Relativity, the Open Future, and the Passage of Time

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The Aristotelian Society

Outline

Motivation and Stage-Setting

Standard A Theory

Non-standard A Theory

Passage and the Open Future

Real Passage and Relativity

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The Agenda-Setting Question

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Claim ("Apparent Passage"):
Pre-theoretically, we *are* inclined to think that time passes, objectively, in just this sense.

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The B Theory: YES

- Fundamentally, all times are on a par
- The reducibility of tense

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   - Provide a B-theoretic account of the apparent passage of time
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4. Deny the first entailment
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   - Provide an A Theory that does without global Nows

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The Plan of Attack

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Pre-Relativistic Theories:

- Standard A Theories
  - Presentism
  - The Moving Spotlight
  - The Growing Block
- Non-standard A Theories
- Passage and the Open Future

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Relativistic Generalizations:

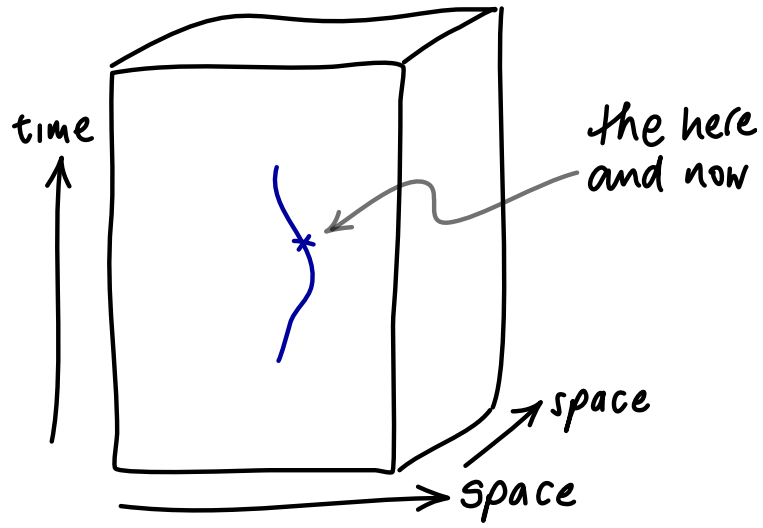
- The Growing Block
- The Moving Spotlight
- Branching Spacetimes

Models and Their Intepretation

Models Specification of an appropriate alternative to the B theorist's "block universe" model

Interpretation An explanation of how the model represents an A-theoretic view of time

Models and Their Intepretation



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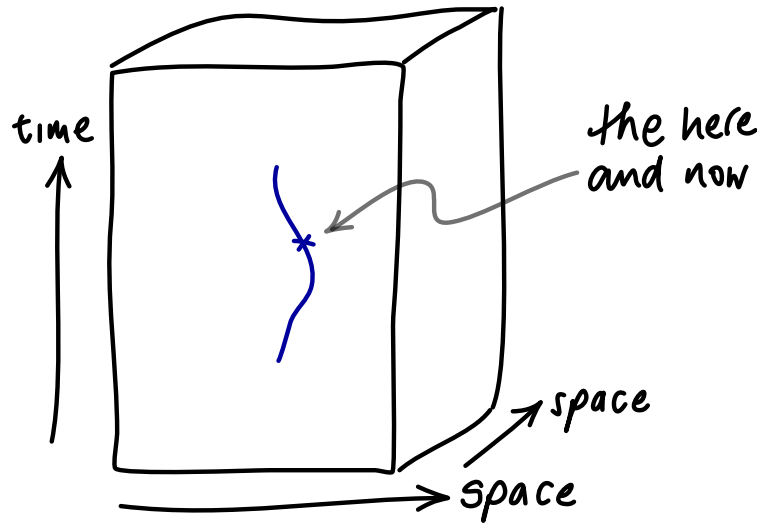

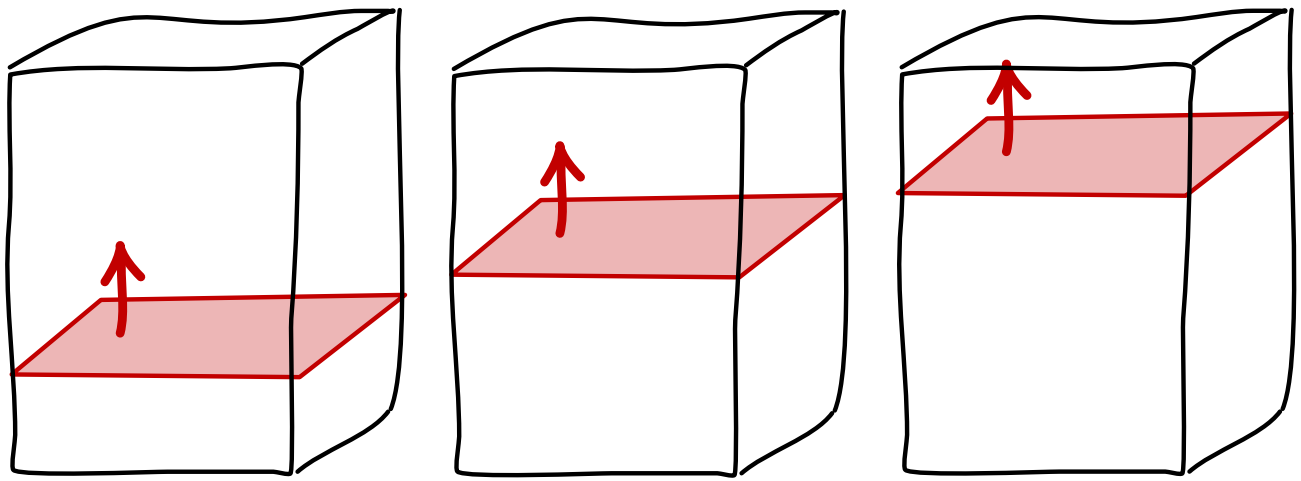

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What sense can be made of this?

Presentism

- Truth *simpliciter* is tensed.
- Does only the present time exist?
  - The spatially-extended, 3-dimensional world is all there concretely is.
  - The tensed facts exhaustively characterise this concrete reality.
  - This includes how it presently is, how it was, and how it will be.

