Teleportative observers versus special relativity observers:

Work in progress

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Abstract

Various authors argue that special relativity implies eternalism. For example, special relativity observers are limited by the relativity of simultaneity and cannot detect a preferred universal chronology, which is an important premise for the Rietdijk–Putnam argument which implies eternalism. However, I introduce "teleportative observers" which cohere with wormhole theory based on general relativity. Teleportative observers do not teleport objects but use hypothetical teleportative sight to detect every event in every quantum system of the universe. The teleportative sight permits detection at a distance. For instance, a teleportative observer detects distant events and respective time dilation as if there were no macroscopic spatial interval and no other interaction between the observer and the events. Similarly, despite the relativity of simultaneity, the detection at a distance permits observers in causally disconnected regions of space to detect a universal chronology of events in every quantum system of the universe. Also, teleportative sight is what I call the "preferred focal pathway for a universal chronology." Furthermore, the observers support a logical theory of relative spacetime and presentism.

Keywords

relativity; spacetime; wormholes; modal logic; presentism; eternalism

1. Introduction

The most perplexing prediction of Einstein's (1961) special relativity (SR) is the relativity of simultaneity. For example, two events are causally disconnected when the time interval between them is less than the spatial interval between them divided by the speed of light; while no two causally disconnected events are absolutely simultaneous to each other. This means that there is no coherent concept of an absolute universal chronology defined by the concepts of before, during, and after. However, scientific observation and human perception typically indicate a chronology of cause and effect. Likewise, there is no coherent concept of an absolute universal chronology, yet scientific evidence suggests the existence of some type of chronology. I call this the *SR chronology puzzle*.

The most prominent contemporary response to the SR chronology puzzle is the SR version of eternalism based on the Rietdijk–Putnam argument (Rietdijk 1966; Putnam 1967; Le Poidevin 1991; Price 1997; Savitt 2000; Penrose 2002, pp. 299–305; Wuthrich 2011). For example, eternalism states that the past, present, and future have always existed without tense; while concepts of eternalism go back to the presocratic philosopher Parmenides who argued against the reality of motion (Aristotle 350 BCEb). Also, Propositions 1–4 define a generalized position of SR eternalism:

> **Proposition 1**. There is no possible preferred universal chronology.
>
> **Proposition 2**. There is no ontological difference between space and time.
>
> **Proposition 3**. All past, present, and future events have always tenselessly existed in what is called the *now*.
>
> **Proposition 4**. Tensed time is unreal and an illusion.

An alternative response to the SR chronology puzzle is the position of an observer in a hypothetical omnicluster of teleportative wormholes (Goetz 2016, pp. 331–332). The hypothetical omnicluster does not teleport objects but connects the observer to every event in the universe, including otherwise causally disconnected events. For example, Einstein and Rosen (1935) proposed that general relativity (GR) predicts the possibility of wormholes that connect distant events in the spacetime universe.

This paper explores a thought experiment that focuses on the logic of the spacetime chronology while comparing the focal pathways of what I call *teleportative observers* and *SR observers*. For example, a teleportative observer has teleportative sight enabled by what I call *the hypothetical universal wormhole*. For instance, a teleportative observer does not teleport objects but detects distant events and respective time dilation as if there were no macroscopic spatial interval and no other interaction between the observer and the events. Also, teleportative observers do not imply the existence of traversable wormholes. Furthermore, this logical analysis does not introduce new mathematical models.

In the rest of this paper, section 2 defines propositions and terms of logic for the thought experiment; section 3 describes physics terms for the experiment; section 4 describes the experiment in the context of Big Bang cosmology and inflationary multiverse cosmology while also comparing three different interpretations of quantum mechanics (QM), that is, the Copenhagen interpretation (CI), quantum logic (QL), and the many-worlds interpretation (MWI); section 5 discusses the experiment's implications for presentism versus eternalism, the cosmogonic boundary versus no cosmogonic boundary, and QM.

2. Propositions and Terms of Logic

The following propositions and terms of modal logic form the basis for this thought experiment.

2.1 Propositions 5–7

Propositions 5–7 are clarified adaptations of Aristotle's (350 BCEa) laws of thought and the foundations of standard logic:

> **Proposition 5.** Anything is absolutely identical to itself and nothing else at any particular point of spacetime.
>
> **Proposition 6.** There are no absolute contradictions.
>
> **Proposition 7.** Any *P* exists or not exists at any particular point of spacetime.

Propositions 5–7 are respectively the law of synchronic absolute identity, the law of noncontradiction, and the law of excluded middle. Also, one might wonder if Proposition 6 implies that some contradictions might not be an absolute contradiction. For example, an incoherent statement or policy is not an absolute contradiction.

2.2 Modal Logic Terms

Nuanced definitions of modal logic terms follow:

1. The adjective *hypothetical* refers to a coherent or incoherent imaginary thing.
2. The adjective *logical* refers to an internally coherent thing regardless if it coheres with the known laws of nature.
3. The adjective *nomological* refers to a thing that coheres with the known laws of nature.

4. A *logical possibility* is an internally coherent proposition regardless if it coheres with the known laws of nature.

5. A *nomological possibility* is a proposition that coheres with the known laws of nature.

6. A *nomological impossibility* is a proposition that incoheres with the known laws of nature.

7. A *logical impossibility* is an internally incoherent proposition.

3. Physics Terms and Concepts

The following physics terms and concepts are foundational for the thought experiment.

3.1 Preliminary Physics Terms

1. The *observable universe* is the physical universe that is potentially observable from Earth regardless of whether technology permits the observation.

2. An *unobservable entity* is a physical entity that technology cannot observe.

3. *Newton's absolute time* exists independently of any observer and elapses at a constant rate throughout the universe.

4. *Spacetime* refers to the four-dimensional unity of the three visible spatial dimensions and the one time dimension.

5. An *event* is a point and all its respective phenomena in the spacetime universe. The point has four relative coordinates that are three spatial coordinates and one time coordinate.

