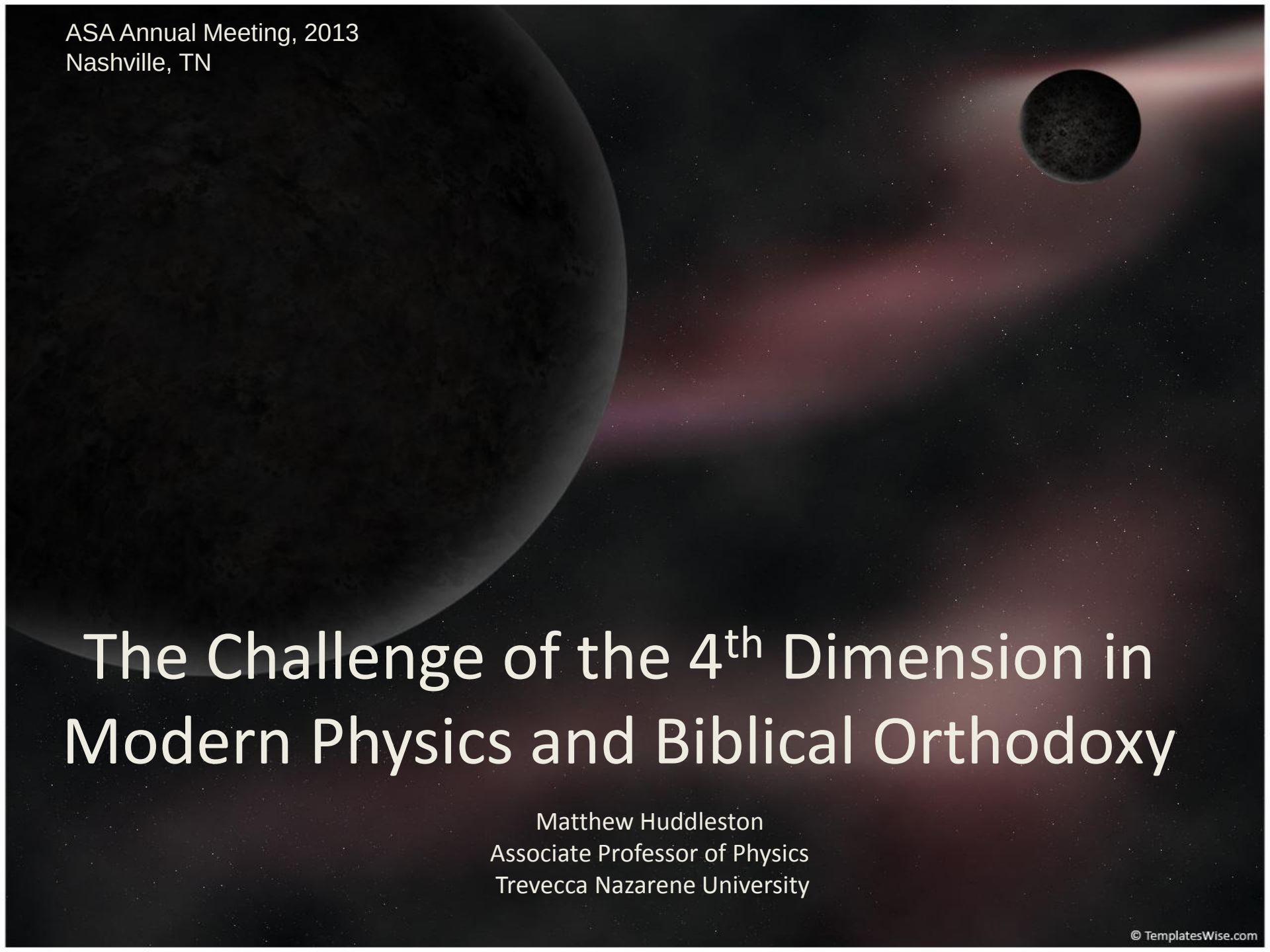
ASA Annual Meeting, 2013
Nashville, TN



The Challenge of the 4th Dimension in Modern Physics and Biblical Orthodoxy

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Outline

- What is time?
- Different theories of time
- Developing a “Christian” view of time
- Modern space-time in the theory of relativity
- The challenge to presentism from relativity
- Arrows to the flow of time
- The challenge to the block universe and the formulation of a theory of quantum gravity
- Conclusions

What is Time?

