

QUANTUM MECHANICS, TIME, AND THEOLOGY: INDEFINITE CAUSAL ORDER AND A NEW APPROACH TO SALVATION

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Abstract. Quantum mechanics has recently indicated that, at the fundamental level, temporal order is not fixed. This phenomenon, termed Indefinite Causal Order, is yet to receive metaphysical or theological engagement. We examine Indefinite Causal Order, particularly as it emerges in a 2018 photonic experiment. In this experiment, two operations A and B were shown to be in a superposition with regard to their causal order. Essentially, time, intuitively understood as fixed, flowing, and fundamental, becomes fuzzy. We argue that if Indefinite Causal Order is true, this is good evidence in favor of a B-theory of time, though such a B-theory requires modification. We then turn to theology, suggesting that a B-theoretic temporal ontology invites serious reconsideration of the doctrine of salvation. This paper concludes that the best explanation for salvation given a B-theory is mind-dependent salvific becoming, a type of psychological soteriological change that occurs through downward causation.

Keywords: B-theory; Indefinite Causal Order; Quantum Mechanics; Salvation; Time

Despite ongoing debates regarding time's nature and structure, both the metaphysics of time and relativistic physics hold that the temporal order between two causally related events when viewed from a single perspective is fixed.¹ However, recent work in quantum mechanics suggest that, at the subatomic level, this may not be the case. In this paper, we examine the quantum phenomenon known as Indefinite Causal Order. The Indefinite Causal Order hypothesis applies the superposition principle to the order of events, widening the principle's domain from that of objects to that of temporal structures. It must be noted at the outset that the scientific term

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[*Zygon*, vol. 00, no. 0 (xxxx 2020)]

www.zygonjournal.org

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“causal order” refers to what would be philosophically deemed “temporal order.” We use the term set out by the scientific community. We then assess the metaphysical implications of Indefinite Causal Order, particularly with regard to the ontology of time. Finally, tracing the metaphysical consequences beyond the boundaries of physics, we suggest some implications for both morality and soteriology. We conclude that the repercussions of Indefinite Causal Order resonate far beyond quantum mechanics.

This paper emerges out of a dynamic interaction between a working scientist and working philosopher. It is motivated by a shared interest in the nature of time, an issue often neglected in interdisciplinary conversations between science and religion. Discourse between science and theology on the issue of time has been overwhelmingly focused on how the nature of time should inform our understanding of God’s relationship to time, and vice versa. The focus on God has brought forth some excellent work, particularly from authors such as William Lane Craig (2000a, 2000b, 2001) and Richard Swinburne (1993, 1996, 2008). Nevertheless, with the exception of Robert John Russell (2012), there is a significant gap in the literature when it comes to the issue of time and salvation. This paper is, therefore, cutting-edge into two domains. It employs recent data from quantum mechanics, which is yet to receive significant metaphysical engagement, and applies it to salvation, itself a neglected dimension of the “theology and time” debate thus far.

METAPHYSICAL SCENE-SETTING

Although the philosophy of time can be traced back as far as the Ancient Greeks,² the contemporary debate took its current form after J.M.E. McTaggart published *The Unreality of Time* (1908). This paper employs McTaggart’s distinction between A-series and B-series time to denote distinct temporal theories.³ The A-theory and B-theory are fundamentally opposed. The A-theory describes time as passing and the observer as somewhat static, while the B-theory describes events in time as coexisting while the observer moves among them.

The term *A-theory* typically denotes a tensed theory of time in which the properties *past*, *present*, and *future* are ontological properties of objects and events. There are two principle A-theories, presentism and the growing block.⁴ Presentists hold that existence entails being present, and only and all that exists are things and events simultaneous with an objective *now* (Mothershead 2011, 122). Presentism is committed to an objective, knife-edge present moment that functions as the axis of becoming. By becoming, we mean the dynamic process through which potential future events become real. The term knife-edge is appropriate to describe the present both because it is sharp and has very little extension, and because it divides the future from the past. The growing block is similarly committed to an

objective present moment at which point potential future events become real. However, where presentism restricts existence claims to the present, the growing block holds that present and past events are real, and the sum total of existing things and events forms a “block” that grows as “fresh slices of existence [are] added to the total history of the world” (Broad 1923, 66). The future remains merely potential until one (or the only, on a deterministic view) potential future becomes the actual present.⁵ Here, the term “A-theory” describes any theory in which time has the following properties: tensed truths are real and fundamental; time is dynamic in the sense that it flows, with successive moments possessing the objective properties of *future*, *present*, then *past*; there is an objective and universal present moment, at which point potential future events become real. The change in degree of the pastness of events “is not supposed to be merely a function of our (changing) perspective on reality: it is a feature of the way time truly is” (Pooley 2013, 322).

The B-theory, conversely, models time as relevantly similar to space in that all temporal points coexist. For this reason, it is dubbed the “block universe” view, as the metaphysical picture provided is (following Einstein’s relativity theories) that of a four-dimensional manifold uniting three dimensions of space with one dimension of time. In the block universe, time does not actually flow and temporal passage is a persuasive illusion. When you look out of the window of a moving train, for example, you perceive the landscape as flowing past you. This is not an ontological property of the space; it is a phenomenological property of your perception. There is no sense in which the various spatial points you currently observe are any more real than those you observed previously. The perceived dynamism is a result of your movement through the space as opposed to the space itself exhibiting flux. The B-theory models temporal passage as analogous to space in this way. The finer details of how this universe operates will generally be filled in by the prevailing physical theory,⁶ but a B-theorist must be committed to the claim that a complete account of temporal reality can be given with “an exhaustive catalogue of which events occur, and how they are temporally related” (Pooley 2013, 324).⁷