6. A *reference frame* consists of an abstract spacetime coordinate system and the set of physical reference points that align the coordinate system and standardized measurements.

7. An *inertial reference frame* is a reference frame without acceleration. *Acceleration* is a change of velocity.

8. A *closed timelike curve* (CTC) is a pathway for a quantum system that travels into its own past.

3.2 Special Relativity

SR is the theory of relative spacetime in the special case of no gravity. SR is based on flat geometry, which is Euclidean geometry. SR has two postulates. One, the laws of physics are identical for all inertial reference frames. Two, the speed of light is the same for all reference frames. This thought experiment focuses on the SR implication for (1) the *relativity of simultaneity* and (2) *velocity time dilation*.

3.2.1 Relativity of simultaneity

The relativity of simultaneity implies that no causally disconnected events are absolutely simultaneous. For example, two events are causally disconnected when the time interval between them is less than the spatial distance between them divided by the speed of light. Also, the relativity of simultaneity implies the nonexistence of Newton's absolute time and Lorentz's (1904) preferred reference frame for a universal chronology that is held together by undetectable ether.

An interesting illustration of the relativity of simultaneity is a relativistic reversal of chronology of causally disconnected events. Consider the following example with *observer A*, *observer B*, *event A*, and *event B*. Each observer and event has its own reference frame in a spacetime region that is causally disconnected from the other three reference frames. Observer A detects event B before event A. Observer B detects event A before event B. This example exemplifies the relativity of simultaneity.

3.2.2 Velocity time dilation

SR implies velocity time dilation. For example, an observer with a higher relative velocity has a slower progress of time compared to an observer with a lower relative velocity.

3.3 General relativity

Einstein (1961) developed GR while using Riemann's mind-boggling curved geometry to add the effects of gravity to SR. For example, the Riemannian geometry of GR permits an infinite number of ways to define reference frames. Also, an observer at any point in the universe sees the same spatial scale factor in every direction. For instance, astrophysics confirms that the current spatial scale factor in every direction from every point in the universe is 46 billion light-years or 10^{23} kilometers. Furthermore, GR implies gravitational time dilations. For illustration, an observer in stronger gravity has a slower progress of time compared to an observer in weaker gravity.

Ironically, scientific consensus says that gravity is fundamental to the observable universe, yet there is no consensus for the cause of gravity. For example, Einstein (1961) stated that gravity is caused by the forceless interaction of mass and bendable spacetime. However, a current majority of gravitational physicists hypothesize the existence of unobservable gravitational force and the respective elementary particle called the *graviton* (Dyson 2012). For instance, Einstein's theory of forceless gravity has no quantum fields and likewise has nomological impossibility of interacting with quantum systems. However, a graviton with zero mass coheres with QM and Einstein's field equations for GR.

3.4 Wormhole Theory

Morris and Thorne (1988) and James, von Tunzelmann, Franklin, and Thorne (2015) describe that a traversable wormhole has two ends, a throat at each end, no black hole, and zero distance between the throats. Also, the formation of temporary traversable wormhole throats would require exotic matter that causes a highly unlikely magnitude of the Casimir effect. Furthermore, given the exotic matter, James et al. (2015) describe that it is uncertain if the wormhole throats could be large enough and stay open long enough for the passage of a macroscopic object such as a spaceship. However, the authors say that wormhole theory is nonetheless useful as a pedagogical tool for teaching elementary GR. Similarly, this paper uses wormhole theory and observers to describe what I call *teleportative observers* and *teleportative sight*. Next, I cite some wormhole research.

Einstein and Rosen (1935) proposed that GR implies the possibility of wormholes that connect distant events in the spacetime universe. Later developments of wormhole theory include traversable wormholes (Bronnikov 1973; Ellis 1973; Morris and Thorne 1988; James et al. 2015), matterless wormholes (Gravanisa and Willison 2007), and quantum wormholes (Maldacena and Susskind 2013; Jensen and Karch 2013; Susskind 2016a, 2016b; Cao, Carroll, and Michalakis 2017, Susskind and Zhao 2018). Additional critiques indicate the nomological impossibility of wormholes with a CTC (Hawking 1992; Pati, Chakrabarty, and Agrawal 2011; James et al. 2015). However, experimental simulations of CTCs are logically possible (Ringbauer, Broome, Myers, White, and Ralph 2014).

I categorize traversable wormholes into two different types, that is, *teleportative traversable wormholes* and *time-traveling traversable wormholes*. A teleportative traversable wormhole could transfer a whole quantum system from one present location in spacetime to another present location. Alternatively, a time-traveling traversable wormhole could transfer a whole quantum system from a present location to another location in the past or future. However, limitations apply. A teleportative traversable wormhole is nomologically possible but highly unlikely. Also, a CTC could involve a time-traveling wormhole because a CTC would transfer a quantum system into its own past. However, as previously noted, a CTC is logically possible but nomologically impossible.

A recent development in wormhole theory is hypotheses of quantum wormholes which logically explain the unity of *action at a distance* in quantum entanglement (Maldacena and Susskind 2013; Jensen and Karch 2013; Susskind 2016a, 2016b; Cao et al. 2017; Susskind and Zhao 2018). Setting aside any extravagances of the cited hypotheses, what I call *the basic quantum wormhole hypothesis* says that an entangled pair of photons and their action at a distance are united by a quantum wormhole which is beyond direct detection. The photons that are otherwise distant to each other have zero spatial distance between them in the wormhole. This is the most logical explanation for the entangled action at a distance. Additional importance of the basic quantum wormhole hypothesis is that laboratories routinely generate quantum entanglement with action at a distance. For example, ground-to-satellite quantum entanglement with action at a distance has reached 1,200 kilometers (Yin et al. 2017).

The goal of the laboratory generated ground-to-satellite quantum entanglement is the development of *quantum teleportation* for future quantum communication and computing technology (Ren et al. 2017; Gisin 2017). The quantum teleportation has two major steps. First, the laboratory generates an entangled quantum system such as the previously noted ground-to-satellite quantum entanglement. Second, the quantum entanglement is used to *instantaneously* (1) destructure quantum information from the sending end of the entanglement and (2) restructure the same quantum information at the other end. I call this *restructural teleportation* as opposed to *whole teleportation*. Also, the basic quantum wormhole hypothesis implies that the laboratory generated quantum entanglement and restructural teleportation involve quantum wormholes.

