, deny the existence of non-material substances, and non-physical causal influences. Larmer's position is that the true incompatibility is not between *laws* and miracles, but *physicalism* and miracles: 'The claim that a miracle occurred would conflict, therefore, not with [conservation laws], but with the metaphysical claim that nature is an isolated system not open to the action of God' (Larmer (1996a), 47). He agrees with his objectors that laws are well-established features of the world, but denies that the natural (physical) world is all there is. An assumption of physicalism would beg the question of miracles by denying the existence and/or causal efficacy of the supernatural – something we must surely not pre-judge in this situation.

But this is not quite correct: elsewhere, Larmer ((1996a), 46) mentions that the problem about the correct application of conservation laws isn't really physicalism itself, but with a 'defining postulate' of physicalism. The portion of physicalism that Larmer is really taking to task is the principle of *causal closure of the physical* (or CCP): the thesis that every event which has a cause has a physical cause. The (natural) world might be an open system, not isolated from

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an insensible supernatural system, and therefore the CCP is an unjustifiably strong assumption. The result of denying CCP: Larmer's (1996d) mechanism for law-abiding miracles as a form of special creation (or annihilation) of material – where the matter isn't 'really' created or annihilated, but only transported to the non-physical portion of the universe.

Though an easy acceptance of CCP does unfairly rule out miracles, Larmer's flat denial of CCP surely goes too far the other way. For, without causal closure of the physical, it appears that almost anything goes! One need not restrict oneself to carefully-worded *ceteris paribus* clauses – one can blatantly violate any natural law once closure is denied. The 'exemption' and 'open-systems' proponents' apparent motivation – to allow for the production of miracles, while minimizing interference with the lawful progression of physical events – seems laudable, but by denying CCP they have obviated *any* requirement for subtlety or discretion in divine intervention. Rejecting it wholesale makes natural laws metaphysically toothless – a result I am not sure they would be particularly happy with. I am sympathetic to their motive, as I suspect are their opponents who maintain that these 'reconciliations' are still objectionable, whether they technically preserve natural laws or not.

What we would prefer, if possible, is a formulation of the intuition embodied in all these discussions of miracles: that they have minimal or no conflict with laws, in spirit, not just with the letter. Here I present an alternative formulation of a causal closure principle that may do the job:

> Principle of causal primacy of the physical (CPP): No physical cause is pre-empted (thwarted, modified, undone) by a non-physical cause.

This principle seems to be an improvement over the CCP; it does not contain a positive prohibition on non-physical causes, only a negative restriction on the role of non-physical causes. Any physical cause, according to this principle, must be allowed to execute its powers without countervailing influences, but in areas where physical cause remains inoperative, there is room for the non-physical to step in. I think this corresponds well with the physicalist insistence that supernatural action not override the course of nature – but does it moderate the physicalist stance enough to permit a meaningful reconciliation between laws and miracles?

First, the CPP appears to exclude the 'exemption' tactic as completely as the more powerful CCP. The CCP's restriction that all caused events be physically caused is in clear conflict with *ceteris paribus* clauses that specifically attempt to circumvent it: it solidly closes the door on events with supernatural causes. The CPP does not close that door completely, but leaves it open so slightly that it appears no miraculous activity can squeak through. The CPP denies the acceptability of *ceteris paribus* circumvention clauses, as they are designed to exempt events that otherwise would be under physical causal

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influences. So, the 'exemption' tactic is out, but perhaps on a slightly less dogmatic basis.

How about the 'open-systems' approach? Can we have creation or annihilation events, with the physical remaining causally primary? It seems so, for two reasons. First, it's not clear that conservation laws are representations of causal powers at all. (What force maintains or enforces a constant quantity of mass-energy? What causal influence forbids the creation of merlot molecules in a glass of water?) We may not even need to postulate that the apparently created matter was pre-existing in another system, and merely being transferred over to the physical universe (as Larmer's 'open systems' would have it). Secondly, the CPP more broadly does not prohibit the tactic of defining the (physical) universe as open; it just requires that physically governed (physically caused) portions of a system are above interference from other sources. But, an under-appreciated connection between natural dynamical laws and conservation laws may, after all, prohibit 'open-system' special-creation type miracles.

A Noether way to closure

Conservation laws seem to be quite distinct from 'regular' dynamical laws: dynamical laws are much more clearly causal in their operation, while conservation laws are more mysteriously like book-keepers. Do conservation laws have causal force? Do events and processes just happen to obey those laws phenomenologically? Are they merely Humean regularities, with no metaphysical necessity? The answer lies in a theorem proven by Emmy Noether (1971), which gives a deep connection between the apparently independent conservation laws and dynamical laws. Succinctly, the connection is this: conservation laws are implications of *symmetries* embodied in dynamical laws. That is, for every symmetry that a dynamical law possesses, there is a corresponding invariant or conserved quantity that forms the basis for a conservation law. For example, time-translation symmetry (the fact that laws of motion apply equably, without regard for what specific time it is) cashes out as energy conservation; space-translation symmetry (Galilean invariance – the fact that laws of motion apply equally well to any inertial frame) results in momentum conservation. So conservation laws are just as causal, just as metaphysically efficacious as dynamical laws. If one breaks a conservation law, one also – necessarily – violates dynamical law. (In fact, *all* dynamical laws that possess the invariance concerned.)

Can we rescue the open-systems approach? Easily: instead of true annihilation or creation, 'mimic' that tactic by (supernaturally) transporting material between the physical universe and a non-physical repository. The conservation laws can operate globally, on the physical + non-physical together (i.e. execute the 'open-systems' tactic as Larmer does). But note that there is a price to pay here for maintaining that position. For if conservation laws are derivative of physical dynamical law, then extending conservation laws to encompass more than just

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the (physical) universe requires that other physical laws reach there as well. It is unclear whether this is a result that would be satisfactory, for now supernatural causes cannot be used to transfer matter or energy between the universe and other parts of the closed system. In other words, by allowing conservation laws into the non-physical, one must first let in dynamical laws – and that appears to effectively make the formerly non-physical portion of the universe physical. (We could call this 'the imperialism of the CPP'.) With Noether's theorem, the causal primacy of the physical appears to grant us effective causal closure of the physical, at least for these two tactics.