TIME IN QUANTUM MECHANICS

There have been several epochs in physics’ understanding of time. Pre-relativistic Newtonian physics, for example, described time as a fundamental flowing feature of the universe. Mechanics was formed within this framework as the scientific description of the laws that govern changing physical systems through time. The time therein was considered absolute, viz. it is universal, it is foliated into absolute simultaneity slices (regions of space with almost zero extension that are strung together by absolute time—all events on a slice occur at the same time and so are simultaneous),

and it flows equitably.⁸ The Special and General Theories of Relativity catalyzed a transformation in this understanding. Special Relativity revealed the nonexistence of absolute simultaneity and a variability between different observers' measurement of temporal passage that was not previously believed possible.⁹ Moreover, in General Relativity, "there isn't a preferred and observable quantity that plays the role of independent parameter of the evolution, as there is in non-relativistic mechanics" (Rovelli 2009, 3). Instead, spacetime itself is dynamical and exhibits curvature in accordance with the presence of matter and energy—this in turn affects the behavior of local clocks. In both theories, time is determined by local classical variables but is no longer understood as passing uniformly for all observers. Such a move marked physics' departure from the Newtonian conception of absolute and universal time. It appears that quantum mechanics promises yet a new epoch for time in physics.

Quantum mechanics is a formal theory with several interpretations. Until disputes between rival interpretations, each of which paints a slightly different picture of the nature of time, are resolved, time remains an open question. Answers may only be provided when a quantum theory of gravity is developed, in which a relativistic understanding of spacetime is incorporated into quantum mechanics.¹⁰ When describing the large-scale interactions of massive bodies in curved spacetime, General Relativity models time as continuous. Quantum mechanics describes the counter-intuitive behavior of subatomic systems; it introduces discreteness into a multiplicity of properties, for example, energy and length. The need to reconcile what these disparate understandings mean for time is known as "the problem of time" (Muga et al. 2008; Anderson 2017). In recent years, several possibilities have been advanced. The purpose of this section is to set out, briefly and broadly, alternative understandings of time in quantum mechanics before focusing our attention on the specific quantum phenomenon with which we are concerned.

One alternative, advanced by Rovelli, holds that a fruitful search for a quantum theory of gravity requires physicists to "forget time." Rovelli argues that to give a fundamental description of nature "we must forget the notion of time altogether, and build a quantum theory of gravity where this notion does not appear at all" (Rovelli 2009, 1). Time may then be reconstructed in particular situations, despite the fact that it must disappear when moving to a deeper level of description. Rovelli urges his colleagues to take General Relativity's lack of a preferred independent time notion seriously, viewing mechanics as describing the relative evolution of variables (and not, as in the Newtonian picture, the evolution of a system in absolute time). Time, then, is understood as an emergent property of macroscopic systems that is not present or effectual at the level of quantum physics.¹¹

An opposing view, that time is irreducible and cannot be left out of fundamental descriptions of nature, is given by Lee Smolin. Smolin argues that the problem of time can be resolved by reformulating the basic mathematical framework used in classical and quantum physics, as opposed to eliminating time as a fundamental concept (Smolin 2001, 3). In effect, by incorporating observers into complex quantum descriptions of the universe, time is shown to be fundamental. He claims that arguments that deny this fail to recognize the observations and experiences of real observers within the universe. Smolin describes quantum cosmology in terms of histories. Although a conventional quantum system requires only one observer to take a measurement of the whole system, the cosmos is far larger, more complex, and has a greater number of variables. Because a quantum description of the cosmos requires multiple simultaneous observations to be made by multiple observers, it need not be conceived of as static, as conventional quantum systems tends to be. Instead, the causal structure of the history of the universe defines a context, and observers experience the reality of time within this context (Smolin 2001, 24). By reconceptualizing quantum physics to accommodate real observers, Smolin argues that time's fundamentality is recovered.¹² On Smolin's view, time is the most fundamental feature of reality—everything else, including the laws of physics themselves, emerge from and evolve in time.

Although the so-called “problem of time” is very much an open question, useful insights may still be gleaned from an analysis of quantum findings.¹³ On this basis, we suggest ways in which Indefinite Causal Order may facilitate developments in the metaphysics of time, all the while remaining cognizant of the fact that any such conclusions inevitably require some form of hedging one's bets.

INDEFINITE CAUSAL ORDER EXPLAINED

At first glance, Indefinite Causal Order seems to throw our commonplace and our philosophical beliefs about time into doubt. Quantum mechanics operates within the domain of subatomic particles, a world of uncertainty. If Indefinite Causal Order is a feature of reality, then this uncertainty applies to temporal relations also. Through investigating the role of “causal order” in quantum mechanics, physicists examine whether the order of events can be objectively defined in quantum theory.

Schrödinger's famous cat paradox brings to light the stark contrast between the goings on in the “classical” realm of our everyday experience and the rules that govern the quantum realm (Villars 1986). The paradox concerns a cat locked in a box with a vial of poison, which will be released when a small amount of radioactive matter decays, and the probability of decay is set at 50%. In the Copenhagen Interpretation of Quantum

Mechanics, until a measurement is made and the wave-function collapses, the atoms are neither decayed nor not decayed. Hence, they are in a superposition. Until the box is opened (*viz.* a measurement is made) and the state of the cat is determined, the cat is deemed both alive and dead. It is the act of measurement that necessarily disturbs the system and destroys the fragile quantum superposition. The paradox expresses the counterintuitive claim that until observed the state of the cat, a classical object, is that of a superposition, a quantum property. The salient feature of the paradox for our purposes is this: at the quantum level, atoms can exist in a variety of states and positions simultaneously. The superposition principle applies to a variety of properties, position being a notable example, but it has only recently been proposed that it may extend to the order of events (Hardy 2009; Chiribella et al. 2013). That is to say, not only is it possible for a quantum object to exist at multiple locations at once (following the application of the superposition principle to spatial location), for example, at location A and location B, but it is also in principle possible for event A to happen before event B *and* for event B to happen before event A.¹⁴ This is Indefinite Causal Order.