The basic quantum wormhole hypothesis can also apply to new discoveries of quantum entanglement in astrophysics. Fascinating new research indicates that the universe is filled with entangled pairs of photons with action at a distance measured to a whopping 2,000 light-years, that is, 10^{16} kilometers (Handsteiner 2017; Rauch 2018). This action at a distance is mind-boggling when considering that there are 80 million stars within 2,000 light years of the Sun. The basic quantum wormhole hypothesis applied to the astrophysics data predicts that the universe is filled with quantum wormholes, including interstellar quantum wormholes, which are a capable medium for restructural teleportation. The quantum wormholes unite the photon pairs with zero distance between them in the wormhole regardless of the non-wormhole distance between them.

Also, as noted in the introduction, Goetz (2016, pp. 331–332) proposes a hypothetical omnicluster of teleportative wormholes. The omnicluster of wormholes contains no throats and is not traversable, but it enables an observer to detect every event in the universe or multiverse as if there were zero spatial distance or no other interaction between the observer and each event. This enables a preferred universal chronology of events without an absolute spacetime scale. The proposal says that GR implies wormhole theory and does not depend on the existence of any actual traversable wormhole. However, the proposal needs modification because there is no consensus that GR implies wormhole theory.

Alternatively, I propose that teleportative observers and teleportative sight cohere with the subset of GR solutions that permit traversable wormholes given highly unlikely or nomologically impossible wormhole throats. Such GR solutions include James et al. (2015). Also, a teleportative observer does not teleport objects but uses teleportative sight to detect every event in every quantum system of the universe. The teleportative sight permits detection at a distance. For example, a teleportative observer detects distant events and respective time dilation as if there were no macroscopic spatial interval and no other interaction between the observer and the events.

Imagine hypothetical James et al. (2015) traversable wormholes. CTCs and all other time travel are impossible, but teleportation of small objects and visual perception through a wormhole are possible. Consider a model of an exotic wormhole throat that has a one meter radius and a microscopic length. Any pair of the throats have zero distance between them and looks like a temporary teleportation portal. Exotic matter generates the model traversable wormholes to any otherwise causally disconnected location. Observers on both sides of a model wormhole see each other as if there was no macroscopic distance between them.

3.5 The Position and Time of a Quantum System

The position and time of a quantum system is mind-boggling and controversial. Preliminary QM terms for this subsection follow:

1. A *quantum state* is a mathematical description of a *quantum system* (Schrodinger 1926).

2. A *pure quantum state* cannot be described as a mixture of other quantum states; pure quantum states include unentangled elementary particles and entangled quantum systems (Einstein, Podolsky, and Rosen 1935).

3. In the rest of this paper, the terms *quantum state* and *quantum system* refer to a pure quantum state and a pure quantum system.

4. The *Schrodinger equation* predicts all possible quantum states for the evolution of a quantum system.

5. A quantum system holds to the conservation of energy on average during its evolution.

6. An *observable* of a quantum state such as position or time has a dynamic variable that can be measured.

7. The Schrodinger equation defines that an observable corresponds to a mathematical *operator* with possible values called *eigenvalues*.

8. The Schrodinger equation implies that some observables have *noncommutative* operators. Examples of noncommutative operators include *position* and *momentum* as well as *time* and *energy*.

The rest of this subsection describes generalized positions of the CI, QL, and the MWI.

3.5.1 The Copenhagen interpretation

QM textbooks are based on the CI use of the Schrodinger equation (Heisenberg 1930; Sakurai and Napolitano 2010). The two most notable features of the CI are the *wave function collapse* and the *Heisenberg uncertainty principle* that is synonymously called the *Heisenberg indeterminacy principle* or simply the *uncertainty principle*.

The term *wave function* for the most part is synonymous with the term *quantum state*. The CI says that a wave function collapse occurs when an undefined observer detects all possible quantum states while the observer's detection causes the possible quantum states to collapse into a single quantum state.

The uncertainty principle implies uncertainty of an observed quantum state based on the Schrodinger equation prediction that some observables have noncommutative operators. Also, the uncertainty principle never applies to classical mechanics.

Furthermore, the CI proposes that all motion of quantum systems involves probabilistic causation. For example, all elementary particle oscillation involves probabilistic causation.

Finally, despite the standard textbook use of the CI, the CI is tentative (Susskind 2016a).

3.5.2 Quantum logic

Von Neumann (1932; 1955) introduced that QM can cohere with standard logic. Then, Birkhoff and von Neumann (1936) rigorously introduced QL. Additional theoretical development of QL includes Mackey (1963); Beltrametti and van Fraassen (1981); Cohen (1989), Coecke, Moore, and Wilce (2000); Engesser, Gabbay, and Lehmann (2009); and Ozawa (2011; 2016). QL in experimental physics includes Sulyok et al. (2015) and Demirel, Sponar, Sulyok, Ozawa, and Hasegawa (2016).

A summary of QL follows:

1. The mathematics of QL is more complicated than the mathematics of the CI.

2. QL agrees with the CI by proposing that the Schrodinger equation predicts all possibilities for the evolution of a quantum system and that all motion of a quantum system is probabilistic.

3. QL disagrees with the CI by proposing that the noncommutative operators of the Schrodinger equation do not imply the uncertainty of quantum states.

4. Any quantum eigenvalue is defined by two-value logic and therefore (1) actually exists or (2) not actually exists.

5. The two-value logic implies certainty of a quantum state.

The set theory approach of QL by Takeuti (1981) and Ozawa (2011) also proposes a state-dependent interpretation of QM as opposed to a particle-dependent interpretation. The state-dependent interpretation permits the certainty of a quantum state for an entangled system and the superposition of common eigenvalues. For example, the state-dependent interpretation of entanglement and superposition resolves problems from the EPR paradox (Einstein et al. 1935); Schrodinger's cat paradox (Trimmer 1980); Bell's (1966) theorem, and the Kochen–Specker (1967) theorem.