"What, then, is time? If no one asks me, I know: if I wish to explain it to one who asks, I know not."
Augustine, The Confessions of St. Augustine Bishop of Hippo, Book XI, Chap. XIV

"I don't think we can answer even the simple question: 'What sort of thing is time?'"
Lee Smolin

"There seems no, simple, non-circular way to finish the defining sentence 'Time is...'"
John Norton

"Time is nature's way of keeping everything from happening at once."
Raymond Cummings

"[Time] is profoundly resistant to simple definition."
Carl Sagan

"Time is what happens when nothing else does."
Richard Feynman

"Time is that which is measured by a clock."
Albert Einstein

What is Time?

According to philosopher John McTaggart, we can understand time in different ways:

A Series Time

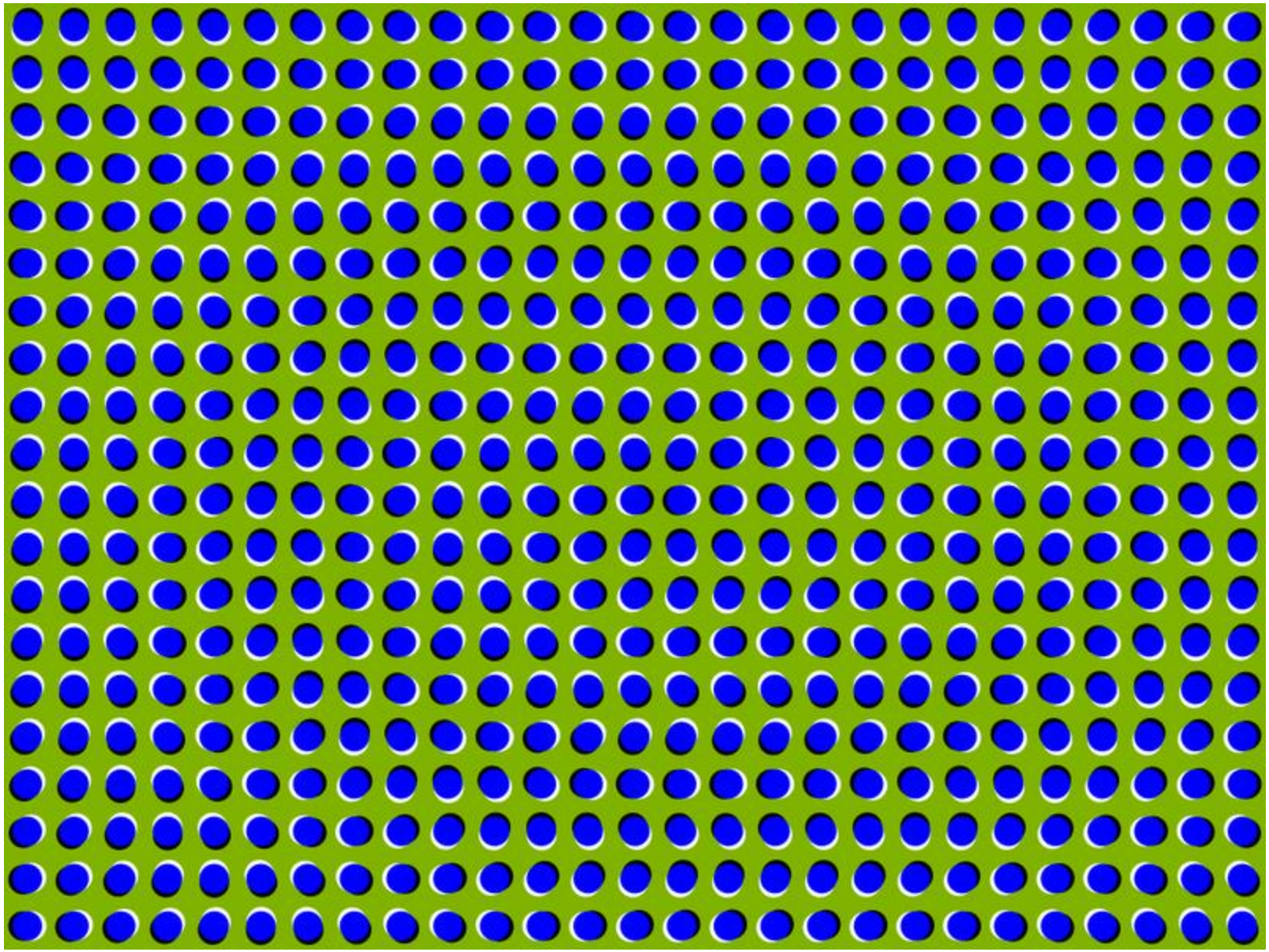
- Events are categorized as either present, past, or future
- The present is all that is real.
- Past events no longer exist.
- Future events do not yet exist.
- The experience of moving through time (aging) is real.
- Ex: Presentism, (Expanding-Block)