Due to the vast swathes of open questions in quantum gravitational research, there is much work to be done in order to establish in what sense Indefinite Causal Order impacts the physical world. However, there appears to have been experimental support for Indefinite Causal Order according to a recent experiment (Goswami et al. 2018). The experiment introduces the quantum switch, which is implemented using the superposition of two causal orders in an optical setting. It involves a polarizing beam splitter that sends a photon straight through it or reflects it at 90 degrees, depending on the polarization of the photon. If the photon becomes polarized in one orientation, it goes one way through the experimental circuit, and if it is polarized in an orthogonal orientation, it takes the alternative route. The route taken was readable at an endpoint C. What the experimenters designed was, in effect, a maze that could be travelled in two routes depending on the polarization of the photon. In this maze, there are two checkpoints labeled: A and B. One route hits A first and then B, the other route hits B first and then hits A. One polarization generates the causal order A then B, the other polarization generates the causal order B then A. The indeterminacy enters the fray as a result of the superposition principle, as the photon can be prepared in a superposition with regards to its polarization. This means it can be polarized in both directions at the same time and therefore both causal orders obtain. In effect, there are two causal paths (A then B, or B then A), and the paths are in superposition. To verify this, the scientists measured the causal nonseparability of the process and found that a superposition of causal orders had taken place, *viz.* evidence for *both* A happening before B, and B happening before A.

It must be noted at this point that, as Ognyan Oreshkov writes, “the interpretation of such experiments as realizations of a process with indefinite causal structure as opposed to some form of simulation of such a process has remained controversial” (Oreshkov 2019, 206). It has been argued that the far stronger type of Indefinite Causal Order that could arise in the presence of a superposition of spacetimes would be more metaphysically and physically interesting. Unfortunately, the experiments required to demonstrate Indefinite Causal Order arising in a gravitational (viz. a spacetime) scenario are not within technical capabilities at the present time. Since the implications of Goswami et al.’s work are still being debated by the physics community, the arguments made here may have to be taken with a grain of salt.¹⁵ Nevertheless, as John Polkinghorne has argued, when working within the murky waters of quantum mechanics, “an element of hand-waving cannot be avoided, but the key thing is to try to wave one’s hands in a suitably promising direction” (Polkinghorne 2001, 190).¹⁶ Oreshkov, for example, argues that Goswami et al. do succeed in establishing Indefinite Causal Order (Oreshkov 2019). Moreover, there is theoretical support for Indefinite Causal Order emerging in gravitational settings, which would mean spacetime itself can be superposed. In a recent paper, Zych et al. “consider a thought experiment with a massive body in a spatial superposition and show how it leads to entanglement of temporal orders between time-like events,” meaning in a quantum theory of gravity, temporal order would become nonclassical (Zych et al. 2019). As there are strong theoretical arguments to support the existence of Indefinite Causal Order, and preliminary experimental support in the form of the experiment in question, it is worthwhile to explore the metaphysical and theological implications.

INDEFINITE CAUSAL ORDER AND A B-THEORY OF TIME

Indefinite Causal Order has, until this paper, remained in the domain of physics. Metaphysical analysis of these findings, particularly what they mean for the ontology of time, are yet to be published. As Tim Maudlin argues, science provides the most reliable, empirical knowledge of the physical world. Hence, “the proper object of most metaphysics is the careful analysis of our best scientific theories” (Maudlin 2007, 104). Robust temporal ontologies must be rooted in contemporary scientific data, even if that scientific data is speculative or incomplete.¹⁷ Baptiste Le Bihan argues that when seeking ontological insight within contemporary physics, “one might look at the specific ontological commitments of one or several research programs, and think about the consequences for metaphysics if this, or one of these, approach(es) turns out to be right” (Le Bihan forthcoming, 3).¹⁸ This is precisely our aim here. In the following sections, we argue that *if Indefinite Causal Order is true, then this is good evidence for a B-theory of time.*

Dispensing with the A-Theory

Indefinite Causal Order poses a significant challenge to the metaphysically orthodox bifurcation between the A-theory and B-theory, as it undermines both an objective present moment and fixed temporal order relations. These are core features of the traditionally defined A and B-theories, respectively. Nevertheless, we argue that following modification, the B-theory emerges relatively unscathed. The same cannot be said for the A-theory. Indefinite Causal Order appears inconsistent with a fundamental claim of the A-theory, namely an objective present moment, the point at which the past fades away into obscurity and the potential future becomes real. To substantiate such a claim, the present *must* be both objective and universal, as it is the ontologically privileged point at which tense is defined. Classical A-theories claim that the previously unreal future comes into being objectively and universally at the present moment. In physics, this requires that spacetime is foliated into objective simultaneity slices.¹⁹ Events which exist *at the same time* are copresent on a simultaneity slice, and these slices define an objective temporal order with a moving present defining the ontologically privileged slice.²⁰ Future objects and events come into being when they become present.

We argue that Indefinite Causal Order makes the present fuzzy, which is a big problem for the A-theorist. An objective present that sharply divides the future from the past is a necessary structural feature of the A-theory, yet Indefinite Causal Order requires the A-theorist to claim that future events both exist and do not exist.²¹ In this context, while the experiment is underway the event “the photon hits checkpoint A” has both happened and has not happened, viz. it is both real and unreal. Following this, the future that holds this event both exists and does not exist. This claim vastly surpasses the findings of the initial experiment that a photon can be in a superposition that affects the order it traverses a maze. An object being in a superposition is not a surprising finding, though its implications for causal order are indeed novel and interesting. The A-theorist, however, would have to extrapolate those findings to claim that reality itself exhibits such fuzziness, as the A-theoretic *now* ontologically determines which events are real and which are not. On an A-theory in which the present is the point when future events become real, this experiment shows the future, and the objects therein, as both existing and not existing. This is incoherent, and therefore, the A-theory is incompatible with such an account.