Presentism and Passage

The passage of time according to Prior (1968):

- My falling off a punt is forever moving into the past.
- My falling off a punt occurred ten years ago, but, as time passes, there will come a time when it was eleven years ago.
- WAS_{10y} (I fall off a punt)
- WILL_{1y} (WAS_{11y} (I fall off a punt))

Kit Fine Against Priorian Passage

The passage of time requires that the moments of time be *successively* present and this appears to require more than the presentness of a single moment of time. The [presentist] at this point might appeal to the fact that any particular future time t^+ *will be* present and that any particular past time t^- *was* present. However, the future presentness of t^+ amounts to no more than t being present and t^+ being later than t...

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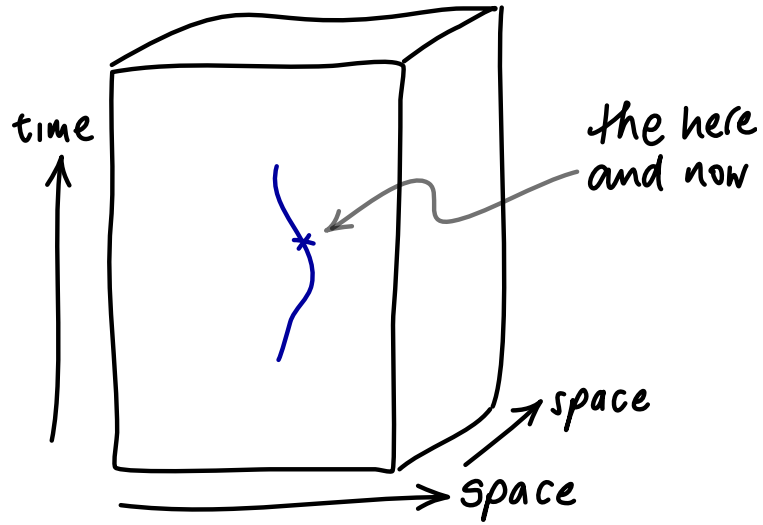
We naturally read more into the [presentist's] tense-logical pronouncements than they actually convey. But his conception of temporal reality, once it is seen for what it is, is as static or block-like as the [B Theorist's], the only difference lying in the fact that his block has a privileged centre. (Fine, 2005, 287)

Models of Presentism



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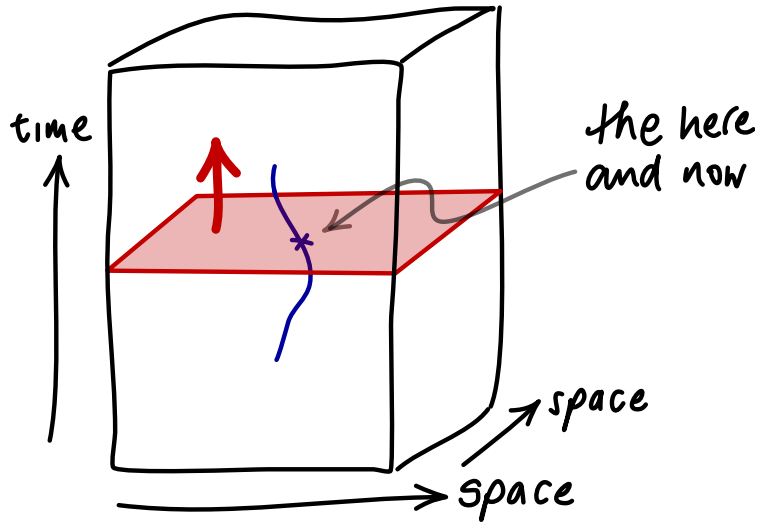

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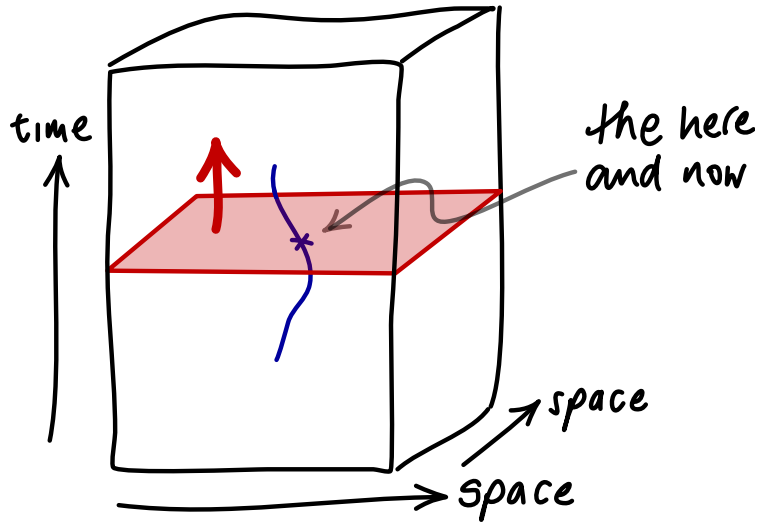