A loophole through effective closure

A quick summary: using a more moderate formulation of causal closure – the principle of causal primacy of the physical – we have not ruled out miraculous activity by fiat, but we have closed the loophole used by the 'open-systems' approach, prohibited 'exemption' attempts, and also prohibited other more egregious violations of natural law. These prohibitions were brought about by recognizing that the required miraculous activity was in fact under jurisdiction of causal natural laws. But CPP is not quite as strong as causal closure of the physical; specifically, it allows for supernatural influence over physically unconstrained (uncaused) events. This loophole is what the rest of the paper will exploit. The first section of the remainder of this paper discusses a replacement for the 'open-systems' tactic (Larmer's special-creation mechanism) in a deterministic (classical Newtonian or Einsteinian) universe, and the second section proposes a mechanism suitable for indeterministic (quantum or stochastic) universes.

In each case, I will argue that there are substantial means available to produce almost – almost! – any sort of miraculous phenomenon, while respecting CPP. (That is, as a limitation on God's activity, this restriction, self-imposed or not, might not be much of a restriction at all.) I will also comment on the specific capabilities and limitations of the mechanisms, and what other assumptions or requirements might need to exist for the production of such miracles.

I must emphasize that none of the following implies anything of consequence, as far as I am aware, to the *epistemic* dimension of the discussion: whether miracles can be law-abiding or not, or respect a variety of causal closure or not, does not seem relevant at all to our detecting them, or to our ability to collect evidence either for or against them.

Miracles in a deterministic universe

The possibility of law-abiding miracles in a deterministic universe has been explored by many authors; Moses Maimonides (Kasher (1999), 32) and St Augustine (Burns (1981), 243) might be read as defending it (and in fact defending

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a version more closely allied to the following than Larmer's). The general idea here is that divine intervention can be exercised, in compliance with natural law, simply by setting up the deterministic system – *at its inception* – to achieve the miraculous effect through the law-like progression of events. In Larmer's words, instead of altering dynamical evolution of natural systems, we must 'change the material conditions to which the laws of nature apply' (Larmer (1996a), 42) – but in a manner that respects the Noetherian connection between conservation laws and dynamical laws.

In most deterministic systems, natural laws play the role of determining how the system evolves, given the initial set-up or arrangement. But the specification of the initial configuration of the system is not something that is typically restricted, in any fashion, by natural law. Larmer uses this idea to argue for miracles as special-creation (or annihilation) events. Virgin births, resurrections, etc. can all be conceived of as instantaneous saltations of material which are then governed by the usual laws. But we saw that this ran foul of a moderate causal closure principle, the CPP. Nevertheless, there is a more subtle way such miracles could be brought about, using the same general schema – just by placing more emphasis on the *initial* in initial conditions. That is, specify the initial conditions *of the universe* (if possible) in such a way as to guarantee, through the normal and lawful evolution of the system, that the intended effect(s) are manifested at the desired time(s). (Contrast this with Larmerian saltation, which suggests a temporally proximate intervention.)

How could this tactic improve on Larmer's variety of miracle production? First, note that it still does not pass causal closure of the physical (CCP): initial conditions, whether they are 'locally' initial (Larmerian) or 'globally' initial (beginning of the universe), are physically without cause. So supernatural participation in their formulation appears ruled out by CCP. But it is allowed by the CPP, in contrast to the Larmerian version, because at the global initial condition (we are hypothesizing) *no* dynamical laws applied to *anything* (for there wasn't yet anything for them to apply to). So, the same things that CPP rules out for temporally-proximate miracles are fair game at the very start of the universe. Only global initial conditions can be set (or re-set) without concern for conservation laws, because only then are initial conditions truly without physical cause or constraint.[2]

Statistical mechanics, chaos and latent anti-thermodynamicity

Is such a specification possible? Can one arrange initial conditions to bring about miraculous events? (How can fiddling with the Big Bang help in any way to produce wine out of water?) In the following, I will describe two mechanisms for CPP-respecting miracles that work in the same general fashion: they rely on determinism to uniquely (causally) connect the desired effects to a specific (global) initial condition, and the (macroscopic) innocuousness of such

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'specially engineered' initial conditions from similar systems and states that do not produce the miracle. We will discuss statistical mechanics and chaos, in turn.

Statistical mechanics is the successor theory to thermodynamics, the science of work and heat. It accounts for the behaviour of systems by connecting their macroscopic properties, such as temperature, with the statistically typical behaviour of their microscopic components. For example, the temperature of a gas is defined as, and determined by, the average kinetic energy of the molecules composing that gas. The exact microscopic behaviour of a particular gas cannot (practically) be known to any substantial degree of precision; we only typically have very limited epistemic access to its macroscopic properties. To obtain predictions of the evolution of macroscopic properties, statistical mechanics averages over the law-like evolutions of the myriad possible microscopic arrangements compatible with those macroscopic properties.

As a simple example, consider a well-shuffled deck of cards. The 'microscopic' state of such a deck is the exact specification, and order, of all the fifty-two cards in it. The 'macroscopic' features would be, say, poker-hand descriptions such as 'full house' or 'spade flush'. Most times such a deck, when dealt, will result in relatively innocuous poker hands. (Perhaps a pair here or there, very rarely anything of more value.) In fact, if we assume the cards are well shuffled, we can specify quite precisely what the odds are for any sort of hand to be dealt. But, some shuffles, just by coincidence, will have a microscopic arrangement that produces a statistically unusual, but still perfectly lawful, macroscopic result: a dealt straight, or four of a kind. There is nothing law-violating occurring here; it is simply the same dynamical laws (the same rules of dealing cards) that are acting on an especially atypical initial arrangement (a 'stacked deck') of cards.

So, crudely, statistical mechanics infers future (macroscopic) behaviour of a system from its current (macroscopic) behaviour, assuming the particular system's microscopic composition and behaviour is 'typical'.[3] But, there are 'atypical' systems that appear, macroscopically, to be typical thermodynamic systems, but – because of their atypical microscopic arrangement – will (lawfully) diverge from the (statistical) predictions of future behaviour. (Just like a 'stacked' deck looks superficially similar to a truly shuffled deck, until it is dealt.) It is these unusual, but still law-abiding states, that could be a source of law-abiding miracles in a deterministic universe.