On this point, Indefinite Causal Order echoes other areas of physics that seem incompatible with an A-theory. The scientific theory most frequently employed to argue against the A-theory, Einstein’s Special Theory of Relativity, similarly indicates that an objective present moment cannot be clearly defined, and thus stands in opposition to an A-theory

of time.²² Indeed, a famous argument claiming that Special Relativity is incompatible with an A-theory can be adapted to show that Indefinite Causal Order is similarly incompatible with an A-theory. The argument, constructed by Hillary Putnam, argues that Special Relativity leads us to the conclusion that, viewed from different perspectives, one has reason to believe that “*future* things (or events) are already real!” (Putnam 1967, 242). As such, a universal present moment at which point the future becomes newly and objectively real is undermined. If things or events that are *future* from one perspective *already exist* (as they are present from another perspective), then the present moment cannot be such a universal and objective feature of reality. In brief, Putnam begins with A-theoretic (particularly, presentist) assumptions, arguing that that everything that is simultaneous with me-now is real, as I-now am real by virtue of being present. As “is real” is a transitive relation, then everything standing in the simultaneity relation with “me-now” is real. Yet, as Special Relativity indicates, an observer simultaneous with me-now could experience events as present (and thus real), which lie in the future of me-now—making future events already real (Putnam 1967).

A similar argument can be applied to Indefinite Causal Order. During the experiment, the causal order of the two operations is indefinite, so both *A before B* and *B before A* occurs. Therefore, from the perspective of A in the first case B is a future event; from the perspective of B in the second case A is a future event. In the system viewed as a whole both of these cases obtain, therefore from each perspective, future events are already real. If this is the case, then the present cannot be the universal boundary at which point future events objectively come into existence. Both presentism and the growing block require such a knife-edge present moment. Therefore, Indefinite Causal Order is incompatible with the most successful A-theories.²³

The significant difference between Special Relativity and Indefinite Causal Order, however, is that while Special Relativity is easily compatible with the B-theory, Indefinite Causal Order is less straightforward. This is due to its apparent incompatibility with either an objective present moment or fixed temporal order relations, core features of the A and B-theories. If neither theory can accommodate Indefinite Causal Order, must metaphysicians return to the drawing board?

MODIFYING THE B-THEORY

We argue that the B-theory *can* remain coherent given Indefinite Causal Order, conditional on modification. The modification we propose is a shift in emphasis when considering the B-theory’s core features from temporal relations to the block universe. Such a move is not unprecedented. Although this has not received significant attention in

the literature, Special Relativity also necessitates modification of the B-theory (Read and Qureshi-Hurst 2020, footnote 8). In its original form, the B-theory holds that a fundamental description of time can be given by the relations *earlier than*, *later than*, and *simultaneous with*. The objectivity of these relations is at least heavily implied. However, though timelike-separated events will stand in objective *earlier than*, *later than*, and *simultaneous with* relations to one another, this is not the case for spacelike-separated events.²⁴ Special Relativity forces the B-theorist to conclude that the class of events standing in these ordering relations is more impoverished than the original B-theory maintained. Thus, following Special Relativity, core features of the B-theory, namely temporal ordering relations, underwent modification regarding their domain of applicability. The ordering relations hold objectively only for time-like separated events.

Although ours is arguably a more radical modification, we argue that if Indefinite Causal Order is true, temporal ordering relations must receive another narrowing of their domain of applicability. Rather than the relations of temporal order *earlier than*, *later than*, and *simultaneous with* being fundamental (viz. holding at the smallest scales), they apply only to large-scale classical systems in which quantum effects do not take force. This facilitates a change in emphasis in the B-theoretic account from the fine-structure of B-series relations to the large-scale block universe description. We argue that the broad metaphysical picture (namely the block universe) should be held as the defining characteristic of the B-theory, given Indefinite Causal Order. The ordering relations are then understood as emergent properties that apply to classical objects and systems, and that do not apply at the quantum level. All that really changes is the *emphasis* one places on the defining features of a B-theory—on our view, temporal relations are involved in a B-theoretical description of reality but do not hold at every level. Rather, at its core, the B-theory describes reality as a *block universe* and is not dependent on objective ordering relations at every ontological level. This idea of time as an emergent property follows Carlo Rovelli's idea, and similar arguments about spacetime's nonfundamentality are made by Baptiste Le Bihan (forthcoming), Nick Huggett, and Christopher Wüthrich (2013). Although quantum processes do not behave in a temporally ordered or B-theoretic fashion, the large-scale picture provided by the macroworld description of middle-sized objects is that of the block universe.

The relativity theories have contributed substantially to the demise of the A-theory by disposing with the idea of absolute simultaneity.²⁵ We believe Indefinite Causal Order is the final nail in the A-theory's coffin. What is left must be some form of a block universe. Within this temporal ontology concepts as basic as change—and those moral theories and theological doctrines involving change—must be revisited.

REVISITING SALVATION

If the B-theory is true, this has significant repercussions for both morality and soteriology. We cannot fully articulate the issues and our proposals for solving them, due to space restrictions. However, in this final section, we sketch out the primary implications for this renewed scientific support for the B-theory. Our focus is on the concept of salvation, broadly conceived. We do not wish to restrict ourselves to denominational specificities, and so will be using salvation in a general sense to denote the deliverance from a state of sin into a state of reconciliation, atonement, or fulfilment. In a sense, the precise mechanism by which this occurs is tangential—our concern is the *change* itself. Although we do not employ religiously specific terminology, this fits most clearly with the Christian doctrines of salvation.