B Series Time

- Events can only be compared sequentially.
- Categorizing events as “past” or “future” has no more meaning than “to the left” or “to the right.”
- The “flow of time” is an illusion.
- All events are equally “real.”
- Time is no longer linked to *change*
- Ex: Eternalism, Block Universe

My Definition: *Time is a quality of nature that **allows for true change.** Any physical variation that can be described entirely by a static shift in coordinates is not “true change.”*

This definition implies more than pure B Series time and that time extends beyond mere geometric measurement or relative position.



What is Time?

Other choices we must make about time

Symmetric vs. asymmetric

- Time symmetric – the same laws of nature work if you move backward in time
- Time asymmetric – the laws of nature we know are specific for moving forward through time

Deterministic vs. open

- Deterministic – all events are entirely determined by a collection of causes (usually past).
- Open – future events are not entirely determined by any finite collection of causes. There is a degree of inherent indeterminacy to future events in the universe.

Relational vs. absolute

- Relational time – time is defined by the relationships or relative "positions" between events
- Absolute time – points in time exist whether there is anything happening or not

All three of these are, strictly speaking, independent of whether A Series time exists or not. However, time symmetric and deterministic laws of nature would seem to be more suggestive of a Block Universe, while an asymmetric open universe would fit easily within Presentism.

What does the Bible say about time?

There was a universal "beginning." (Gen 1:1). The entire universe, including our notions of time and space, originated in God.

God is eternal (Rev 1:8). This does NOT necessarily imply that God is "timeless." God is, was, and will be. Time may be a part of God's eternal nature.

God views time differently than us (2Pe 3:8). God's experience of time does not correlate with the flow of time that we experience. Scripture do NOT explicitly teach that God experiences no time at all.

God is the ultimate "Changer" (Isa 43:19, 2Cor 5:17). God enacts *change* on the world. God does not change but He is constantly doing new things.

God desires relationship with His creation (2Pet 1:4-8). Biblically, it is hard to construct a merely geometric relationship between God and creation. We are called to be "partakers of the divine nature." Can traits like hope, patience, or perseverance exists without A Series time?

The case for Christian Presentism

Many theologians (including Aquinas) have argued for a completely timeless God who simultaneously looks down on all of history. This is most compatible with a strict B Series view of time, where all change is an illusion. In this case, from God's perspective real change does not exist!

God can be lord and master of the future even if it doesn't exist yet. A God who knows the future by simply looking down on it is the ultimate form of deism.

Is God deceptive? If presentism is an indispensable part of our experience, either it is real, or it is a divine illusion. If we are committed to physical realism, then for similar reasons we should adopt a doctrine of temporal realism.