For example, we could explain the parting of the Red Sea, in the same vein as Maimonides, using this more contemporary understanding of physics. The arrangement of molecules of seawater – their microscopic state – is highly underdetermined (largely unspecified) by the macroscopic properties of the sea. It could be that a very calm sea is actually in a highly atypical microscopic state: one where, at some specific time, the individual molecules of seawater independently jostling each other, all rebound off a partner, or series of partners, sending them and those partners off in two opposite directions. (Think of a sea, divided by two

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partitions. Remove the partitions, and the sea flows together. The colliding molecules that initially had great opposite momenta rebound in various directions, and the macroscopic state of the water evolves towards a calm sea. Now: run that backwards. Initially apparently uncoordinated jostlings of molecules suddenly organize; collisions between molecules no longer result in a uniform spread of outcomes, but instead all result in the colliding molecules parting ways in the same two directions. The sea parts. Now, engineer this special sea-state into the very beginning configuration of the universe, and *voila*!) This mechanism is preferable to the Larmerian mechanism on two partly aesthetic and partly physicalist grounds. First, it is just more subtle in approach – no crass annihilation or creation of uncountable gallons of water, for example. Second, it seems more in line with our intuitions about what it really means to obey physical laws, as we attempted to encode in our variant of causal closure, the CPP.

Turning water into wine would also be quite manageable under this method. In this case, we'd need to rig some unlikely motions into scattered Merlot-molecules in the region around the glass of water. Some ordinary evaporation of alcohol from other wine glasses in the vicinity might be miraculously jostled into the water, rather than uniformly dissipating into the atmosphere. Other necessary molecules might be assembled/created from unusual collisions between otherwise innocuous atoms in the vicinity, and then transported into the glass via the same sort of jostling as the evaporated alcohol. Impurities within the water (dissolved minerals, dirt, etc.) could be a resource for assembling Merlot-molecules as well. (Note that wine – or any liquid drink we consume – is mostly composed of water, with only a small fraction, by weight or volume, of other material. The quantity of material that might need to be carried by the air, into the glass, could be kept below our threshold for visual detection quite easily.)

It must be stressed here that, on even the most modest execution of such a miracle, the precision of the initial condition arrangement upon which success depends is incredibly high: The vast majority of micro-states are 'thermodynamic' (non-miraculous, typical) ones. Only an infinitesimal proportion ('measure zero', in technical terms) are atypical. So, to execute such an event seems easily to demand a divine command, and knowledge, of micro-states. The difficulty is only exacerbated when we are required to specify and institute these latent correlations *in the initial conditions of the universe*, rather than intervening at some temporally proximate time to establish the intended arrangement.

Another scientific theory which we may exploit to argue for this alternative to Larmerian special-creation miracles is chaos theory. Chaos theory is a theory about deterministic systems – systems that follow unique evolutions, given a specified initial setup. The 'chaos' involved here is not a metaphysical chaos, contrasting with lawfulness; it is a chaos of unpredictability. One popular example we all have personal knowledge of is the weather: meteorologists can predict very confidently what the weather will be tomorrow (you or I could

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predict the next few minutes with moral certainty!), but that confidence diminishes rapidly as we push predictions further into the future. But (assuming for the moment we do indeed live in a deterministic world) this failure is not because of some metaphysical indeterminateness to next month's weather. It is because (goes the story) the weather is a chaotic system, and its future evolution depends quite sensitively upon the exact state at present – a state we have only limited epistemic access to, a state we can only specify to finite precision. (Note the similarities here with the statistical mechanics discussion, above.) For chaotic systems, even states that are infinitesimally different in their initial specifications will, with some degree of rapidity, diverge in their future evolutions.

A simple example of a chaotic system would be a pencil, balanced on its sharpened tip. Release the pencil, and it will surely fall – but in which direction? The direction it eventually falls depends very sensitively on its centre of gravity; any small departure triggers a fall in a particular direction. This could be the result of imperfect balancing in the first place, but could also come from air currents, light pressure, or any other miniscule disturbance. But, the point of chaos theory is that we have imperfect access to any state's specification – our precision is necessarily exhausted at some decimal place or other – yet the final resting place of the pencil may depend on the value of the next decimal, or the one after that. In the case of the pencil (if it is truly chaotic), increasing our abilities to precisely specify and put the pencil in an initially balanced state will surely keep the pencil balanced for longer. (Think of how quickly a sloppily balanced pencil falls over.) But, in the end, the pencil will fall: and where it falls, we will not be able to predict.

There are two key elements to chaotic systems that are relevant to our discussion: (1) initially very similar chaotic systems eventually diverge quite rapidly in the future; and (2) the closer two systems are in their initial states, the longer it takes for the divergence to manifest. This should remind you of our preceding discussion about statistical mechanics as a method to institute miracles: both are utilizing the same general 'loophole' I remarked upon earlier. In this case, one with sufficient control and precision over the initial conditions of a chaotic system may be able to institute an evolution that, for a long time, is indistinguishable from other systems with similar (very similar) initial conditions. But, because of the chaotic nature of the system, at some point its evolution will differentiate that system's properties from its kin's.[4] A divine intervenor could use such intrinsic unpredictability to cloak His actions in arranging the initial conditions to be 'just so', without violating any natural laws (in fact, crucially depending upon their deterministic perfection!).

Capabilities and limitations of deterministic miracles

There are, of course, caveats to be made here: not *everything* is possible through these two mechanisms. And there are difficulties, both practically and philosophically.

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As illustrated by the example of the parting of the seas, fairly impressive occurrences can be engineered through this mechanism. The shared characteristic of these sorts of events is simply that they are strictly law-abiding, but *hugely unlikely* – given 'normal' conditions. But the assumption of typical (global) initial conditions is one that determinism does not necessitate, and does not restrict in any substantial way. But restricting ourselves to initial conditions still gives us plenty of room, especially if one can use statistical mechanics or chaos to cloak the specialness of the initial conditions, until their manifestation is required.

A sample follows of what can in principle be done.

(1) Levitation – but not by suspending gravity! Winds focused specifically on the underside of one's feet may, if sustained, be sufficient to lift any weight. (The winds would just have to be sufficiently fast – not a true obstacle.) However, this may result in quite a gusty environment, as the spent wind needs somewhere to go – unless the wind is engineered to have a specific, unobtrusive exit trajectory (as it could.) An initial push could be given by the ground, as well – just a statistically fantastic coincidence of the ground's molecules' natural microscopic movement being in coordination.