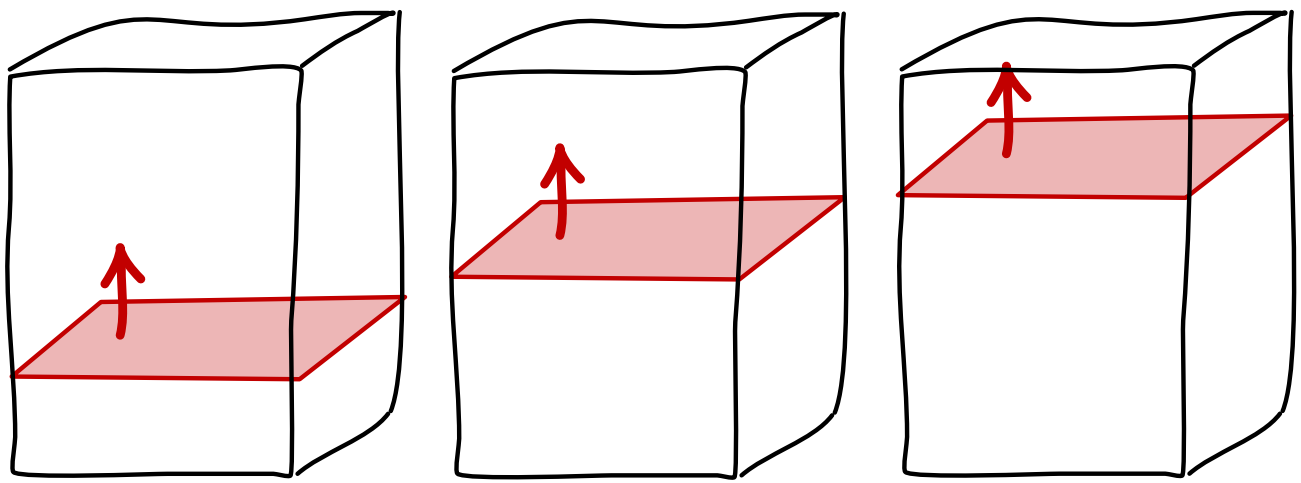

Truth *Simpliciter* Changes

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  - I am standing, but I was, not so long ago, sitting.

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- One simply cannot accept all the present, tensed truths without accepting that what is true undergoes genuine change.

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Skow's diagram:

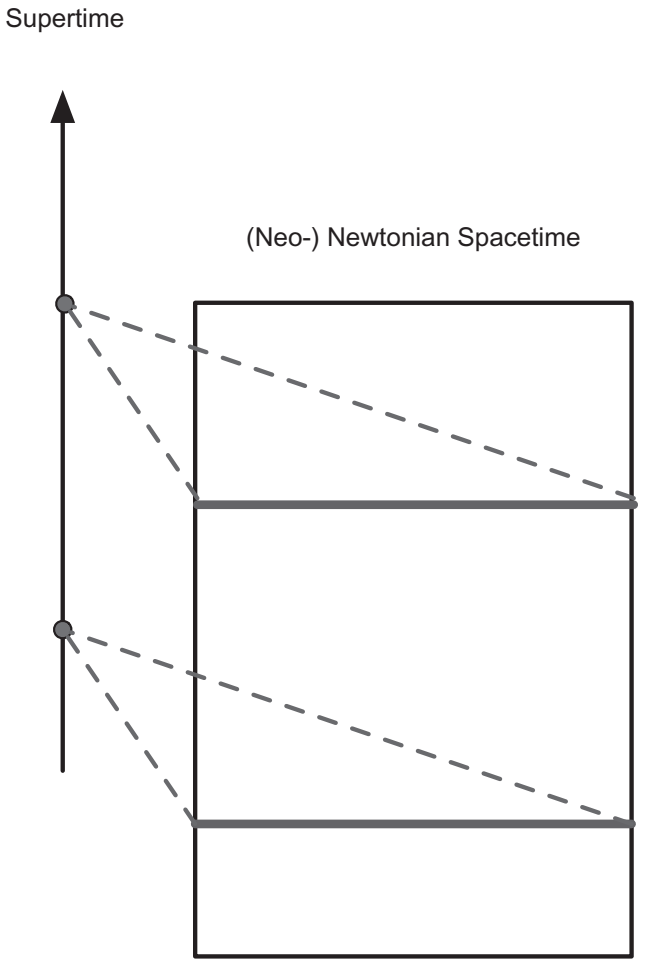

Figure 1

The “Movement” of the Spotlight

The *metaphor*

From the perspective of each point of supertime, just one time is NOW. But from different perspectives in supertime, different times are NOW.” (Skow, 668)

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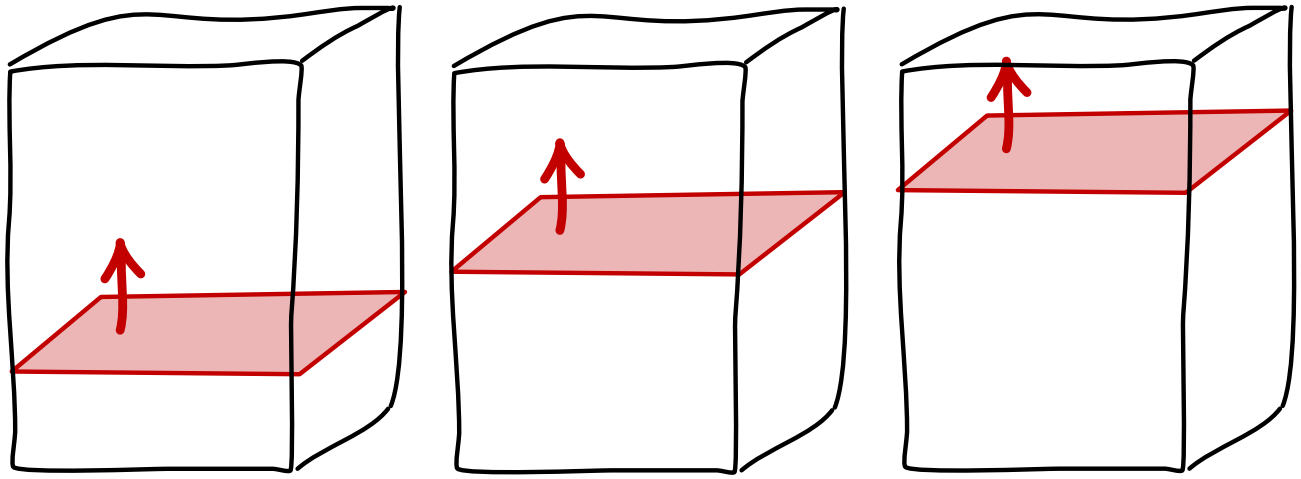
The Official Story

Suppose it is NOW time t. The NOW moves from past to future = “*it was the case that* a time before t was NOW, and *it will be the case that* a time after t [will be] NOW.…”

Models of the Moving Spotlight



- *One* element in the sequence represents how reality *is*, absolutely.
- The others represent how it *was* and how it *will be*.

Tense, Time and Supertime

- "It will be the case that t' is NOW" does not mean the same as the claim that (and is not true just in case that) at a time later than this utterance, t' is NOW" (Skow, 2009, 668).