"There exists only the present instant ...There is no yesterday nor any tomorrow, but only Now..." Meister Eckhart

"[Temporal knowledge] implies a true divine engagement with unfolding time... This picture seems to correspond closely to how God is portrayed in the Bible…" John Polkinghorne

"The past as past is gone and is no more… the present thus remains as the real. God ever is both the changeless and creative content of His own eternal present." Nels F.S. Ferré

"…the claim that God is timeless… seems to contain an inner incoherence and also to be incompatible with most things which theists ever wish to say about God." Richard Swinburne

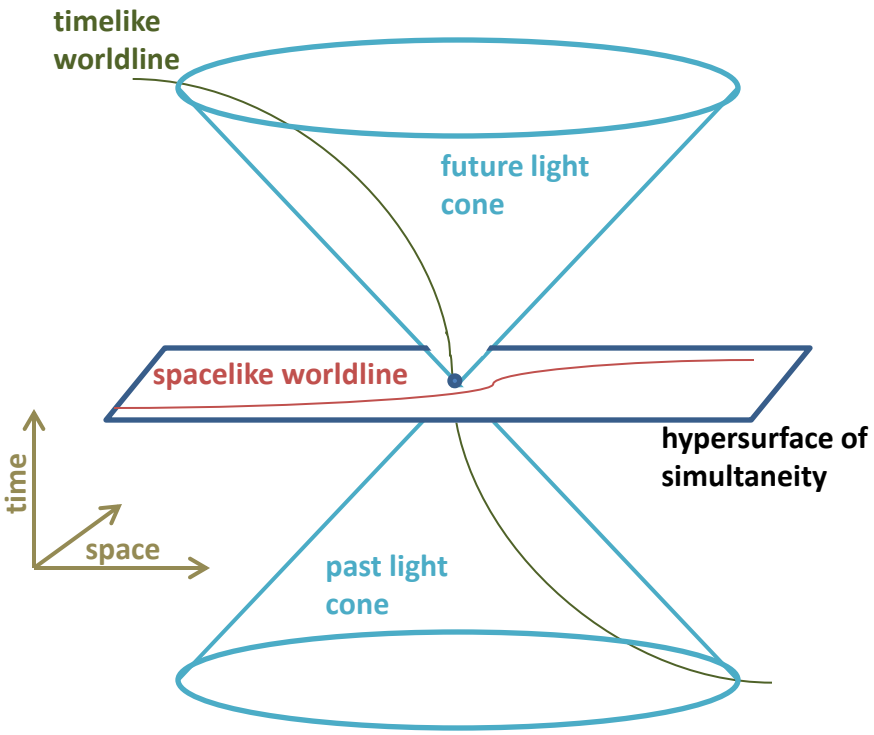
Space-time in Relativity

Einstein's theories of relativity were formulated using a four dimensional "space-time" metric. Time was treated as another kind of geometric dimension.

Relativity seems to directly imply that:

- measurements of the passage of time are reference frame dependent
- Measurements of simultaneity are relative to one's reference frame
- The order of events along spacelike worldlines is reference frame dependent

Relativity has been experimentally verified millions of times over.



Does relativity allow A series time to exist?

"…a consequence of this new space-time view is that motion through time… is replaced by static time."

John Wheeler

"There is no dynamics within space-time: nothing ever moves therein; nothing happens; nothing changes."

Robert Geroch

"I believe in a timeless universe for the childlike reason that time cannot be seen… the universe is static"

Julian Barbour

"The philosophers who maintain that past and future objects are not real existents, or that future events do not have determinate reality, are refuted out of hand by special relativity."

Lawrence Sklar

"For those of us who believe in physics, the distinction between past, present and future has only the meaning of a stubbornly persistent illusion."

Albert Einstein

"Time is an illusion, lunchtime doubly so."