(2) Saltation/creation: Though typically a lawbreaker, given the laws of conservation of mass/energy and causal closure, a reasonable facsimile could be cobbled together. Already existing atomic or molecular components could spontaneously assemble themselves into the desired object, from apparent nothingness (as long as the components were not especially visible when suspended in air currents or on the ground). For example, only around 24 per cent of our bodies, by mass, is not oxygen, hydrogen, or nitrogen (all naturally present in air). So, to produce a 170-pound man via saltation, the air would have to swirl together around 40 pounds of ash (primarily carbon), and coordinatively arrange it into a human body along with nitrogen and water vapour present in the air.

(3) Revelations/apparitions: These could be produced in several ways, depending upon how ambitious one (or One) is. Private revelations need only impact the brain; public experiences may be accomplished by the same feat (in each observer), or by an actual outside-the-head event. Personal mental revelations need only arrange for small electrical disturbances in the brain, perhaps through latent chemical imbalances. If no physical/tangible interaction with the apparition is required, then public illusions could be easier than saltation: only enough atoms would be required to create an illusion or spectre of the objects or events. The generation of sound would also not be difficult

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(as that is just the coordinated movement of air's constituent molecules).

(4) Stopping the Sun's motion in the sky (i.e. stopping the Earth's rotation): a little trickier, indeed. The basic problems here would be: (a) finding enough material to house the angular momentum of the Earth for the duration of the stoppage (and then restore it!), and (b) reducing/compensating for the jerk of the stoppage.[5] That is: we could easily get the Earth to stop rotating by transferring its angular momentum to something else, just as we could levitate someone by transferring the momentum of the wind to their soles. But the difficulty here would be in finding that something else – the space the Earth travels in is quite sparse in terms of candidate material, especially when compared to the Earth's mass.[6] Not conclusively physically impossible, but perhaps a public visual illusion would be more manageable.

But these are merely physical possibilities, speculations: to be feasible, even for someone with control over the minutiae of the initial conditions of the universe, such events must be causally linked to those initial conditions, using the mechanisms we discussed earlier. Using statistical mechanics' route, rigging the evolution of a system to be apparently normal, until the anti-thermodynamic, miraculous event is required, seems most generally applicable. Chaotic systems, though perhaps common, are likely not persistent enough to last from the start of the universe to the present day; they must also be carefully situated and crafted to be in a position to have their chaotically divergent evolution matter. That is, we have examples of many chaotic systems around us – the balanced pencil is (or could be) a ubiquitous phenomenon. But, in addition to this chaos, we need it 'hooked up' in the right way to other events that will produce the miracle – unless having a pencil fall *just so* is the miracle we're interested in producing. The basic problem: most chaotic systems' chaotic properties don't seem very relevant, directly or indirectly, to human life.

It seems that statistical mechanics is the most promising route, for it promises us the possibility of engineering facades of normal behaviour, under which miraculous (but law-abiding) capabilities lurk. As the brief listing above indicates, there seems to be not much that is outside the power of a carefully rigged microstate. However, there do seem to be at least conceptual and philosophical problems with such a mechanism: even the more modest miracles premised on determinism *are* premised on determinism, which has a quite notorious relationship with free will, a cornerstone of many theologies. But, even if one resolves such philosophical difficulties with determinism in general, even the most modest interventions appear to require a quite massive intervention and

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recruitment of the surrounding material to achieve the miracle. The point is that, even though the effect may be quite isolated, the causes required to produce them are quite extensive: though a saltation may gather material from the immediate vicinity, the impetus provided to the air to pick it up comes from somewhere, and that comes from somewhere, and so on, all carefully tailored for the desired effect – *all the way back to the beginning of the universe*. This may create a specific problem with free will, perhaps more acute in this case than the general problem of reconciling determinism with freedom: free agents appear to be required as 'instruments' of a miracle in a wholly new and unintuitive way – our micro-states (and not our macroscopic actions) may have to be part of the engineering of a miracle. This is something completely different from the typical understanding of being an instrument of God's will, in that he caused you to raise your arm just so, etc. – now, we're talking about minute and specific tailorings of your micro-structure that may remain quite unapparent, even after the miracle is produced. How does this impact our ideas of agency and free will?

Another problem may concern the deceptiveness of this general mechanism (of an atypical micro-state disguised as a normal system). The apparent ease with which one may arrange for departures from the statistically overwhelmingly likely behaviour of, well, anything, may create substantial problems for our epistemologies in the face of an interventionist deity. One may make the argument that, by exploiting a latent micro-state to create a miracle, the divine is deceiving us substantially about our surroundings. Note that this deception is markedly different than that of a Larmerian miracle, or a miracle produced by another more blatant circumvention of natural law. The occurrence of a miracle (identified as such, or not) would cause us to question some laws of nature, to doubt our understanding of nature's workings. But this mechanism seems most corrosive to our beliefs after we find out it was a miracle (if such a diagnosis is possible, rational or empirically justifiable), for only in this mechanism is the influence so pervasive. If God were to flagrantly break a law temporally proximate to the miracle – to produce a Larmerian saltation, or suspend gravity, perhaps – we might be able to isolate the damage to our scientific knowledge. (It was a 'one-off' thing; the law otherwise applies perfectly, etc.) But in this case, the interference is vast and subtle, involving insensible alterations to microstates throughout the history of the universe. Would we really be justified 'to continue for *practical purposes* to consider L a valid set of natural laws', (Basinger & Basinger (1986), 14) even if the event is non-repeatable? What impact might this have on our understanding of our relationship to the divine?

Indeterministic miracles

The previous section can be seen as an updated version of the Larmerian tactic of explaining miracles lawfully, hopefully made less objectionable to those

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tending towards physicalism. This section brings to bear some recent (post-1900) elements from both physics, and philosophy, to show another substantially different route to the production of miracles. This avenue for the production of miracles involves the concept of indeterminism. One can take Leibniz's (1714) assertion of the principle of sufficient reason as a repudiation of indeterminism, for indeterminism denies that there is always a sufficient reason for events being as they are.