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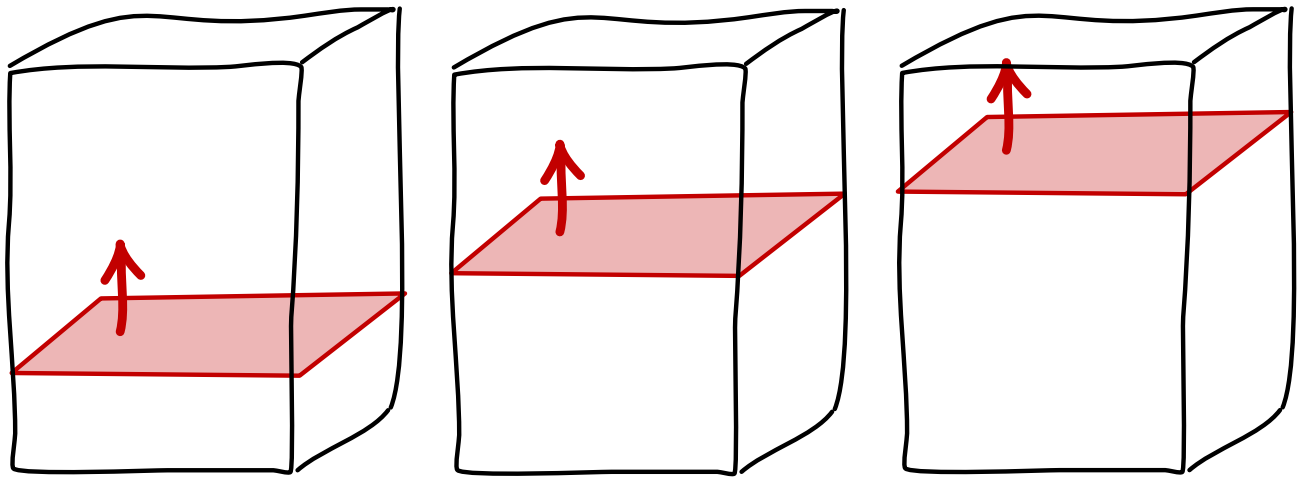
Some consequences:

- Ordinary times persist (in the presentist sense).
- One faces a dilemma when analysing ordinary tensed claims: some structure appears redundant.

This picture "spatializes time."

The Growing Block



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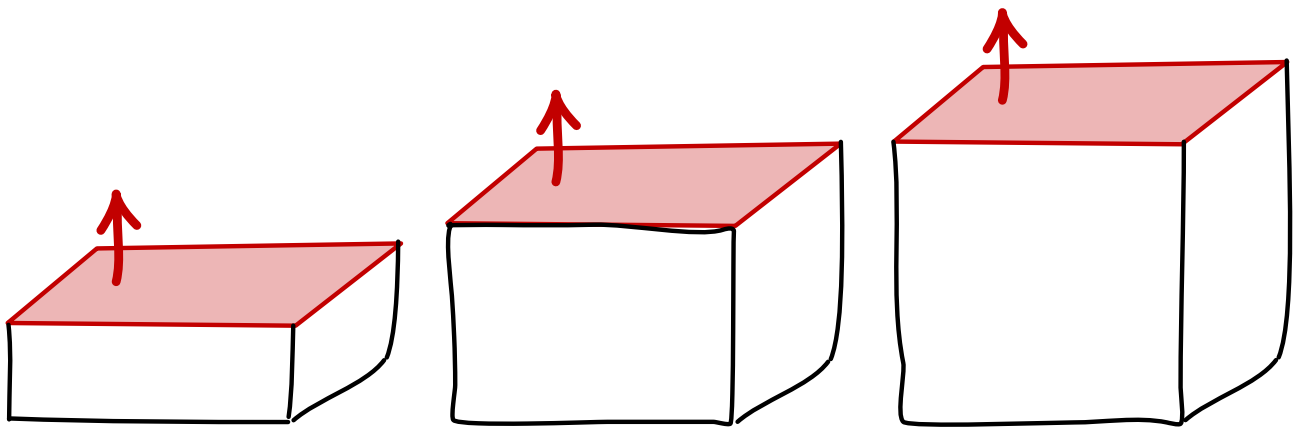

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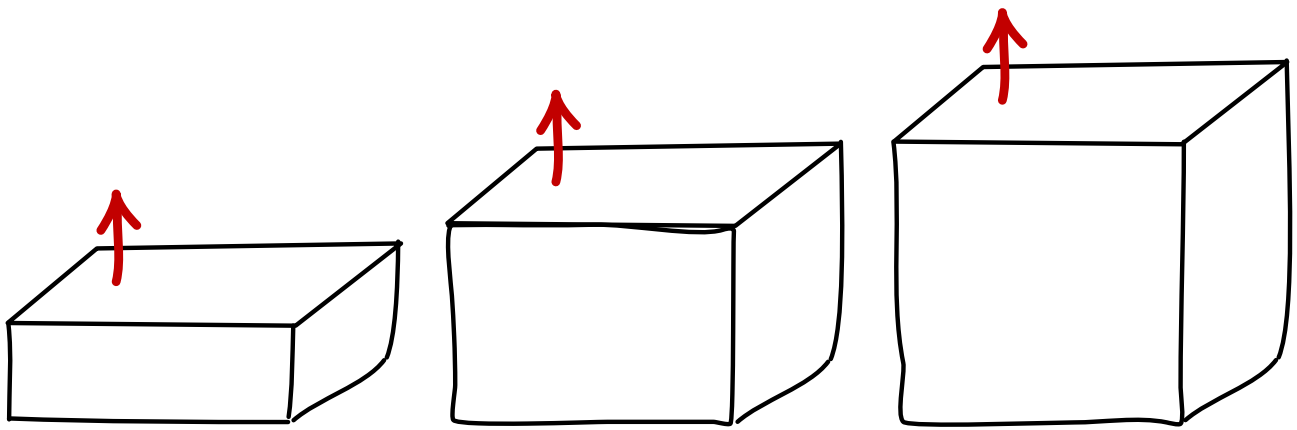