3.5.3 The MWI

The MWI proposes that QM coheres with standard logic (Everett 1957). A simple summary of the MWI follows:

1. The MWI agrees with the CI and QL by proposing that the Schrodinger equation predicts all possibilities for the evolution of a quantum system.

2. The MWI proposes that all possible quantum eigenvalues for any quantum system actually exist in a deterministically branching multiverse.

3. Experimental physics in a world branch cannot detect any other world branch, except through a hypothetical wormhole.

3.6 Probability Distributions in Classical Mechanics

The detection of probability distributions in classical mechanics includes Galton board experiments (Barile and Weisstein n.d.), celestial mechanics, fluid dynamics, thermodynamics, chemical reactions, and nuclear reactions.

3.7 A Relative Spacetime Coordinate System

Preliminary terms:

1. A *Planck time* is the theoretically smallest possible unit of measurable time; 1 Planck time equals 10^{-43} seconds, which is the time required for light in a vacuum to travel the distance of 1 Planck length.

2. A *Planck Length* is the theoretically smallest possible unit of measurable length; 1 Planck length equals 10^{-35} meters.

A relative spacetime coordinate system has four relative axes for each spacetime point, for example, (t, x, y, z). The time axis is (t) and the three spatial axes are (x, y, z).

In this thought experiment, the intervals for the axes (x, y, z) are Planck lengths and the intervals for the axis (t) are Planck times. For example, axis (x) is perpendicular to axes (y, z); the first interval is ($0 \le x < 1$); the second interval is ($1 \le x < 2$); the third interval is ($2 \le x < 3$); and so on. Also, astrophysics indicates that the observable universe has a scale factor of roughly 46 billion light-years that equals (2.7×10^{62}) Planck lengths in any given direction from any given point in the universe. Therefore, axes (x, y, z) are currently three perpendicular lines with intervals that extend from (-2.7×10^{62}) to ($+2.7 \times 10^{62}$), and any observer is located on its own ($x = 0$, $y = 0$, $z = 0$). Furthermore, present cosmic time relative to observers on Earth is roughly 13.8 billion years or (8×10^{60}) Planck times, so a present observer on earth is located at ($t = 8 \times 10^{60}$). Moreover, other present regions of the observable universe could be relatively younger or older due to different histories of time dilation.

3.8 Chronology of the Big Bang

The Big Bang theory begins with the Planck epoch that was the first Planck time interval of the observable universe. The first Planck time interval possessed the initial singularity. For example, a singularity is a dimensionless point with infinite curvature and the initial singularity was a singularity with infinite density. The very early universe endured from the Planck epoch to the end of baryogenesis that is the first millionth of a second or the first 10^{37} Planck times. For instance, baryogenesis produced elementary fermions that are matter particles. In the context of the Standard Model of particle physics, that first millionth of second exhibited the formation of 10^{90} quantum systems that were mostly photons and 10^{80} fermions.

The fermions moved rapidly and probabilistically in the state of plasma. Their distribution throughout the universe was nearly uniform with small fluctuations of density. The distribution of the density fluctuations was also nearly uniform. The expansion of the universe and thermodynamics cooled the plasma. After 400 thousand years, the universe expanded and cooled enough for the formation of hydrogen and helium gas that mixed with the remaining plasma. The plasma and gas moved rapidly and probabilistically. Eventually, gravity formed the density fluctuations into molecular clouds that collapsed into stars.

3.9 Inflationary Multiverse Cosmologies

Inflationary multiverse cosmologies propose that the observable universe is a pocket universe in the multiverse (Guth 2007). Proponents of inflationary multiverse cosmologies debate if the multiverse has a finite past or an infinite past (Linde 2015). For example, an object with a finite past has a finite age with a foremost beginning; while an object with an infinite past has an undefined infinite age and no beginning. Also, experimental physics in a pocket universe cannot detect another pocket universe, except through a hypothetical wormhole.

3.10 Number Theory and Infinity

Physics papers sometimes use the symbol ∞ that represents infinity. Correct use of infinity includes geometry, set theory, and limits, but erroneous use of infinity abounds.

Consider the following correct uses of infinity:

1. A line segment has an infinite number of points.

2. The countable set of natural numbers has an infinite number of natural numbers.

3. The infinite set of real numbers and the infinite set of rational numbers are infinite sets with different sizes.

However, any standard arithmetic operation with the symbols $\mp\infty$ is undefined. For example, there is no natural number ∞ and no real number $\mp\infty$.

Aristotle (350 BCEa; 350 BCEb) distinguished between *actual infinity* and *potential infinity*, and the difference between them sometimes causes confusion. For example, the term *potential infinity* refers to no natural number but to a never ending process. For instance, the process of individually counting each natural number in the countably infinite set of natural numbers would never end. In other words, completing the process of counting natural numbers individually is logically impossible. Also, any erroneous use of $\mp\infty$ in arithmetic operations results in a hypothetical calculation that is undefined or logically impossible.

3.11 The Philosophies of Presentism and Eternalism

Presentism and eternalism are competing philosophies of time.

3.11.1 Presentism

Presentism proposes that the present tense is objectively distinct from the past and future (Zimmerman 2011). My clarified presentism outlined in this paragraph defines that only the present tense of quantum systems and their mixtures tangibly exist; while tensed modes support intangible facts of past history and future possibilities. For example, past events included tangible events that no longer exist; while factual history of those past events intangibly exists in the present. Also, no future possibility tangibly exists while facts about future possibilities intangibly exist. In sum, *Proposition 8* states the central claim of my clarified presentism:

Proposition 8. Only the present tense of quantum systems and their mixtures tangibly exist.

Furthermore, the following *Proposition 9* summarizes scientific evidence that supports Proposition 8:

> **Proposition 9.** Scientific evidence indicates that (I) all quantum systems oscillate; (II) disorder in an isolated system probabilistically increases during the progress of time; and

(III) experimental physics has never detected a tangible past event or a tangible future event.