The most empirically successful and well-supported theory ever produced by science – quantum theory – is an example of an indeterministic theory. There are properties and events that quantum theory says are strictly underdetermined – truly unfixed *possibilia*. Examples include the moment of atomic decay, where (exactly) a particle will be found, or what fundamental properties a particle might have when measured. But, it is important to note that quantum theory is not saying that such things are completely open: quantum theory is such a useful and accurate theory because it establishes very precise constraints and restrictions on the possibilities available to physical systems, even when it doesn't reduce the possibilities down to one (as a deterministic theory would). Quantum theory's great achievement is to turn possibilities into probabilities: it dictates which possibilities are open, and provides very (*very*) accurate odds for those possibilities. It only remains silent about which possibility will be actualized.[7]

As an instructive but surprisingly un-simple example, take a regular coin flip. We usually imagine that coin flips are random: they're indeterministic systems. The best we can do is give odds on 'heads' or 'tails'. But, if we wanted to, we could do much better than that: there are many ways to spoil the fairness of a coin flip (without actually biasing the coin materially, by 'loading' it). We could train our thumbs to flip the coin more consistently, resulting in a preponderance of, say, 'heads'. The supposed randomness of the typical coin flip comes not from the flip itself, but from the initial conditions of the flip and our ignorance of them (Peterson (2004)). So coin flips are really quite deterministic, and *not* a good example of indeterminism. But (regardless), it is an accessible, intuitive example, so let's imagine that we have a 'quantum' coin that is, actually and honestly, indeterministic in its flips: the process is truly random, such that we can't, even in principle, cheat. Now, just because this coin is indeterministic doesn't mean that all possibilities are open, or that they are all equally open: a fair coin has a substantial restriction on its behaviour! It must land, on average, 'heads' 50 per cent of the time. So, there is no restriction on an individual toss, for a truly indeterministic coin – no fact of the matter about how it will land – but there is a collective constraint on a series of tosses.

So, of what relevance is a coin flip to miracles? Simply this: because indeterministic physical laws only partially constrain physical reality, there could be some room here for divine intervention to influence the remainder. If

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coins were, in fact, truly indeterministic systems, then perhaps there is room for supernatural interference in coin tosses, without running foul of the (non-dogmatic) physicalist's intuitions. First, we should note that the hard-core physicalist (one who identifies with the causal closure principle in its original form) will be just as unsatisfied with the divine mucking about with coin flips as they are with the interference in (global) initial conditions. The very fact that indeterministic events lack a (physical) causal story is what conflicts with the CCP: physically *un*caused events cannot have any other cause.

What about our newly-proposed principle – the causal primacy of the physical (CPP)? This only requires that supernatural (or more generally non-physical) causes operate without conflicting with physical causation. This seems a natural fit: in indeterministic cases, physical law explicitly disavows a role in some aspects of the determination of nature. Indeterministic laws, such as the fair coin-flip ones, only fix *some* aspects of fair coin-flip systems. The parts that remain unfixed could be influenced, apparently without any conflict.

As another example, let's return to the transmutation of water into wine: if the universe is indeterministic, could this method be used to achieve a transmutation? Yes. All it would require (!) is some fantastically unlikely events, possible under quantum theory, but staggeringly improbable. The most likely methods would exploit the Heisenberg uncertainty relations: the fact that quantum objects' positions are not as determinate as we ordinarily think, but instead 'spread out', de-localized, slightly. (Instead of fixing a definite location to any object, quantum theory defines a 'probability amplitude' for location, which though it may be very sharply peaked at a particular spot, nevertheless is non-zero everywhere. In plain English: every thing has an infinitesimal, but non-zero, chance of 'teleporting' to an arbitrary location.)

First, we could mimic the deterministic method of transmutation (carrying needed material from the surrounding regions via conspiratorial air diffusion). This time, instead of having to establish highly improbable initial conditions at the Big Bang that lie latent and undetectable until the moment required, we can institute the highly unlikely conspiracy more proximately to the desired effect: just take advantage of the uncertainty inherent in air-molecule positions and motions to tweak their trajectories enough to use them to guide the needed merlot-molecules to the glass. As a second, more ostentatious option, we could instead exploit the Heisenberg uncertainty relations to 'quantum teleport' an entire glass of wine into the glass of water (and 'teleport' the water out).[8]

But there are significant niceties to be worried about: God could not simply decide to make every (fair) coin flip turn up 'heads', because *that* would conflict with the collective property of the whole class of fair coin flips that is (strictly) governed by natural law. And this loophole may be no loophole at all, depending upon the details of natural physical laws' metaphysical implementations of indeterminism. That is, there is a crucial element of probabilistic laws that could

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allow, or deny, the possibility of supernatural action: the interpretation of probability that is used in those laws.

Two theories of probability

Probabilities are everywhere, but not all probabilities are created equal. There are some, like those in real coin flips, that are merely expressions of our ignorance. There are others, like those quantum theory asserts exist, that pertain to metaphysical indeterminacy and the non-existence of certain facts in the world. God could intervene in events that are epistemically probabilistic, without our knowledge – but this would be a potentially law-violating activity, as epistemic probabilities are grounded in determined events that we are merely ignorant of. The loophole for supernatural action lies in ontic probabilities – perhaps. There is more than one interpretation of ontic probability that philosophers subscribe to, and it turns out (I shall argue) that the particular interpretation one does subscribe to might make a very big difference to the possibility of these sort of miracles in an indeterministic universe.[9]

The frequentist interpretation of probability views probability as applying not to individual events, but only to classes of events as a whole. Probabilities are meaningful, says this view, only when they are attached to a (hypothetical) infinite collection of relevantly similar systems, and interpreted as the frequency of the event's occurrence in that collection. So, a frequentist will make sense of a fair 'quantum' coin flip having 50/50 odds by (abstractly) placing that event in an infinite class of similar events which collectively has an equal frequency of 'heads' outcomes as 'tails'. (Biased coins belong in a different class of events, with a different collective frequency.)

In contrast, the propensity theorist views probability as applying to individual events: an indeterministic event has, in itself (somewhere), an innate, intrinsic propensity to actualize each of its possible outcomes. The frequentist's conception of probability as the frequency of an infinite collection, says the propensity theorist, derives (metaphysically) simply from the sum of the individual propensities of each event in the infinite collection. So, for the fair 'quantum' coin flip, the propensity theorist makes sense of things by saying that this particular coin flip has an inherent, localized potential to land heads and tails, and that those potentials are the same for all fair flips. Biased coins/coin flips have a different constitution, and therefore a different propensity to land 'heads' than a fair coin.