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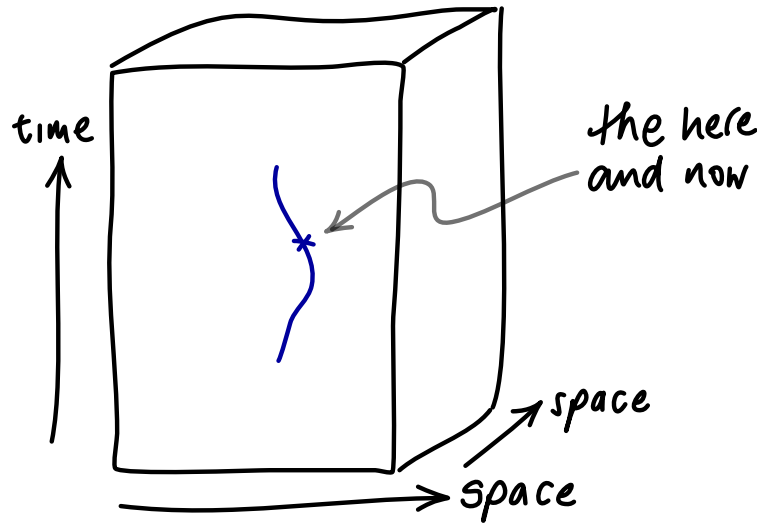

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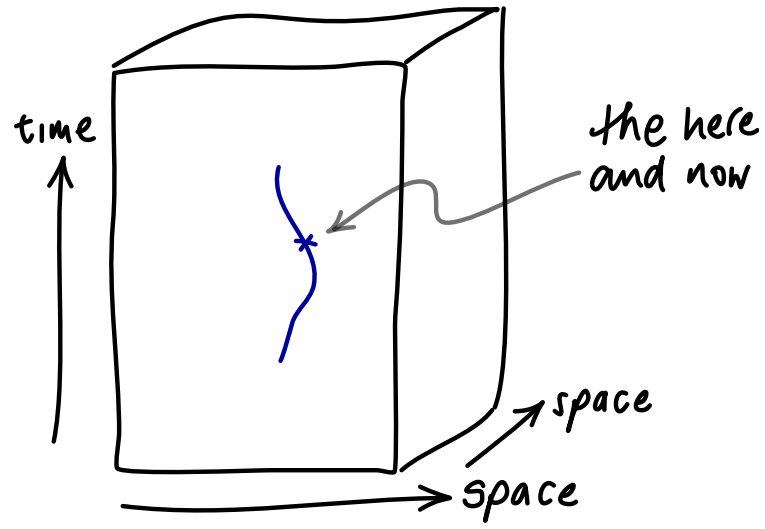

- I am standing at t
- t' is five minutes after t
- *Relative to* t', I was standing five minutes ago.

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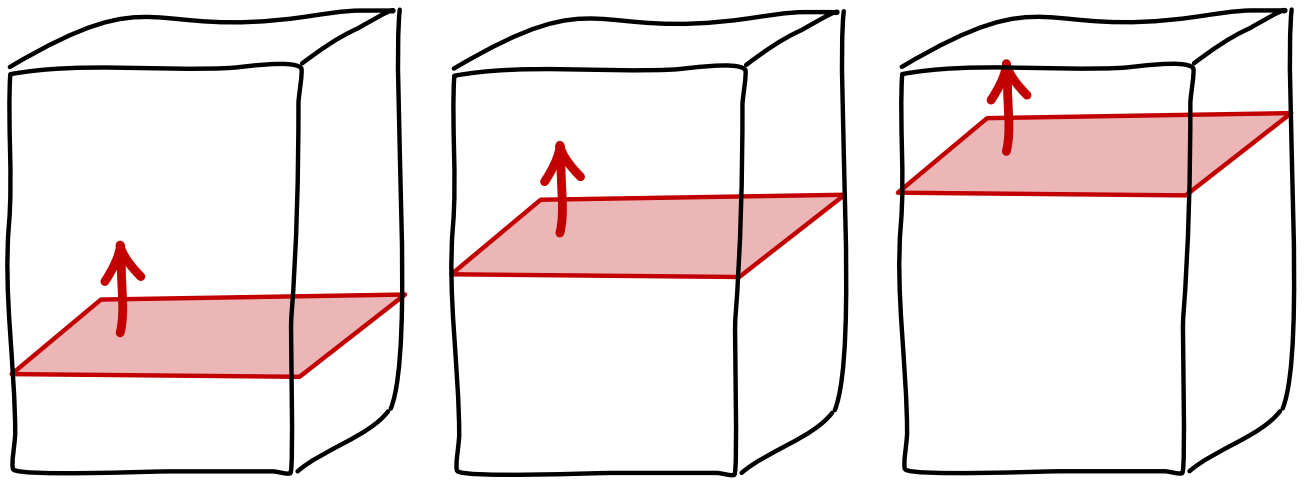

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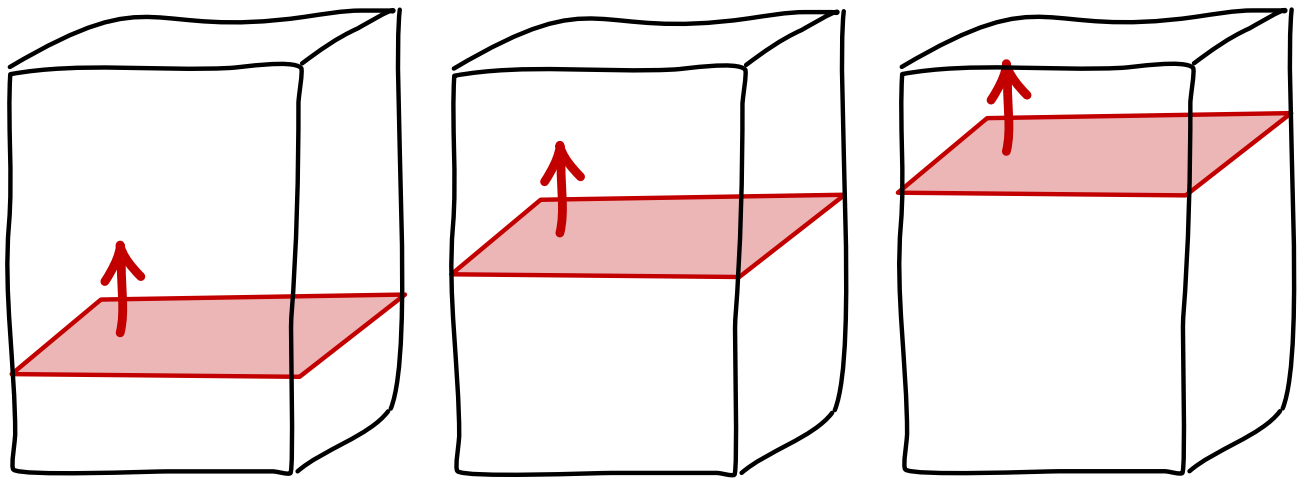