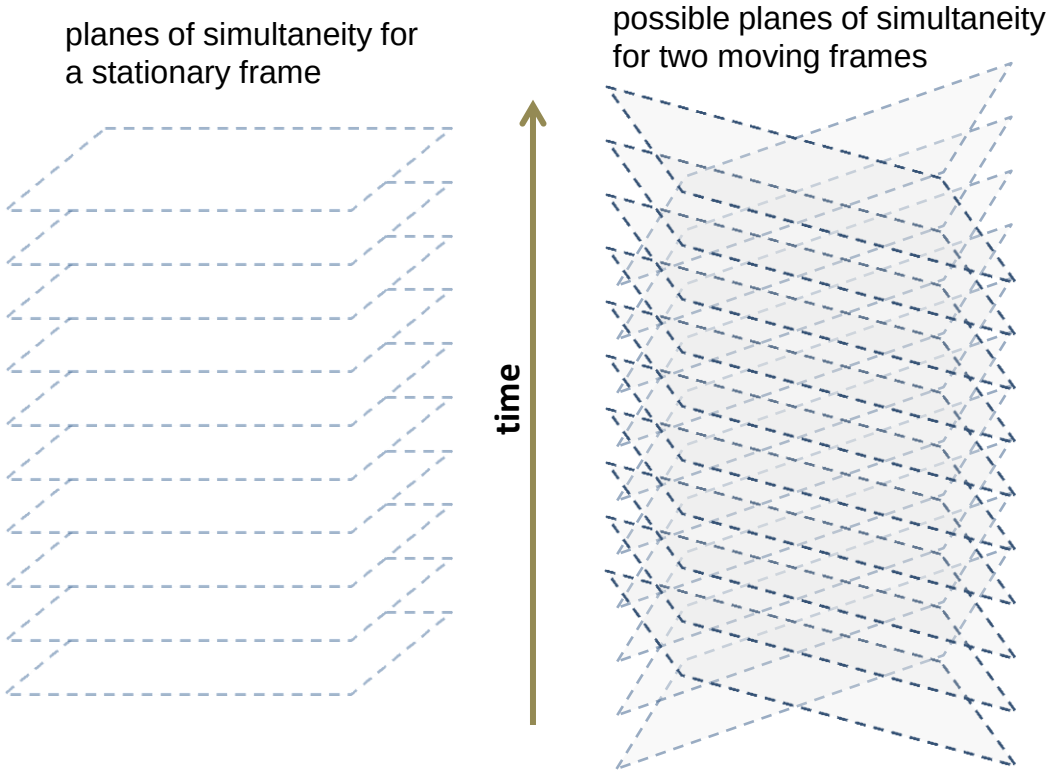
Douglas Adams

Trouble for Presentism?

One thing is clear--**relativity does NOT allow for a universal "now."** Different reference frames have different "now slices" through the universe. Add them all together and it *seems* like you get a B series block time.

If we assume the principle of locality, however, a relativistic form of presentism can easily be preserved. Local becoming occurs along the *proper time* of material objects which travel on timelike worldlines given by $d\tau^2 = dt^2 - dx^2 - dy^2 - dz^2$.

In relativity, *proper time* does NOT vary with motion, acceleration, mass, etc.



The arrows of time: trouble for a block universe?

Most laws of physics are time-symmetric, most phenomena in nature are not. Relativity is the most time-symmetric of all.

Penrose's seven "arrows of time"

1. Memory Arrow
2. Electromagnetic Arrow
3. Quantum Arrow
4. Black Hole Arrow
5. Cosmological Arrow
6. Kaon Arrow
7. Entropy Arrow

Many try to argue some of these arrows away by invoking special initial conditions, but if this is true, future special boundary conditions should be able to produce similar time-reversed phenomena which have never been observed.

Quantum mechanics: trouble for a block universe?

The laws of quantum mechanics describe dynamical entities that evolve through Hilbert space in a naturally time-dependent way through the Schrodinger equation,

$$\hat{H}|\psi\rangle = i\hbar\partial/\partial t|\psi\rangle$$

Although wave functions are described by deterministic laws, *observable* measurements of the wave functions seem to require both time irreversibility and a true indeterminacy within statistical boundaries.