How does the interpretation of probability matter, to the possibility of indeterministic miracles? Frequentism provides room for divine intervention, and propensities do not. Because the frequentist's interpretation attaches probabilities – and law-like restrictions on natural behaviour – to infinite classes of events, not to particular events themselves, it does not relevantly restrict the behaviour of

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individual indeterministic events, such that divine intervention would conflict with those restrictions. On the other hand, propensities apply to, and inhere in, individual events: modifying or influencing an outcome would directly conflict with the causal operations of a propensity-type probabilistic law, and hence conflict with the CPP.

In the language of Leibniz, both interpretations agree that (for some events), there are no sufficient reasons for the event. But, the interpretations do affirm Leibniz's principle for one aspect of indeterministic events: they agree that there is sufficient reason for *the probabilities of* the event. That is, indeterministic laws may not fix (sufficiently cause) *events*, but they do fix *odds* of events – they do give reasons why the probabilities 'should be so and not otherwise'. Where the interpretations differ is in a more subtle application of Leibniz's principle: is there a sufficient reason for the probabilities of *this particular* event? Frequentism says 'no', propensity theory says 'yes'. Frequentism says that probabilities only apply to entire classes of events; to discuss the probability of a particular event's outcomes is meaningless, a category mistake. Propensity theory defines probabilities using individual events, and so affirms Leibniz's principle for individual events' probabilities.

Transmuting water into wine, then, would be something that might be permissible under a frequentist interpretation: the probabilities defined by quantum mechanics don't directly and specifically apply to *this* single glass of water and its immediate environment, but to a reference class of similar situations. This particular instance of water-in-a-glass may exhibit a very unusual (statistically speaking) evolution – really odd and unlikely possibilities are getting actualized. But that's OK – there is 'wiggle room' for that under the frequentist interpretation. But, if the quantum probabilities for the glass are taken as propensities, then the miniscule probability of transmutation (by any specific route) applies specifically to this glass of water. God's intervention to transmute the water directly contravenes that – it changes the probability of transmutation from close to zero, to 1 (certainty.)

So, the result of this foray into theories of probability is the conclusion that indeterministic miracles are possible only if we use a frequentist interpretation of probability; propensities will not allow divine influence to alter the probabilities of events without conflict, not even if such influences are undetectable by us. Frequentism leaves individual events' probabilities undefined, and only restricts the collective probability of all similar events, so supernatural action could alter or influence the outcome of one (or more) indeterministic events in the class, without conflict with the class's law-like constraint.

Capabilities and limitations of indeterministic miracles

As with the deterministic mechanisms for miracles discussed earlier, the loophole opened by a frequentist interpretation of probability is not unbounded.

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Currently, the indeterminism of quantum theory (our only scientific theory that currently postulates ontic probabilities) appears well confined to microscopic activity only; only very unusual circumstances (engineered by experimenters, in expensive and delicate machinery) boost this indeterminacy into the macroscopic realm, and only for brief periods. The indeterminacy of quantum theory seems only to reveal itself indirectly, rather than macroscopic events being obviously indeterministic. But, this sort of reasoning should be familiar: the assertion that the microscopic is irrelevant to the macroscopic was precisely what we denied in the deterministic case. Usually – overwhelmingly likely, in typical cases – the exact behaviour of the microscopic constituents does 'wash out', and become irrelevant to the macroscopic behaviour. But this need not always be the case.

In the deterministic scenario, I argued that a careful selection of initial conditions could establish a microscopic state that would appear macroscopically typical, until its atypicality manifested itself. In the indeterministic case, divine intervention might be able to take a system that is both macroscopically and microscopically typical and nudge it into a macroscopically indistinguishable, but microscopically atypical state. So, instead of setting things up right at the start, to co-ordinate at a later time to produce a miraculous event, the indeterministic method is to intervene temporally, guiding what might initially have been an unremarkable or irrelevant event towards being a miraculous one through perhaps a multitude of separate, microscopic interventions.

For example, parting an indeterministic sea could be accomplished by influencing the individual collisions. Indeterministic laws might restrict the possibilities of the collision (to, say, '40 per cent of the time, collisions like this make this particle go *this* way, 60 per cent they go *that* way'), but for crucial collisions, He could ensure they resulted in the right collision result to establish the cooperation needed to have the water recede.

This sort of intervention would be both much less and much more extensive than the deterministic variety. Indeterministic interventions would be comparatively less extensive, as the interventions would be temporally proximate to the intended miraculous event rather than involving a chain of causation reaching back to the beginning of the universe. However, instead of one single intervention (the establishment of the correct initial condition), indeterministic miracles would generally require many and repeated interventions to establish and maintain the desired path of events. This is because of the indeterminism: we (He) could not simply tweak things once to set them in motion, then step back to watch things unfold, because the way they unfold will likely be substantially dependent upon other indeterministic events. Supernatural activity may be required to ensure that continuing indeterministic processes to not derail the miracle.[10]

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Again, though, it is easy to go overboard with the possibilities here: if (as quantum theory says) all microscopic activity is in some respects indeterministic, then could the supernatural not really 'let loose' and comprehensively rig indeterministic processes to guide any system along a strictly lawlike, but extremely unlikely path? Is there any reason why the divine would be constrained to operate only at crucial junctures where some relatively small tweaks could accomplish the goal? (Why opt for subtlety, when extravagance also works?) After all, any finite interference in results would not affect an infinite collection – change one, two, 3 million coin tosses to 'heads', and the infinitely large class of coin tosses still has a frequency of 50 per cent 'heads'. Doesn't this disconnect between finite collections of outcomes, and a frequency derived from an infinitely large collection, give us arbitrary leeway to fix results the way we desire? (Even if, somehow, our finite number of tweaks impacts the infinite average, couldn't we simply restore the original frequency with *more* intervention, by (say) tweaking some unimportant coin tosses to land 'tails' to compensate for all the 'heads' we made?)