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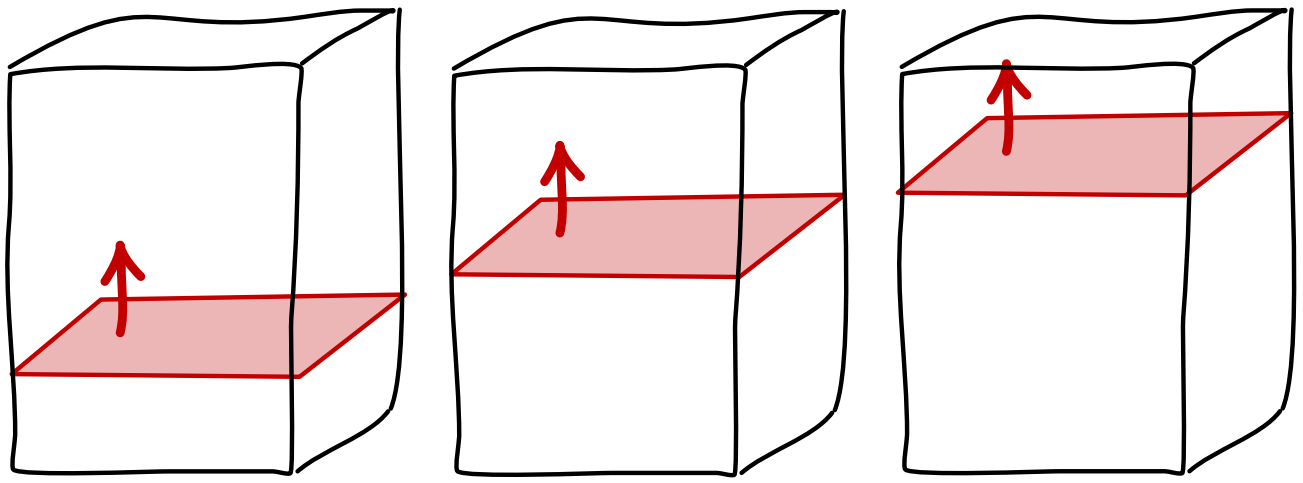

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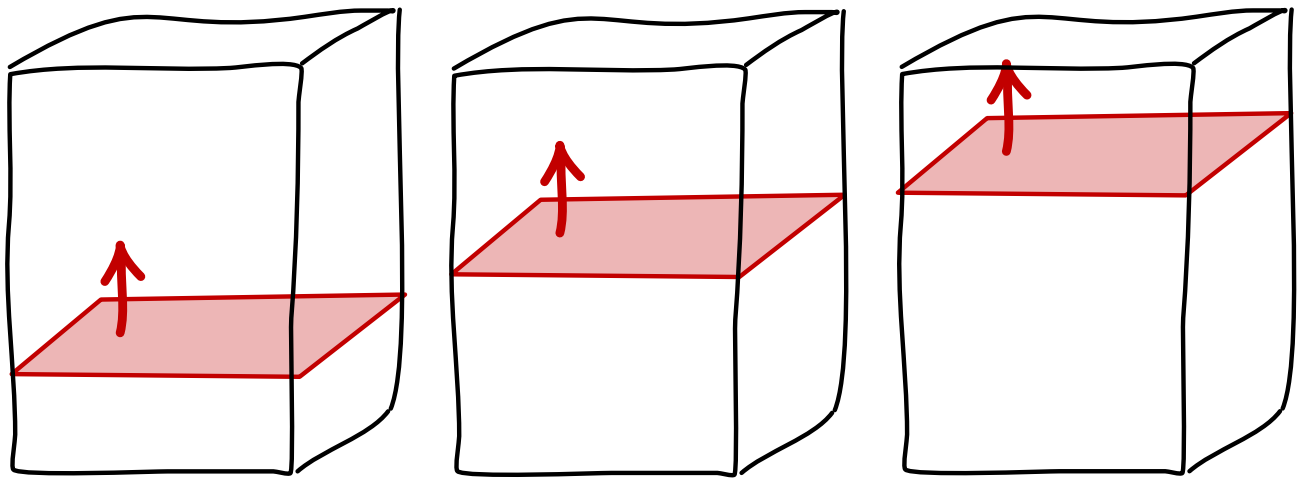

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Passage According to Non-standard A Theory

The two forms of non-standard realism are not subject to these difficulties since they do not single out any one time as the present. . . Presentness is not frozen on a particular moment of time and light it sheds is spread equitably throughout all time.