3.11.2 Eternalism

As previously stated, Propositions 1–4 generalize SR eternalism.

4. The Thought Experiment

The thought experiment imagines two teleportative observers (section 3.4), the time evolution of quantum systems (section 3.5), a relative spacetime coordinate system (section 3.7), and the chronology of the universe (sections 3.8–9). Section 4.1 describes the teleportative observers. Section 4.2 describes the time evolution of quantum systems in generalized contexts of the CI, QL, and the MWI. Section 4.3 describes the chronology of the Big Bang in the contexts of the CI and QL. Section 4.4 describes the chronology of the Big Bang in the context of the MWI. Section 4.5 describes the chronology of an inflationary multiverse. Section 4.6 summarizes what I call *the preferred focal pathway for a universal chronology*.

4.1 Teleportative Observers and the Relativity of Simultaneity

An SR observer detects events through an interval of flat space. GR adds gravity to the mix and a GR observer detects events through an interval of curved space. Also, section 3.4 describes teleportative observers which detect distant events with teleportative sight. This observation is detection at a distance. For example, a teleportative observer detects distant events and respective time dilation as if there were no macroscopic spatial interval and no other interaction between the observer and the events.

The rest of this section imagines two teleportative observers with bifocal pathways. One focal pathway is called *teleportative sight* and detects events through the above teleportative detection wormholes. The other focal pathway is called *space-interval sight* and detects events through space intervals that are subject to the relativity of simultaneity, which is the same pathway used by a standard SR or GR observer.

Imagine four objects called *observer A*, *observer B*, *event A*, and *event B*. Each of the four objects is located in a spacetime region that is causally disconnected from the other three regions. The observers A and B possess bifocal pathways described in the previous paragraph.

According to the space-interval sight of observer A, event A occurs before event B. According to the space-interval sight of observer B, event B occurs before event A. This describes a relativistic reversal of chronology for the two events and likewise exhibits the relativity of simultaneity implied by SR and GR.

However, the teleportative sights of observer A and observer B are identical. They both detect event A and event B without a relative space interval. For example, observer A and observer B detect the same chronology of event A and event B.

Imagine the above scenario with a four-part chronological order for each observer defined as (T_1, T_2, T_3, T_4):

1. The space-interval sight of observer A at T_1 parallels event A.
2. The teleportative sight of observer A at T_2 parallels event A.
3. The space-interval sight of observer A at T_3 parallels event B.
4. The teleportative sight of observer A at T_4 parallels event B.
5. The space-interval sight of observer B at T_1 parallels event B.
6. The teleportative sight of observer B at T_2 parallels event A.

7. The space-interval sight of observer B at T_3 parallels event A.

8. The teleportative sight of observer B at T_4 parallels event B.

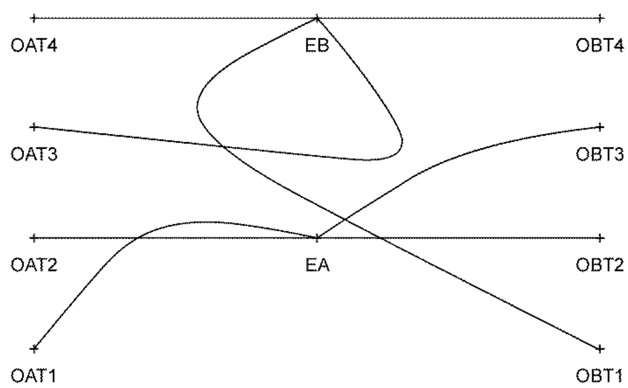

Figure 1. Schematic illustration of observer A (*OA*) at (T_1, T_2, T_3, T_4); observer B (*OB*) at (T_1, T_2, T_3, T_4); event A (*EA*); and event B (*EB*). Curved lines represent space-interval sight; straight lines represent teleportative sight.

The time parallels of the space-interval sight exhibit no transitivity as implied by the relativity of simultaneity. For example, imagine the space-interval sights that detect EA:

1. OAT1 parallels EA.

2. OBT4 parallels EA.

3. OAT1 un-parallels OBT4.

The un-parallel times between OAT1 and OBT4 exhibit no transitivity. However, the time parallels for the teleportative sight exhibit transitivity. For example, imagine the teleportative sights that detect EA:

1. OAT2 parallels EA.

2. OBT2 parallels EA.

3. OAT2 parallels OBT2.

The parallel time between EA, OAT2, and OBT2 exhibits transitivity.

4.2 Time Evolution of Quantum Systems

Every quantum system with a wave nature exhibits wave oscillation. One of the simplest examples of an oscillation is a swinging pendulum. For example, imagine a pendulum that swings back and forth. We see a single oscillation cycle when the pendulum swings from right to left and then left to right, or vice versa. Therefore, each swing is a half cycle. An oscillation cycle of a quantum system is more complicated than the oscillation cycle of a swinging pendulum, and I will use the term *quantum half cycle* to refer to half the oscillation cycle of a quantum system. For instance, if a quantum system oscillates at a frequency of 2 gigahertz, then each quantum half cycle is a billionth of a second or 10^{-34} Planck times. Also, this thought experiment assumes the existence of gravitational force. Therefore, each quantum half cycle is a discrete motion.

Consider the *world line* of a quantum system. For example, a world line is the pathway that an object abstractly traces in four-dimensional spacetime. In the case of a quantum system, its world line progresses every quantum half cycle. For the purpose of this thought experiment, the *local clock* and *progress of time* is specific for each quantum system. For example, a local observer can measure the progress of time for a quantum system that progresses every quantum half cycle.

Next, consider the comparison of world lines for two quantum systems in a causally connected region of space. Differences of velocity and differences of gravity between the two quantum systems cause relative time dilation (sections 3.2.2 and 3.3).