The primary problem the B-theory presents for salvation is that it seems to prohibit ontological change. If all things and events coexist in the space-time manifold, then in what sense can genuine change be accommodated? Change is defined as an act or process by which something *becomes* different. It is precisely such becoming that is prohibited by the static temporal ontology of the block universe. That change is a necessary feature of time was McTaggart's primary reason for concluding time was unreal. He held that it is only within an A-series that genuine change is possible. The only conceivable B-series change is if "an event ceased to be an event, while another event began to be an event. But this is impossible . . . an event can never cease to be an event. It can never get out of any time series in which it once is" (McTaggart 1908, 459–60). Thus, McTaggart concludes that genuine change is impossible on the B-series.²⁶

The problem is now clear. Salvation requires change from a prior state of sin to a subsequent state of atonement, and this change is generally understood to bring something fundamentally new to the life, indeed the being, of the saved individual. Moreover, on a Christian worldview, this salvation was brought by Jesus of Nazareth, the Son of God, who entered physical reality to be present in a way he was not before, bringing the genuinely new possibility of salvation into the cosmos and the lives of those who inhabit it. Such change, particularly the introduction of something *new* into the spacetime manifold that was not previously present, appears incompatible with the B-theory. If one accepts this point, then two alternatives seem apparent:

- (1) Conclude that salvific change is impossible on a B-theory, and that therefore the doctrine of salvation must be rejected altogether.
- (2) Try and reconceptualize the mechanism of salvific change so that it is coherent within a block universe.

Although one may hold initial appeal to opponents of religion, there are good reasons for rejecting it. First, it dismisses the core beliefs of many

systems that are theologically or spiritually committed to doctrines that require ontological change. Science is not in the business of refuting religion. Paul Tillich makes such a point when distinguishing between preliminary concerns, namely those that arise in culture in the form of art, science, and politics, and ultimate concern, namely God. Tillich argues that, “the theologian *as* theologian is no expert in any matters of preliminary concern. And, conversely, those who are experts in these matters should not *as such* claim to be experts in theology” (Tillich 1953, 15). If salvation is a matter of theological importance, then science should not be trying to refute it. Whether one takes Stephen Jay Gould’s dictum that science and religion are “non-overlapping magisteria” (Gould 1999), namely, independent domains which should not interfere with one another, or Alister McGrath’s view that they can be mutually enriching (McGrath 2016), or Robert John Russell’s proposal for science and religion engaging in Creative Mutual Interaction (Russell 2012), the view that science and religion are inherently conflicting is a view increasingly relegated to the past.²⁷

The second reason for rejecting (1) is that if change cannot be accommodated within temporal reality, then one must dismiss many other important concepts with it. If the block universe is so rigid as to prohibit any flexibility or dynamism (physical or otherwise) then hard determinism follows, a thesis many believe to be incompatible with free will. There is a range of literature available on the issue of quantum physics and free will.²⁸ This issue transcends the boundaries of physics and seeps into metaphysics and morality. If (1) is chosen, and the possibility of salvation is restricted *precisely because the B-theoretic temporal ontology forbids change*, then the implications for free will are clear. Free choice is prohibited if change is not possible, and without the possibility of choice, one cannot make decisions that bring about a transformation, soteriological or otherwise. With regards to free will: if Alice had cereal for breakfast this morning, Alice could have had nothing else. She could not change her mind from cereal to eggs, as the block universe does not permit such flexibility. If the events of the future already exist in distant regions of spacetime, then agents do not make free choices as to which future is instantiated. Freedom depends upon having multiple options that one can instantiate with one’s chosen action. The range of possible futures, that is, the various possible worlds in which Alice has eggs, pancakes, or no breakfast at all, do not exist. The future is ontologically fixed, meaning she cannot make the choice to change which possible future she instantiates, and thus her choices are not free. If change is prohibited, then choice is an illusion. This relationship between change and freedom provides strong motivation to explore other avenues. Dismissing the possibility of salvific change altogether necessitates the rejection of any relational, ontological, or mental change. We argue that advocates of this position throw the baby out with the bathwater, and they do so too hastily.

Hence, (2) is more productive. As science shouldn't be in the business of refuting core theological claims, we suggest that Indefinite Causal Order's support for the B-theory should instead be taken as an open invitation to clarify and fortify the concept of salvation rather than disposing of it altogether. We propose adapting a concept first advanced by Adolf Grünbaum and employed by a multiplicity of B-theorists to explain our perception of temporal passage.²⁹ The concept is *mind-dependent becoming*, and is a promising step toward a solution. If one can accept the dualist claim that mental properties are not reducible to brain states (and therefore that the mind is not entirely restricted by the physical restrictions a B-theory imposes on matter), then the mental transition to a state of salvation is possible.³⁰

MIND-DEPENDENT SALVIFIC BECOMING

The purpose of this section is to explore some initial ideas on the topic, and unfortunately, this exploration must be brief. The argument we offer has two stages. The first, employing an argument from Carl Hoeffler, shows how free choice can be compatible with a B-theoretic ontology. The second draws on the work of Adolf Grünbaum to argue that the precise mechanism of salvific change is best conceived as mind-dependent becoming. On this model, individuals freely choose to respond to a saving power. They then *experience* a salvation-transformation as a result. Essentially, we argue that the change required by religious and spiritual formulations of salvation is sufficiently accounted for by a subjective change in the consciousness of the individual. From the perspective of the saved person, we contend that a subjective and psychological change can be just as significant and transformative as an objective, ontological change.³¹ A subjective transformation can be accommodated within the block universe through the mechanism of free action dubbed "downward causation," and the salvific change that comes as a result of this action takes the form of mind-dependent becoming.