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- What was always true absolutely is now true relative to each time
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    - *Branching-Time Models*
2. only *one* of which happens (as time passes)

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‘Predictive’ probabilism: the future, like the past, is now in reality entirely fixed and determined even though the basic laws are probabilistic and not deterministic

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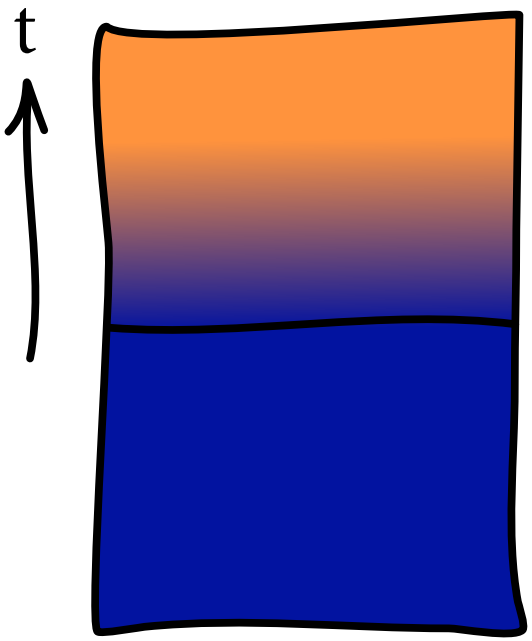
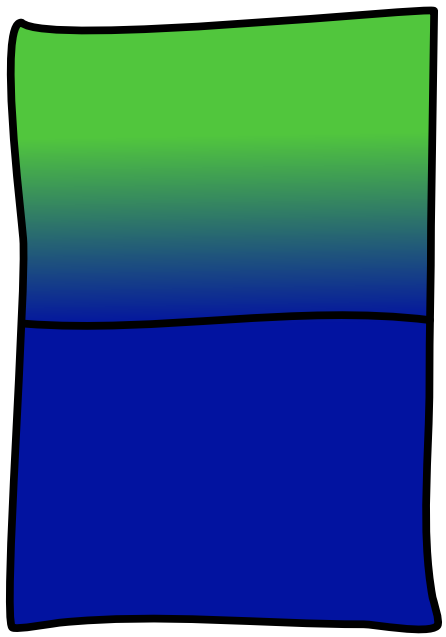


The Actual World



A Non-actual Possible World

“Ontological Probabilism”

Ontological probabilism: the basic laws are probabilistic *and the future is now in reality open with many ontologically real alternative possibilities*

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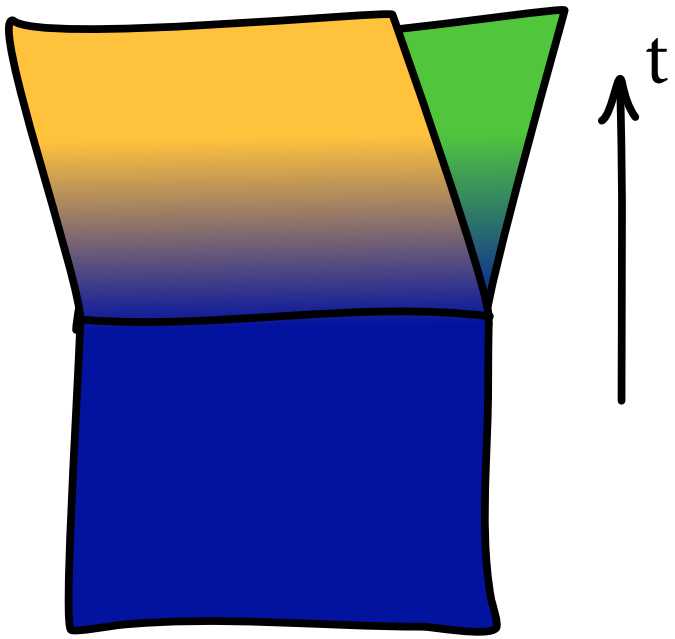
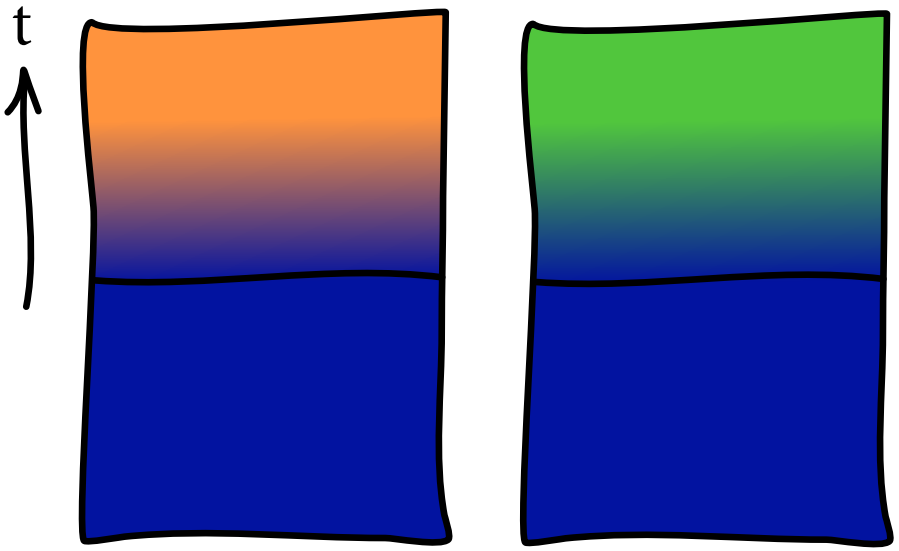


B-Theoretic Open Futures

Predictive Probabilism



1. Single-history Montague-style indeterminism

B-Theoretic Open Futures

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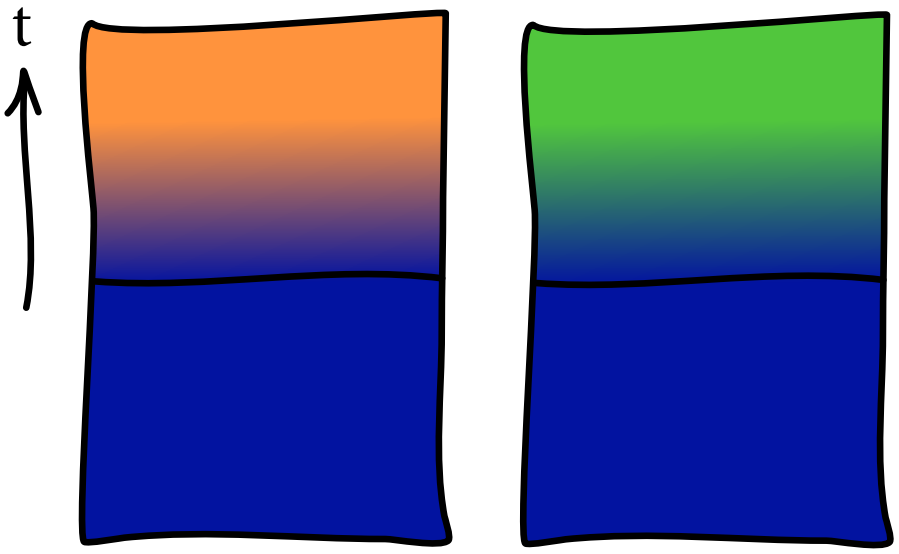