I think there are two reasons to answer 'No' to these questions: one philosophical, one theological. The frequentist interpretation relies on all these events that are collected into the same reference class being relevantly similar; there are established, technical criteria for constructing these reference classes. Simply: we wouldn't want to allow some biased coin flips into our fair-coin-flip class. We need ways to exclude those biased events from our reference class, so we get the correct frequency. One of these technical criteria is that finite subsets of the infinite set of events 'resemble' the infinite set in certain ways: that parts of the collection don't, mathematically, look different than the whole collection. Of course, demanding that any given subset of the fair coin-toss collection give you exactly 50 per cent 'heads' is too strong a requirement for this resemblance. The criterion of resemblance is more mathematically subtle than that, but may achieve the aim of excluding pervasive influences on probabilistic outcomes, even for a frequentist interpretation. The supernatural intervention might have to remain subtle (i.e. rare) to fit through the frequentist loophole.

The theological reason is similar to that raised in the discussion of deterministic miracles: a comprehensive rigging of outcomes at the microscopic level, to produce a macroscopically significant change, risks a charge of deception. Though perhaps following the letter of natural law, wouldn't such massive interference and invalidation of the elsewhere amazingly accurate statistical predictions of those laws be troubling? For, though quantum theory (and statistical mechanics) admit to the possibility of many unusual occurrences, they both bestow precise probabilities to such occurrences, and they are *miniscule*. That such an amazingly improbable, though strictly not impossible, event occurs would not logically conflict with the truth of our theory, it would most definitely be powerful evidence against its accuracy. Such unsubtle interventions would most certainly give us

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excellent (but incorrect) justification to doubt the empirical support of our theories. Would this be an acceptable side-effect of such miracles, to sow real, rational doubt in the laws that the intervenor took great care not to violate?

Concluding remarks

One further limitation to note briefly is the exclusivity of these two general mechanisms for producing miracles. Of course, the indeterministic method – exploiting frequentism's under-determination of individual events' probabilities – can't work in a universe without irreducibly chancy events. But note that the deterministic method can't be (effectively) used in an indeterministic universe, either. The precision we require of the initial conditions, to produce a latent manifestation of a statistically unlikely state, will be consistently and reliably undermined by the effects of indeterministic processes. The exact specification of the initial state that is required for the miracle will be washed out by chance processes with overwhelming likelihood.

Though I have tried to stress this throughout the essay, it is worth reiterating that we cannot underemphasize the knowledge required to execute miracles, both in degree and kind. Obviously, engineering such things will require a vast quantity of information, on an order of magnitude certainly unachievable and also likely inconceivable to most of us. The number of molecules in 1 gallon of seawater is on the order of 10^{23} – that's 1 million billion billion things to keep track of. But that's not really the most daunting aspect of miracle engineering: it's the *quality* of information that truly staggers. For we do not merely require rough estimations of those molecules' locations, nor even extremely precise, femtometer-scale (10^{-15} metre) error bounds (which are safely far beyond our capabilities, now and in the foreseeable future). What we require, for either mechanism, is *exact* precision: real numbers (in the mathematical sense), not decimal approximations to any finite degree. This is because the atypical states of statistical mechanics, or the desired probabilistic outcome, reside in a proper continuum of states, and their immediate (mathematical) 'neighbourhood' consists entirely of undesirable (i.e. non-miracle-producing) states. So there is no such thing as 'close' when it comes to specifying initial states, or tweaking probabilistic outcomes: there's either perfection, or failure.

Another requirement that we rely on, in order to accomplish significant miracles (significant to the macroscopic world – specifically, humans) is some sort of 'magnifier' mechanism. For one could have the power and knowledge to engineer microscopic happenings as desired, but unless such machinations result in macroscopic effects, this would only remain a curiosity. Chaos seems to be the natural magnifying mechanism, in both the deterministic and indeterministic cases – chaotic systems are those with that inherent characteristic that initially

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similar states differentiate rapidly. This allows for a very small change, made at the microscopic level, to have profound macroscopic effects in the future. This is the sort of thing we require for the microscopic action of interventions to become relevant: 'sensitive' systems.

But, not all (not most?) systems or properties are chaotic/sensitive: though a pen balanced on end is a chaotic system in some respects (e.g. its orientation after it falls), it isn't in others (e.g. its material properties and approximate location). Some systems (or, some aspects of systems) are what we might call 'damped' instead: they tend to eliminate or reduce dissimilarities between initially dissimilar states, e.g. your digestive system efficiently extracts nutrients and energy from a wide variety of foods. (Changing what you ate for breakfast – within reason (!) – won't affect your daily activities one whit. The inflationary period of cosmological evolution that is responsible for the uniformity of the cosmic background radiation is an extreme example of a damping mechanism.) If all systems and properties of the world had characteristically damped behaviour, then it seems quite unlikely that any of the mechanisms we discussed would be successful in producing miracles. But, it seems evident that there is a substantial proportion of sensitive systems and properties; whether they are sufficient and extensive enough to allow for either type of miracles is unclear, however. Without a natural magnifier like chaos, the macroscopic effect would have to be engineered 'by hand' – as in the uncountable number of indeterministic interventions required to guide individual merlot-molecules into the water glass.

Summary

We need a more perspicuous, intuitive and non-question begging closure principle to discuss fruitfully the possibility of law-abiding miracles, and the principle of causal primacy of the physical (the CPP) seems a good candidate. Larmer's saltation-miracles are less intuitively egregious than miracles that alter the dynamical course of events (whether we see such as truly law-violating, or just law-exempt), but they still run foul of the CPP when the connection between conservation laws and dynamical laws (i.e. Noether's theorem) is properly appreciated. Yet, CPP does not preclude the possibility of miracles in an a priori fashion as CCP seems to; we can find loopholes where current physical theory may be reconciled with divine activity at the metaphysical (rather than just the epistemological) level. The character of both the deterministic and indeterministic versions of the loophole is that there are physically uncaused, or insufficiently physically caused, events that CPP will allow the supernatural to influence (as long as such influence doesn't frustrate physical causes). Both mechanisms rely on the idea that important but macroscopically innocuous changes can be instituted at the microscopic level, and that such changes can

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later manifest themselves in strictly law-abiding but extremely unusual and apparently law-violating occurrences.[11]

References

ALBERT, DAVID Z. (1994) *Quantum Mechanics and Experience* (Cambridge MA: Harvard University Press).