The Wheeler-DeWitt equation, $\hat{H}(x)\,|\psi\rangle = 0$, in canonical quantum gravity attempts to re-freeze time by removing time dependence from the universe as a whole, by making the unverifiable assumption that the entire universe can be modeled by one quantum mechanical wave function. This equation ignores the problem of defining energy without time--the low energy limit of the Hamiltonian becomes meaningless.

In conventional quantum processes, there appears to be true change that defies standard B series time descriptions. At least some of the conceptual paradoxes within QM may come from attempts to describe this theory without the use of A series time.

Trouble for a block universe

- At least some of the arrows of time seem persistent even after accounting for special boundary conditions. Fundamental time asymmetry does not seem compatible with block universe descriptions of relativity.

- Despite a century of work, our two major physical theories of quantum mechanics and general relativity have not be fully reconciled. Until recently, practically all efforts to do so relied on a timeless block universe.

- All of science is built upon what we can observe with our senses. The sensation of time is fundamental to all direct observation. If time itself is questioned, the very foundations of science crumble.

Is block time falsifiable? It is very difficult to disprove B series time directly, especially if the direct sensation of A series time is regarded as irrelevant.

Is presentism falsifiable? Yes! Just build a time machine and go back in time! Observation of closed timelike loops would deal a serious blow to presentism.

Other problems with the relativistic block universe

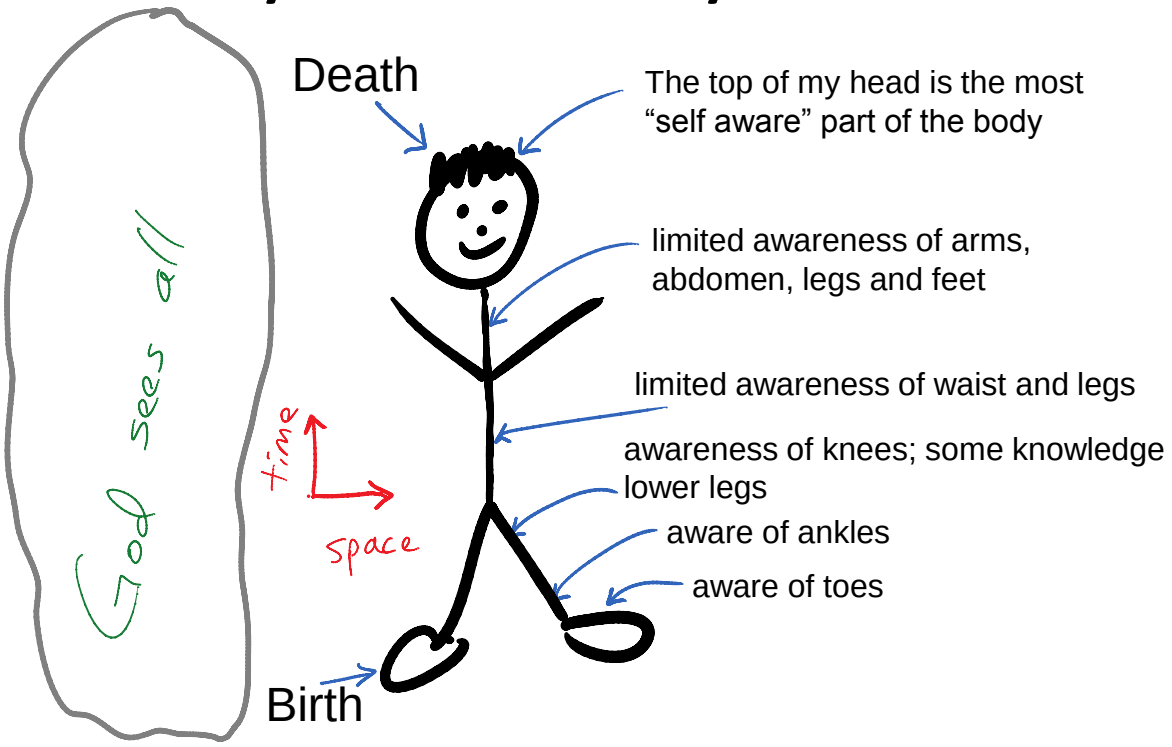
Who am I?