Hoeffler argues against the view that the A-theory is the only temporal theory that can accommodate free choice, arguing that B-theory choice operates as "freedom from the inside out." Typically, the block universe is considered hostile to free will for reasons alluded to above, whereas the ontological openness inherent within the A-theory is believed to facilitate free choice. However, Hoeffler argues:

The very 'timelessness' of the 4-D block (in an A-series sense) leaves us free to reject the customary view that past events determine present choices. From the B-series perspective there is no reason to think of past → future determination as more important or real than future → past determination. And, even more to the point, one can equally view a set of events in the middle as determiners of both past and future events . . . Our free actions,

intentions, thoughts etc., in the middle of the block universe, are part of what determines how the rest of the block shall be. (Hoeffer 2002, 205)

The crux of the argument is this—the block universe says nothing about *causal* relations between slices of spacetime, merely that they all coexist. Hoeffer is advocating a break between determination and causal explanation by arguing that our experience of temporal asymmetry does not necessitate causal determinism running from the past to the future. In the block universe, there is no ontologically privileged location. All slices of spacetime are concurrent, and there is no more reason that the past must determine the future, than that the future must determine the past. Our intuitive sense that the past causes the future, he argues, is the result of an “unholy marriage of A-series time with deterministic physics” (Hoeffer 2002, 208). This union, though phenomenologically understandable, is nonetheless a mistake. Hoeffer argues that regions of the block logically determine one another, in that each slice is dependent on the others for its existence, but there is no physically compelling reason to believe that the past *temporally* or *causally* determines the future, even less so if quantum mechanics does support a fundamentally indeterministic ontology.³² Physical determinism, Hoeffer argues, implies *no explanatory priority* of the past over the future, or the future over the past, or the middle over either. None of these tenses are objectively privileged, and so there is no reason to believe the early regions of the block universe have any deterministic effect on later regions. This leaves space for action to be uniquely determined by desires, beliefs, and intentions.³³ Hoeffer summarizes his argument thus:

We are perfectly justified in viewing our own actions *not* as determined by the past, *nor* as determined by the future, but rather as simply determined (to the extent that this word sensibly applies) *by ourselves, by our own wills*. In other words, they need not be viewed as *caused* or *explained* by the physical states of other, vast regions of the block universe. Instead, we can view our own actions, *qua* physical events, as primary explainers, determining—in a very partial way—physical events outside ourselves to the past and future of our actions, in the block. We adopt the perspective that the determination or explanation that matters is from the *inside* (of the block universe, where we live) outward, rather than from the *outside* (e.g. the state of things on a time slice 1 billion years ago) in. (Hoeffer 2002, 207)

Hoeffer’s argument for “freedom from the inside out” requires a further step, *downward causation*, initially developed by John Dupré, to explain how free action is causally efficacious in the block universe. The standard block universe view appears hostile to the kind of counterfactual choice required for libertarian freedom. We acknowledge the *prima facie* grounds for this but offer a form of compatibilism which affords genuine choice to agents, in so far as that choice comes from “the inside out.”³⁴ Downward

causation holds that higher-level processing, viz. our choices and intentions, are the primary explainers for the effects produced on the “lower” ontological levels, viz. our actions. Hoeffler gives a mundane but illustrative example. When writing, he wishes to type certain words to express his ideas. In order to do that, he must type particular letters. His intention to type “t” makes the atoms in his hand move toward the “t” key—the higher-level intention precedes the lower-level effect. Thus, human consciousness, intentionality, and mental processing are the first link in the causal chain that generates action (Hoeffler 2002, 201).

Dupré argues that this is possible because “causal order is everywhere partial and incomplete. But humans, by virtue of their enormously complex but highly ordered internal structure, provide oases of order and predictability . . . the causal structure that impinges on a human being, whether externally from macroscopic causal interaction, or internally, from constitutive microstructural processes, is not such as to threaten the natural intuition that humans are, sometimes, causally efficacious in the world around them” (Dupré 1996, 386). By saying that reality is causally incomplete he means that there is not sufficient causal explanation for every event by virtue of physical regularities alone. He then locates free action within this open causal structure.³⁵ Downward causation, namely the mechanism through which this is possible, occurs through creative acts of the human mind.³⁶ If free choice is compatible with a block universe, then the idea of salvific becoming stands on firm ground. Although the block universe may seem to prohibit choice and change, agents can make choices through downward causation and instantiate one choice over others. Alone, however, this is not sufficient to establish salvific change on a B-theory, it merely establishes that agents are capable of making choices and creating change. We now turn to the second stage of the argument that sets out the precise mechanism of salvific change: mind-dependent becoming.

Adolf Grünbaum constructs a psychological theory of time whereby temporal passage is explained as a mind-dependent phenomenon. He writes, “what is *necessary* so to qualify the event is that at the time t at least one human or other *mind-possessing* organism M is conceptually aware of experiencing at that time either the event itself or another event simultaneous with it in M ’s reference frame” (Grünbaum 1971, 206). All that is required of an event to be deemed as present is a conscious mind experiencing it as such. The successive experiences of events as present is sufficient to string together the phenomenological experience of temporal passage, without requiring that passage be grounded in any dynamic temporal ontology or objective present moment. McTaggart identified the only real change as A-series change, in which an event goes from possessing one temporal property (i.e., *being present*) to another (i.e., *being past*). Grünbaum accepts this, offering a weaker threshold for what counts as possessing a temporal property, viz. a mind experiencing it as possessing that property. If event

e is present for me, and then past for me, then phenomenologically *e* has changed from present to past.