BASINGER, DAVID (1984) 'Miracles as violations: some clarifications', *Southern Journal of Philosophy*, **22**, 1–8.

BASINGER, DAVID & RANDALL BASINGER (1986) *Philosophy and Miracle: The Contemporary Debate* (Lewiston NY: Edwin Mellen Press).

BURNS, ROBERT M. (1981) *The Great Debate on Miracles: From Joseph Glanvill to David Hume* (Lewisburg PA: Bucknell University Press).

COLLIER, JOHN (1996) 'Against miracles', in R. Larmer (ed.) *Questions of Miracle* (Toronto: McGill-Queen's University Press). Originally published in *Dialogue*, **25** (1986), 349–352.

FLEW, ANTONY (1967) 'Miracles', *The Encyclopedia of Philosophy* (New York NY: Macmillan), V, 346.

HAWKING, STEPHEN (1993) *Black Holes and Baby Universes* (New York NY: Bantam Books).

HOWSON, COLIN & PETER URBACH (1993) *Scientific Reasoning: The Bayesian Approach* (London: Open Court Publishing Co.).

KASHER, HANNAH (1999) 'Biblical miracles and the universality of natural laws: Maimonides' three methods of harmonization', *Journal of Jewish Thought and Philosophy*, **8**, 25–52

LARMER, ROBERT A. (1996a) 'Miracles and the laws of nature', in *idem* (ed.) *Questions of Miracle* (Toronto: McGill-Queen's University Press). Originally published in *Dialogue*, **24** (1985), 227–235.

(1996b) 'Against ''Against miracles''', in *idem Questions of Miracle*; originally published in *Sophia*, **27** (1988), 20–25.

(1996c) 'Miracles and conservation laws: A reply to Professor MacGill', in *idem Questions of Miracle*; originally published in *Sophia*, **31** (1992), 89–95.

(1996d) (ed.) *Water into Wine?: An Investigation of the Concept of Miracle* (Toronto: McGill-Queen's University Press).

LEIBNIZ, WILHELM (1714) *The Monadology*. Also available at: http://www.earlymoderntexts.com/pdf/leibmon.pdf

MACGILL, NEIL WHYTE (1996) 'Miracles and conservation laws', in Larmer *Questions of Miracle*; originally published in *Sophia*, **31** (1992), 79–87.

MCKINNON, ALASTAIR (1967) 'Miracle and paradox', *American Philosophical Quarterly*, **4**, 308–314.

NOETHER, EMMY (1971) 'Invariant variation problems' (M.A. Travel, Trans.), *Transport Theory and Statistical Physics*, **1**, 183–207 (original work published 1918).

ODEGARD, DOUGLAS (1982) 'Miracles and good evidence', *Religious Studies*, **18**, 37–46.

PETERSON, IVARS (2004) 'Heads or tails?', *Science News*, **165**. Also available at: http://www.sciencenews.org/articles/20040228/mathtrek.asp

SKLAR, LAWRENCE (1993) *Physics and Chance: Philosophical Issues in the Foundations of Statistical Mechanics* (Cambridge: Cambridge University Press).

SWINBURNE, RICHARD (1970) *The Concept of Miracle* (London: Macmillan).

Notes

1. See especially Collier (1996) and McGill (1996), objecting to Larmer's special creation miracles.
2. If it turns out that there is physical restriction on the Big Bang or global initial conditions, then we likely will have problems with this version of deterministic miracle as well. One possible source of such a difficulty is the so-called 'no-boundary' proposal of Hartle and Hawking (Hawking (1993)).
3. This is usually a very reliable assumption – on most mathematical measures of phase space, the space containing all possible microscopic arrangements, the 'atypical' microscopic states are of measure zero. This is not to say that the assumption of typicality is without controversy. See Sklar (1993) for a discussion of this central issue in the philosophy of statistical mechanics.

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4. It seems unlikely we could use this route to turn water into wine; glasses of water are not chaotic in a way we can exploit for this effect. (Now, the pattern of ripples on the surface: that may well be chaotic. But, the composition and arrangement of molecules composing the water – we have good reason to believe that is dynamically non-chaotic.)
5. 'Jerk' is the technical name for the rate of change of acceleration. One doesn't feel anything strange in an elevator in smooth, steady motion – no acceleration. One may also find it very hard to detect an elevator that is smoothly accelerating. But one always knows when an old, poorly maintained elevator is on the move – not because it's accelerating, but because the acceleration is changing rapidly. Minimizing jerk (while maximizing speed) is also the main issue in amusement park rides. (It's not the acceleration or speed that's dangerous, it's the jerk.)
6. The interplanetary vacuum is quite good: ~10 particles per cm^3. The most significant inhabitant of near-Earth space is the solar wind – matter streaming outward from the Sun. Even the largest of the Sun's coronal mass ejections (associated with solar flares) – carefully targeted on the Earth instead of being relatively diffuse clouds – could only provide about 10 per cent of the momentum required to stop the Earth from rotating. (Never mind arranging for an equally large coronal mass ejection to get the Earth restarted again.)
7. Actually: it says there is no fact of the matter about which possibility will be actualized. Quantum theory is very difficult to reconcile with an 'ignorance interpretation' – the view that there actually is a fact of the matter about which possibility will be actualized, but that fact is just epistemically inaccessible to us. See Albert (1994) for a discussion.
8. Why is the second approach 'more ostentatious'? Because the location of any particle is sharply peaked, influencing its location or trajectory slightly is not doing as much violence to the probabilities as a wholesale shifting of billions of molecules to places they are fantastically unlikely to be. It may not take anything more than very slight probabilistic nudges in the first method to achieve the desired results.
9. See Howson & Urbach (1993) for more discussion on theories of probability.
10. Quantum theory asserts that there are non-zero chances – very small, but still non-zero! – for even macroscopic objects to do very weird things, like teleport instantaneously. The divine intervenor would at least have to police such small possibilities out of existence to ensure that the miracle comes off as planned, as well as prevent more likely derailing events.
11. I would like to thank the referees of this journal for helpful comments on an earlier draft of this paper, and the support of my colleagues at Montclair State who listened to and read early drafts. I would specifically like to thank David Benfield, whose own curiosity prompted this investigation.

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