4.3 The Chronology of the Big Bang, the CI, and QL

A spacetime coordinate system for Big Bang cosmology begins with the coordinates for the initial singularity that ranged from ($t = 0$, $x = 0$, $y = 0$, $z = 0$) to ($t > 1$, $x = 0$, $y = 0$, $z = 0$). For the purpose of this section, the CI and QL have more in common than differences. For example, the number of quantum systems in the observable universe is the same for both the CI and QL. Also, the difference between the CI and QL is minor uncertainty versus no uncertainty of the time and position of the quantum systems. Noting those differences, the rest of this section assumes QL and two teleportative observers called *observer A* and *observer B*.

The experiment arbitrarily jumps to the end of the very early universe when there were 10^{90} quantum systems with an age of 10^{37} Planck times, and 10^{80} of the quantum systems were fermions. The observers A and B were located at ($t = 10^{37}$) while they were causally disconnected to each other. Despite the relativity of simultaneity for causally disconnected events, observer A and observer B detected that all 10^{90} quantum systems possessed events that existed simultaneously because the observers detected with teleportative sight described in section 4.1.

All of the quantum systems continued to evolve by changing every quantum half cycle. The different types of quantum systems possessed different oscillation frequencies. For example, the photons possessed no mass and the fermions possessed mass. The differences of mass and other factors caused differences of velocity and gravity among the 10^{90} quantum systems that caused relative time dilation. The different oscillation frequencies and the time dilation implied that the progress of time lacked synchronization throughout the observable universe.

The differences of the aging and progress of time increased because the distribution of the fermions throughout the universe was nearly uniform with small fluctuations of density, and the small fluctuations eventually evolved into enormous differences of density such as the density differences between intergalactic space and stellar black holes.

The observers A and B remained causally disconnected from each other. However, they detected the exact same chronology of every event in every quantum system of the observable universe because their teleportative sight is not subject to the relativity of simultaneity.

4.4 The Chronology of the Big Bang and the MWI

As previously noted, the MWI proposes that every possible quantum state of any quantum system predicted by the Schrodinger equation actually exists in a deterministically branching multiverse. We arbitrary assume the chronology of the Big Bang in the context of the MWI and begin with 10^{90} quantum systems that each have an age of 10^{37} Planck times at the end of the very early universe. Also, we arbitrarily assume a simple calculation where each quantum system on average deterministically changes into 10 different quantum systems after each 10^{-9} seconds. Therefore, all possible combinations of quantum half cycles for the next 10^{-9} seconds result in 10^{90} combinations of branch worlds that each possessed 10^{90} quantum systems. I call each of these worlds a *combination-branch world*. After the next 10^{-9} seconds, the 10^{90} combination-branch worlds developed into 10^{180} combination-branch worlds. The exponential growth of combination-branch worlds continued with each new 10^{-9} seconds. Furthermore, the different oscillation frequencies and relative time dilation described in section 4.3 caused unsynchronized multiplication of the combination-branch worlds.

Alternatively, the Schrodinger equation predicts an infinite number of possible eigenvalues for each observable. For example, each quantum half cycle has an infinite number of possibilities. In this case, each quantum system deterministically changes into an infinite number of quantum systems. Therefore, the number of combination-branch worlds is an infinite number. Also, the infinite number of combination-branch worlds exponentially increases on an average of every 10^{-9} seconds.

In any MWI scenario, the teleportative observers A and B were located in causally disconnected regions of the MWI multiverse. They each detected the same chronology of every event in every quantum system of the multiverse because their teleportative sight is not subject to the relativity of simultaneity.

4.5 The Chronology of Inflationary Multiverse Cosmologies

Inflationary multiverse models can have an infinite past or a finite past; while they can combine with the CI, QL, or the MWI. Regardless of these details, the teleportative observers A and observer B located respectfully in causally disconnected regions will detect the same chronology of every event in every quantum system of an inflationary multiverse because their teleportative sight is not subject to the relativity of simultaneity.

4.6 The Preferred Focal Pathway for a Universal Chronology

As previously mentioned in section 3.2, Einstein's SR implied the nonexistence of (I) Newton's absolute time and (II) Lorentz's preferred reference frame for a universal chronology that is held together by undetectable ether. GR added an infinite number of possible reference frames to the mix. However, the impossibility of an absolute timescale does not imply the impossibility of a preferred universal chronology. For example, this thought experiment supports that teleportative sight is the preferred focal pathway for a universal chronology.

5. Discussion

5.1 Presentism versus SR eternalism

SR eternalism is more popular than presentism among contemporary philosophers. However, the section 4 thought experiment implies that SR eternalism is invalid except for the GR solutions that incohere with teleportative observers.

For a refresher, Propositions 1–4 define a generalized position of SR eternalism:

Proposition 1. There is no possible preferred universal chronology.

Proposition 2. There is no ontological difference between space and time.

Proposition 3. All past, present, and future events have always tenselessly existed in what is called the *now*.

Proposition 4. Tensed time is unreal and an illusion.

The experiment implies that Propositions 1 is invalid except for GR solutions that incohere with teleportative observers. I clarify that merely proving the nomological impossibility of traversable wormhole throats does not invalidate the thought experiment, but only GR solutions that incohere with teleportative observers invalidate the thought experiment. This permits limited versions of SR eternalism. Consider the limitations. The Rietdijk–Putnam argument coheres only with GR solutions that incohere with teleportative observers and likewise any model of traversable wormholes that include time-traveling traversable wormholes. Likewise, the Rietdijk–Putnam argument incoheres with time-travel through wormholes.

Now we consider Carroll (2010, pp. 105–106). He leans toward presentism and the nomological impossibility of CTCs instead of eternalism and the nomological possibility of

CTCs. However, he says that the nomological possibility of CTCs would definitively support eternalism and refute presentism because nomologically possible CTCs would not permit a series of present events. I agree with him that the nomological possibility of CTCs would not permit presentism.

As previously defined, a CTC is a world line for a quantum system that returns to its own past. Also, CTCs are a notable physics hypothesis of time travel into the past. Furthermore, for the purpose of this paper, a CTC by definition does not cause a new MWI branch world. For example, if a quantum system travels to another branch world through a world line that resembles a CTC, then the quantum system travels into a branch world that is nearly identical to its past. Therefore, the respective MWI world line that resembles a CTC is not an actual CTC.