On this view, agents subjectively experience the world as changing by virtue of their consciousness piecing together such change from a thread of events experienced in a certain order. Perceptual awareness is all that is required to phenomenologically substantiate the type of change required to transform an individual's life from a state of fallenness to a state of salvation. In Tillichian terms, this transformative experience occurs through conscious receptivity to being grasped by the Spirit, who was brought by Christ into the finite realm of existence. God reaches out to individuals through this saving power, and individuals are free to respond (Tillich 1957). The salvific becoming is mind-dependent, but this does not make it any less real. Essentially, individuals *experience* a transition from being fallen to being saved, and that is enough to constitute salvation.³⁷ Persons can choose to instantiate actions that lead to an authentic life. In Christian terms, individuals are free to respond to the power of the Spirit in their lives, opening themselves up to the renewed existence of a life with God. The enhanced psychological existence, enriched relationality, or fulfillment that follows constitutes salvation. Though each event a person experiences has always existed in a distant region of the block universe, humans have the ability to bring about genuine, albeit subjective, change into their lives through the mechanism of freedom outlined above. One form this change takes is the psychological transformation from an unfulfilled, fallen existence to a saved one. Any further specificities are not within this paper's scope. Nevertheless, the mechanism outlined here provides a framework within which personal salvation can be reconciled with a block universe. This conclusion may be a weaker form of salvific change than libertarian theologians would like, but the significance is in the subjectivity. In terms of human experience, this may well be enough.

CONCLUDING REMARKS

This is a paper of two halves. The first half examines the metaphysical implications of Indefinite Causal Order. Though it appears incompatible with either metaphysically orthodox temporal theory, as it is incompatible with both an objective present moment and fixed ordering relations (tenets of the A-theory and B-theory, respectively), we argue that upon modification, Indefinite Causal Order is most easily accommodated within a modified B-theory, viz. the block universe. The second half concerns salvation. There is certainly more to say on this than can fit in a single paper. Nevertheless, we hope to have sketched out a novel and interesting way of accommodating salvation within the block universe. Our solution pertains to formulations of salvation that require a change from a state of sinfulness to a state of redemption, particularly in the mental state of the individual.

Such choice and change can be accommodated within a B-theory when conceived as downward causation and mind-dependent becoming. This paper has been ambitious in scope, and at times, the reader may find some arguments cursory. Nevertheless, we have offered a novel way in which salvific change can be accommodated within the B-theory, given renewed support for such a temporal ontology provided by Indefinite Causal Order. Much more will need to be done if the B-theory is to be firmly established, both metaphysically and scientifically. Moreover, the relationship between Indefinite Causal Order, free will, and morality remains a largely open question. We also suggest that there is scope to assess the implications of Indefinite Causal Order for Non-Interventionist Objective Divine Action, particularly the work of Robert John Russell (1997, 2006, 2018). Exploration of the relationship between quantum mechanics, time, and theology has only just begun.

AUTHOR CONTRIBUTIONS

This paper is the result of a collaboration between Anna Pearson, a physicist, and Emily Qureshi-Hurst, a philosopher. The project began with Pearson contacting Qureshi-Hurst with the hope of writing a science and religion paper assessing the metaphysical and theological implications of Indefinite Causal Order. This article is the outcome. Though the initial thrust of the project came from Pearson, her aim was to bring Indefinite Causal Order into science and religion discourse and generate dialogue. As such, she is unwilling to commit herself to any particular argument at this stage. The paper itself was written by Qureshi-Hurst and reflects her philosophical views on the matter.

ACKNOWLEDGMENTS

We owe great thanks to Bethany Sollereeder for introducing us for the purpose of this project. We are also grateful to Alister McGrath, Robert John Russell, Alexander Arnold, Andrew Briggs, Shaun Henson, Hlér Kristjansson, George Klaeren, and Christopher Bennett for advice on earlier drafts of the paper. All oversights or inaccuracies are entirely our own.

NOTES

1. Adrian Bardon cites this as one of “two essential facts about time that most will agree on” (Bardon 2013, 1). In the Special Theory of Relativity, this is due to the light cone structure. See (Maudlin 2012, 68-76). In both Special Relativity and General Relativity, the temporal order of two events will not always be the same in from all observational perspectives (viz. inertial frames). Distant events can be perceived as happening in different orders if there is a significant difference between the duration it takes the light from each event to reach the observer. If one observer is right next to an event E and very far away from an event F (imagining the two events would be deemed simultaneous for an observer equidistant between them), for example, an observer right beside E will measure E as happening before F. An observer next to F will measure

F as happening before E. Temporal order is not invariant between all perspectives. From one perspective in relativity, however, the temporal order of events will necessarily be perceived as fixed.

2. Particularly, in Parmenides' commitment to a static ontology (Graham, 2019), and Heraclitus' opposing philosophy of flux (Palmer 2016).

3. McTaggart defined the A-series and B-series—the temporal theories that have been built upon these are the result of subsequent scholarship.

4. A third view, the “moving spotlight,” has been omitted from the discussion as we believe it has deep philosophical problems. For more details, see (Skow 2009).

5. There are a variety of reasons one may be committed to an open future. The three primary reasons: our *experience* of the future as open, belief in libertarian freedom, and theological commitments. For more on the last, see (Swinburne 1993).

6. For example, whether spacetime is Galilean or Lorentzian.

7. That is, the fundamental features of time can be sufficiently described tenselessly, through describing events and the ordering relations that obtain between them. This includes a tenseless description of tensed facts. For such an account, see (Mellor 1981).

8. Newton gave such a definition of time in (Newton, Scholium to Definition viii).

9. The literature on this is vast. See, for example, (Gödel 1949; Grünbaum 1964; Brown 2005; Bohm 2006; Callender and McCoy 2017).