The 4-D person in a block universe is a succession of time dependent partial identities

There is no present, past or future.

Even my own successive awareness is static.

My 4-D "Block Body"



The idea of my present actions causing future reactions means about as much as my waist supporting my upper body.

Re-introducing A series time to physics

New theories of quantum gravity may be able to preserve presentism

- **Elementary "processes" given equal ontological weight to elementary particles and fields.**

The flow of time could be an inherent property of all material particles rather than part of a background space-time fabric. Nature may require a physics that at its core has an ontology of becoming. (E.g. Bohmian mechanics or Hiley's Implicate Order which describe quantum mechanics in terms of Clifford algebras instead of Hilbert space.)
Challenge: to develop a "non-static" mathematical system that has the predictive success of standard quantum mechanics; fully merging this system with general relativity.

"After the discovery of GR we are no longer sure of what is space-time and after the discovery of QM we are no longer sure of what matter is. The very distinction between space-time and matter may be ill-founded." Carlo Rovelli (proponent of a timeless block universe)

Re-introducing A series time to physics

New theories of quantum gravity may be able to preserve presentism

- **Elementary "processes" given equal ontological weight to elementary particles and fields.**
- **Emergent laws of physics**

If the universe is finite in time, why should we expect the law of physics that govern it to be eternally true? All solutions to the cosmological horizon problem invoke laws acting on the early universe that cease to apply as the universe ages. Smolin uses Neother's theorem to argue that the "timeless" conservation laws of Newtonian mechanics are based in symmetries in space and time that have resulted from the dynamical evolution of the universe.

Challenge: to form a "meta-law" encompassing all forms of physical law becomes a new static paradigm.

"We must find a way to unfreeze time—to represent time without turning it into space… It's terribly hard to represent time, and that's why there's a good chance that this representation is the missing piece [in physics]." Lee Smolin

Re-introducing A series time to physics

New theories of quantum gravity may be able to preserve presentism

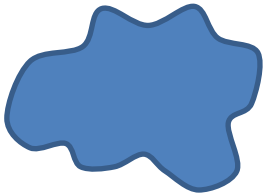
- **Elementary "processes" given equal ontological weight to elementary particles and fields.**
- **Emergent laws of physics**
- **Quantum gravity with "fundamental time"**

Geometric dimensions of space and time emerge as dynamic properties of a purely relational universe in fundamental time. "Causal Dynamical Triangulations" (Ambjorn and Jurkiewicz) and "Quantum Graphity" (Fotini Markopoulou) describe a universe where spacetime geometry is NOT fundamental, but A series time is.

Challenge: to fully recover a relativistic invariance under diffeomorphisms of the spacetime manifold at the low energy limit.

"By making the geometry not fundamental, we are able to make a distinction between the geometric and the fundamental time, which opens up the possibility that, while geometric time is symmetry, the fundamental time is real." Fotini Markopoulou

Drop of liquid water
no geometric structure
within the drop



Cooling

Ice crystal
geometric structure appears
throughout the crystal

Hot universe
no spacetime geometry;
microscopic quantum
degrees of freedom evolve
in fundamental time

Cooler universe
spacetime and matter emerge
as physical properties

Conclusions

- **There are radically different ways to understand the fundamental nature of time**
- **Over the past century modern physics has largely dismissed the real passage of time as an illusion; many theologians are tempted to follow suit.**
- **Scripture does NOT support a timeless universe or a timeless God.**
- **Despite the natural timelessness of relativity, strong scientific arguments exist for A series time.**
- **Taking time more seriously may be essential to the next unification theory in physics**

Perhaps time cannot be seen as Julian Barbour claims, but nothing can be seen without time.