Back to CTCs, Ringbauer et al. (2014) developed a computer simulation of a Deutsch (1991) CTC. I suggest no fault in the logic of the CTC simulation; while I discuss problems with a critical assumption. For example, consider the logically necessary Proposition 10:

> **Proposition 10.** CTCs and any other time travel to the past would require the tangible existence of past quantum systems.

Proposition 10 suggests the importance of investigating the nature of the past when evaluating the possibility of CTCs and other time travel. Two prominent positions that imply the tangible existence of the past are SR eternalism and the growing block (Miller 2013). For example, SR eternalism implies that past, present, and future events tangibly exist; while the growing block position states that past and present events tangibly exist.

First, consider the possibility of a CTC in a growing block universe. The growing block's existence of the past might at first glance look promising for the possibility of a CTC. However, past events in a growing block never change. For example, a CTC would change the past unless the CTC has always existed. Therefore, a CTC is logically impossible in the case of a growing block because no CTCs or any tangible events could have always existed in a growing block.

Second, consider the possibility of a CTC in an eternalist universe that coheres with Propositions 1–4. If an SR eternalist universe was possible, then a CTC logically could have always existed in an eternalist universe. However, Proposition 1 and time-traveling wormholes are incompatible. Also, a CTC and the Rietdijk–Putnam argument are incompatible unless there is a reasonable model of a CTC that does not use a wormhole for traveling to the past.

Also, consider a CTC that always exists in an eternalist universe defined by Propositions 2–4:

> **Proposition 2**. There is no ontological difference between space and time.
>
> **Proposition 3**. All past, present, and future events have always tenselessly existed in what is called the *now*.
>
> **Proposition 4**. Tensed time is unreal and an illusion.

One could imagine CTCs and other time travel in a hypothetical eternalist universe with no ontological difference between space and time. For example, relativity implies that the three spatial dimensions and the time dimension are four equivalent geometrical values on a four dimensional coordinate system. Also, traveling back and forth in time would be no different than traveling back and forth in space. Furthermore, any time travel would have always existed.

One could also imagine time travel in what I call a *hypothetical dynamical quasi-eternalist universe* that has no ontological difference between space and time. In this case, traveling to the relative past and changing the past would immediately cause a ripple effect that changes the relative future. For example, the past, present, and future would have always existed with a pliable nature. In this scenario, somebody could travel to the past and kill their grandfather before their father was born and immediately eliminate their own existence.

However, the fact that relativity implies that the three spatial dimensions and the time dimension are equivalent geometrical values does not imply that there are no ontological differences between space and time. For example, scientific observation indicates that many tangible objects have taken a round trip through a spatial interval, but there is no scientific evidence that any tangible object has taken a round trip through a time interval. Also, scientific observation indicates the second law of thermodynamics. The thermodynamics of an isolated macroscopic system over time always exhibits a probabilistic increase of disorder which is a violation of time-reversal symmetry. The increase of disorder always includes microscopic reversibility of disorder permitted by time-reversal symmetry, but the macroscopic increase of disorder always prevails. Likewise, the physics of travel and thermodynamics indicates that the geometrical unity of space and time does not imply that there is no ontological difference between space and time. Proposition 2 is false.

There is no scientific evidence against the progress of time except for the subset of theoretical GR solutions that incohere with teleportative observers. In the case of those exceptions, one could argue that all evidence for progress of time and change is unreal and illusionary. However, the cost of the argument includes the antirealism of ubiquitous scientific observation and human perception. Alternatively, the reasonable subset of theoretical GR solutions that cohere with teleportative observers avoids the great cost of the antirealism of ubiquitous scientific observation and human perception.

5.2 McTaggart's Scientific Antirealism

McTaggart (1908; 1927) famously proposed the antirealism of time and change. He did not merely argue for the antirealism of tensed time and change but also argued for the antirealism of tenseless time. The argument completely rejects relativity's implication of four-dimensional spacetime. One of McTaggart's primary points is that tensed time is a contradiction because it implies that the same event is in the past, present, and future (1927, pp. 18–31). He also counterargues all opposing counterarguments based on laws of thought that explain the noncontradiction of a single event being in the past, present, and future. His counterargument says that his opponents' counterarguments depend on circular logic.

I appreciate warnings against circular logic. However, the laws of thought are self-evident axioms. For example, the law of noncontradiction and the prohibition against circular logic boil down to self-evident axioms. Consider McTaggart's argument that tensed time is unreal because it implies contradictions while all propositions that define tensed time with noncontradiction are circular arguments (1927, pp. 18–31). He ultimately uses the self-evident axioms of noncontradiction and prohibition against circular logic while objecting to somebody else's self-evident axioms. Likewise, the prohibition of circular logic does not include the prohibition of self-evident axioms unless we use circular logic to prohibit circular logic.

McTaggart (1921; 1927) used skepticism to develop his antirealism and idealism. For example, he set the foundation for his idealism by challenging the validity of inductive logic (1921, pp. 38–52); while the scientific method depends on inductive logic.

I understand that induction and the scientific method cannot establish absolute proof of anything, but I nonetheless object to global skepticism and McTaggart's idealism. For example, rigorous development of the *no miracles argument* for *scientific realism* includes Dawid and Hartmann (2018). A primary point of the no miracles argument is that many scientific theories have obtained a cross-cultural global consensus after many years of experiments and rigorous analysis. For instance, the theory of the periodic table of elements is taught as fact in schools around the world. The ubiquitous success of the scientific theory supports that the periodic table of elements is fact based on rigorous scientific research instead of a worldwide miracle without rational basis.

5.3 The Cosmogonic Boundary

Next, I discuss teleportative observers and the debate of a cosmogonic boundary versus no cosmogonic boundary. The cosmogonic boundary is the boundary at the origin of the universe or multiverse. For example, inflationary multiverse models have a finite past with a cosmogonic boundary or an infinite past with no cosmogonic boundary (sections 3.9 and 4.3).