10. For an interesting alternative take in which the author suggests ways the search for quantum gravity can stimulate metaphysical discussion *now*, see (Le Bihan, forthcoming).

11. For an argument that goes further than Rovelli's claim that time is not fundamental to argue that time is not real, see (Barbour 1994, 1999, 2009). For further arguments that time is non-fundamental, see (Le Bihan, forthcoming; Huggett and Wüthrich 2013, 276-85).

12. He makes similar arguments regarding the fundamental reality of time in (Smolin and Unger 2015).

13. For detailed discussion of this and related issues, see (Muga et al. 2008; Isham 1993, particularly section 2). For a comprehensive survey of Quantum Cosmology, see (Halliwell 1990).

14. It must be noted that this is only the case if the events A and B are in the same spacelike domain. In an Everettian interpretation of quantum mechanics, involving a branching of spacetimes, this would not be the case. We acknowledge this limitation on our claim but have chosen to construct our argument in a non-Everettian context. Hence, our discussion assumes a non-Everettian universe. To the best of our knowledge, Indefinite Causal Order has yet to be discussed in an Everettian setting—there is scope for future work in this area.

15. For an argument that the photonic experiments do indeed implement indefinite causal order, as time-delocalized operations, see (Oreshkov 2019, 206).

16. These comments were made in the context of the search for a mode of divine action that fits with the ontological openness provided by the Copenhagen Interpretation of quantum mechanics. As both these cases involve examining the theological and philosophical implications that arise in (as yet unproved) areas of QM, the point also applies *mutatis mutandis* to the present case.

17. Special and General Relativity are incomplete due to their incompatibility with quantum physics, and presently their “completion” viz. a theory of quantum gravity, is speculative.

18. This statement was made in the context of doing metaphysics within the speculative domain of the search for quantum gravity.

19. For a discussion of whether such foliation is provided by GR, see (Smeenk 2013; Wüthrich 2013; Read and Qureshi-Hurst 2020).

20. There is a debate about the present and its extension, often termed the specious present. First introduced by William James (1890). See also, (Mabbott 1955; Kelly 2005; Power 2012).

21. While one could argue that the superposition principle provides scope to make such an argument, the principle has thus far only been applied to existing objects. To claim that reality itself can be in a superposition at the fundamental level with regard to ontological tense vastly expands the scope of the superposition principle. We claim that this is unwarranted at this time, though we do not rule out the possibility of some argument or experiment confirming otherwise. An answer may be provided once a theory of quantum gravity has been formulated.

22. For arguments to this effect, see (Gödel 1949; Williams 1951; Grünbaum 1964; Putnam 1967; Pooley 2013).

23. One might make some headway trying to accommodate Indefinite Causal Order within the moving spotlight view. However, this view is problematic for metaphysical reasons, and as such we have chosen not to pursue this line of argument.

24. Spacelike separation means that there exists a reference frame where the two events occur simultaneously, but in different places. Timelike separation means that there exists a reference frame where the two events occur at the same place, but at different times.

25. There are still many supporters of the A-theory. However, the general consensus in the scientific community is that time is B-theoretic or unreal, and hence that the A-theory is false. Two insightful A-theorist interpretations of relativity, each worthy of serious engagement, are the neo-Lorentzian interpretation championed by William Lane Craig (Craig 2001) and Robert John Russell's reinterpretation of Special Relativity (Russell 2012). Unfortunately, discussion of such arguments is not within the scope of this paper's focus on Indefinite Causal Order in quantum mechanics.

26. As change is only compatible with an A-series description of time, and McTaggart held that the A-series is self-contradictory, he concluded that time must be unreal. This paper agrees that change and the B-theory seem incompatible. Nevertheless, we do not conclude with McTaggart that time is unreal. Temporal passage and the objectivity of tensed facts are not necessary components of *time* itself. There is not space to develop such arguments here.

27. Of course, new atheists would strongly disagree. For such a perspective, see (Dawkins 2007).

28. (Hoofdt 2007; Stapp 2008). For an argument against the idea that Quantum Mechanics is connected to free will, see (Lopez-Corredoira 2009).

29. For example: (Bardon 2013, 79-111; Maclaurin and Dyke 2002).

30. More work needs to be done to establish a model for bodily salvation on a B-theory. We have no space for this here. However, it is worth noting that in a block universe the body of a deceased person does not vanish into a nonexistent past, as it would with presentism, and therefore, the concept of bodily resurrection is coherent within the spacetime ontology of the B-theory, as the body is in principle recoverable.

31. The most notable articulation of this type of view is provided by Paul Tillich, particularly his doctrine of salvation as a transformation from fallenness (characterized by anxiety, guilt, and lack of fulfillment) to a state of reconciliation (characterized by the alleviation of the psychological consequences of fallenness), which he calls the transition from Old Being to New Being (Tillich 1957).

32. The Copenhagen Interpretation, the theoretical interpretation of quantum formalism that is most widely accepted in the scientific community, holds that nature is fundamentally indeterminate. If such indeterminism is true, each choice made by an agent need only be compatible with probabilistic, rather than strictly deterministic, laws—a looser set of constraints. Hoeffter considers such arguments (Hoeffter 2002, 217-19).

33. This position has its roots in Kant.

34. This compatibilist position should be understood as firmly Humean, whereby all that is needed for an action to be free is that it is *caused by the agent*. See (Russell 2014).

35. Similar arguments have been made by Robert John Russell regarding divine action within the causal openness provided by the Copenhagen Interpretation of QM.

36. Dupré develops this idea both Humean and Kantian ideas in the 'Concluding Remarks' section (Dupré 1996).

37. Though it will always have been in one's future, and so in that sense it is not radically new or undetermined, it comes into one's perceptual awareness as something apparently new.

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