This section focuses on the debate about the existence of a cosmogonic boundary. For example, assuming the preferred focal pathway for a universal chronology (section 4), the argument for presentism (section 5.1), and number theory (section 3.10), consider Propositions 11–13:

> **Proposition 11.** An actual infinite series of tensed Planck time intervals is logically impossible.

Proposition 12. Proposition 11 implies that any cosmological model with an actual infinite past of tensed Planck time intervals is logically impossible.

Proposition 13. Proposition 12 implies that any tensed cosmological model that is logically possible possesses a foremost cosmogonic boundary for the origin of tensed Planck time intervals.

Proposition 11 is logically necessary and implies Propositions 12–13. One might object to the reality of tensed cause and effect while deeming that Propositions 11–13 are irrelevant to physics, but the propositions are nonetheless logically necessary while scientific support for eternalism is limited to the subset of GR solutions that incohere with teleportative observers.

A complete survey of cosmologies with no foremost cosmogonic boundary is beyond the scope of this paper. Nonetheless, consider the case of Linde (2015) conceding to another argument that implies a finite past for an inflationary multiverse cosmology, yet Linde proposes an infinite past series of cosmogonic boundaries for his inflationary multiverse cosmology. This infinite past of inflationary universes implies no foremost cosmogonic boundary. For example, Riemannian geometry permits the possibility of an infinite number of Riemannian manifolds with infinite size. In the case of inflationary multiverse cosmology, a Riemannian manifold represents a pocket universe and similarly Riemannian geometry can model an infinite past series of cosmogonic boundaries. However, the abstract geometric possibility of an infinite past series of pocket universes does not affect the logical necessity of Propositions 11–13. Linde's proposal would be logically possible only if eternalism was possible. But Linde's proposal is logically impossible with presentism because the infinite past series implies an actual infinite series of tensed Planck time intervals.

Alternatively, Propositions 11–13 cohere with an absolutely static universe which has an infinite past or an absolutely static singularity with an infinite past. For example, an absolutely static universe would possess no original boundary, no terminal boundary, and no motion such as fluctuations or oscillations. It would be continuous with no quantum fields. Therefore, it would exhibit internal tenselessness and no progress of time. Relative to any event in the observable universe, the absolutely static universe would have an infinite past.

5.4 Quantum Mechanics

The teleportative observers detect every detail of every quantum system. Section 4 explored implications of the observers in the contexts of CI, QL, and MWI. The three interpretation of QM agree that the Schrodinger equation predicts the possible evolution of a quantum system. The CI and QL agree on the probabilistic causality of quantum evolution and the correct use of number theory. QL and the MWI agree on quantum certainty.

5.4.1 The CI

The biggest problem with the CI is that the uncertainty principle proposes absolute contradictions. Some eigenvalues both exist and not exist at the same point of spacetime. Unqualified concession to the noncommutative operators has resulted in absolute contradictions while defining a quantum state with uncertainty is simpler than the mathematics of QL, but the cost of the simplicity is absolute contradiction. The heuristics of the principle of parsimony forces a choice between simplicity with absolute contradiction versus complications with noncontradiction. I support noncontradiction over simplicity.

5.4.2 The MWI

Everett (1957) responded to the logical impossibility of the CI with the MWI. However, the MWI suffers from a subtle logical impossibility and unsubtle extravagances.

The logical impossibility begins with the correct use of an abstract infinite set. For example, each observable has an infinite number of possible eigenvalues. However, proposing that this infinite set of possibilities changes into an infinite number of real quantum systems is an erroneous use of number theory according to section 3.10.

One might argue that there is only a finite number of possible eigenvalues for each observable. If a finite number of possible eigenvalues is successfully defended, then the MWI would be a logical possibility. However, that would still result in extraordinary extravagances outlined in Propositions 14–17:

> **Proposition 14.** There is no causal explanation for the multiplication of branch worlds that would occur from every quantum change.
>
> **Proposition 15.** Experimental physics in a combination-branch world cannot detect any other combination-branch world, except through a hypothetical wormhole.
>
> **Proposition 16.** There is no detection of determinism at the quantum level or any other level in the observable universe.
>
> **Proposition 17.** The magnitude of exponential multiplication of nearly identical quantum systems and humans is beyond comprehension.

Consider the extravagances in the framework of the simple calculation of 10^{90} new combination-branch worlds every 10^{-9} seconds (section 4.4). This implies that every living human branches into 10^{90} nearly identical humans every 10^{-9} seconds. Likewise, every 1 second, every living human branches into $10^{90^\wedge(10^\wedge 9)}$ nearly identical humans.

Also, the MWI determinism implies that the detection of probability distributions in Galton board experiments, celestial mechanics, fluid dynamics, thermodynamics, chemical reactions, nuclear reactions, and quantum oscillations merely appear probabilistic in the observable universe, yet they are actually deterministic in the MWI multiverse.

On one hand, there is no known mechanism for the wave function collapse that results in the probabilistic causality of quantum changes. Perhaps, the wave function collapse is a consequence of the conservation of energy. Regardless, consider the principle of parsimony. The problems of the extravagances of Propositions 14–17 far outweigh the problem of the lack of knowledge about the mechanism that causes wave function collapses during quantum changes.

5.4.3 QL

QL coheres with standard logic as its name implies. The scope of this paper excludes rigorous mathematical evaluation of the citations in section 3.5.2. However, QL should replace the logically impossible CI if any formulation of QL is mathematically possible. Also, QL needs to cohere with gravitational force. For example, Anderson (2017) describes major problems with hypotheses of quantum gravity.

5.5 Toward a Logical Paradigm of Modern Physics

Adjudicating between all the GR solutions is beyond the scope of this paper, but various GR solutions cohere with teleportative observers and the preferred focal pathway for a universal chronology which support a logical theory of relative spacetime and presentism. Also, QL and the logical theory of spacetime support a logical paradigm of modern physics.

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