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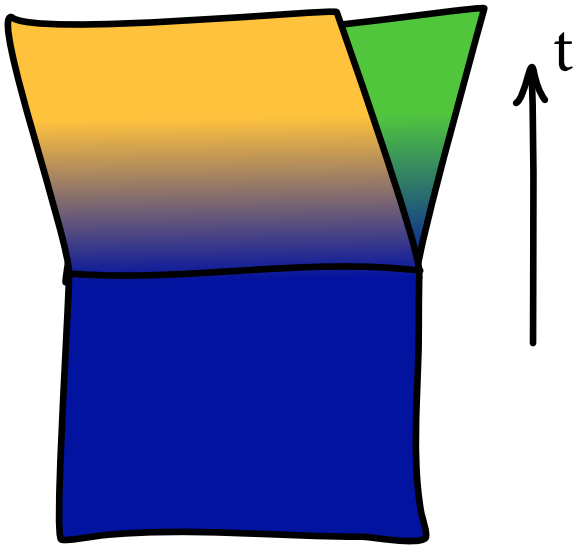


1. Single-history Montague-style indeterminism
2. The “Block Multiverse”

Determined versus *Determinate*

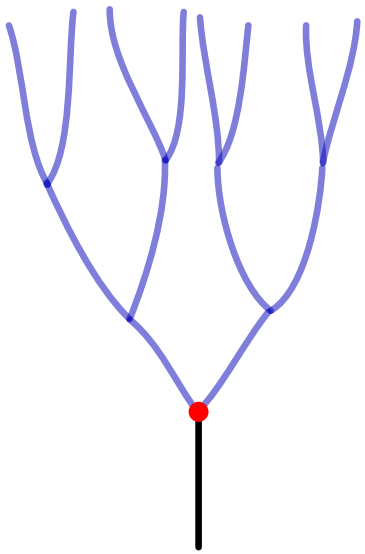
Single History Picture (as of a time) the future is determinate but not determined

Determined versus *Determinate*

Single History Picture (as of a time) the future is determinate but not determined

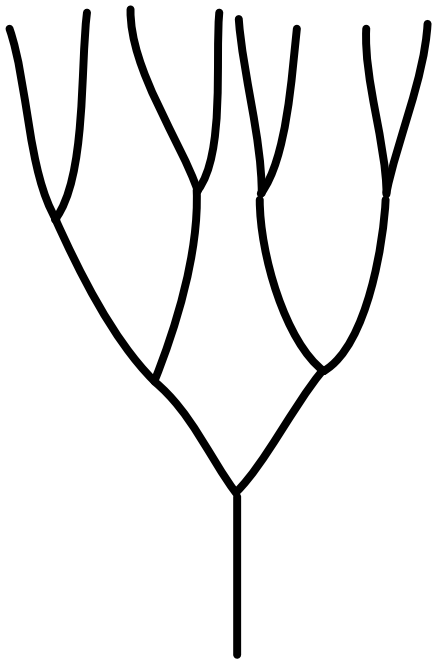
Block Multiverse Picture Whether the future, as of a time, is determinate is controversial. However, any genuine (tensed or time-relative) indeterminateness is reducible to non-relative determinate facts.

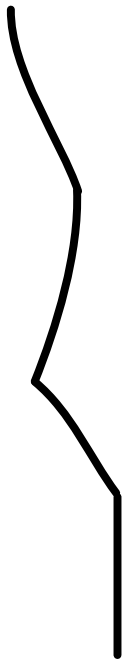
A-Theoretic “Branching”



- There might be a sea battle tomorrow
- There might not be a sea battle tomorrow
- It’s not settled that there will be a sea battle.
- It’s not true that there will be.
- It’s not true that there will not be.
- But it is true that either there will be or there won’t.

Towards An A-theoretic Open Future





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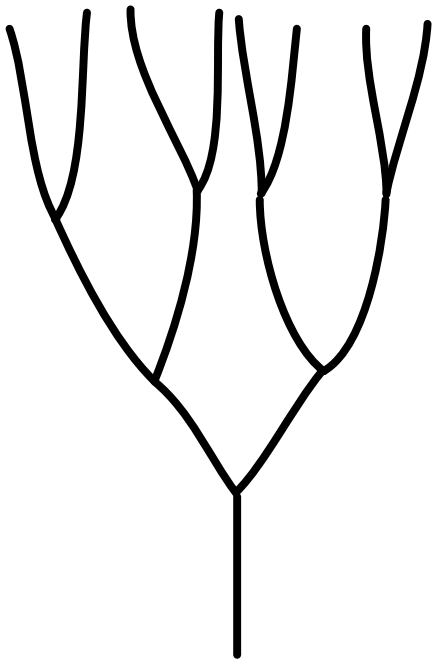

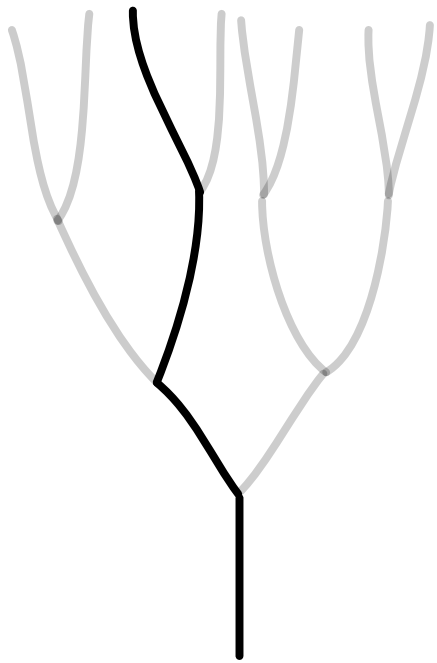

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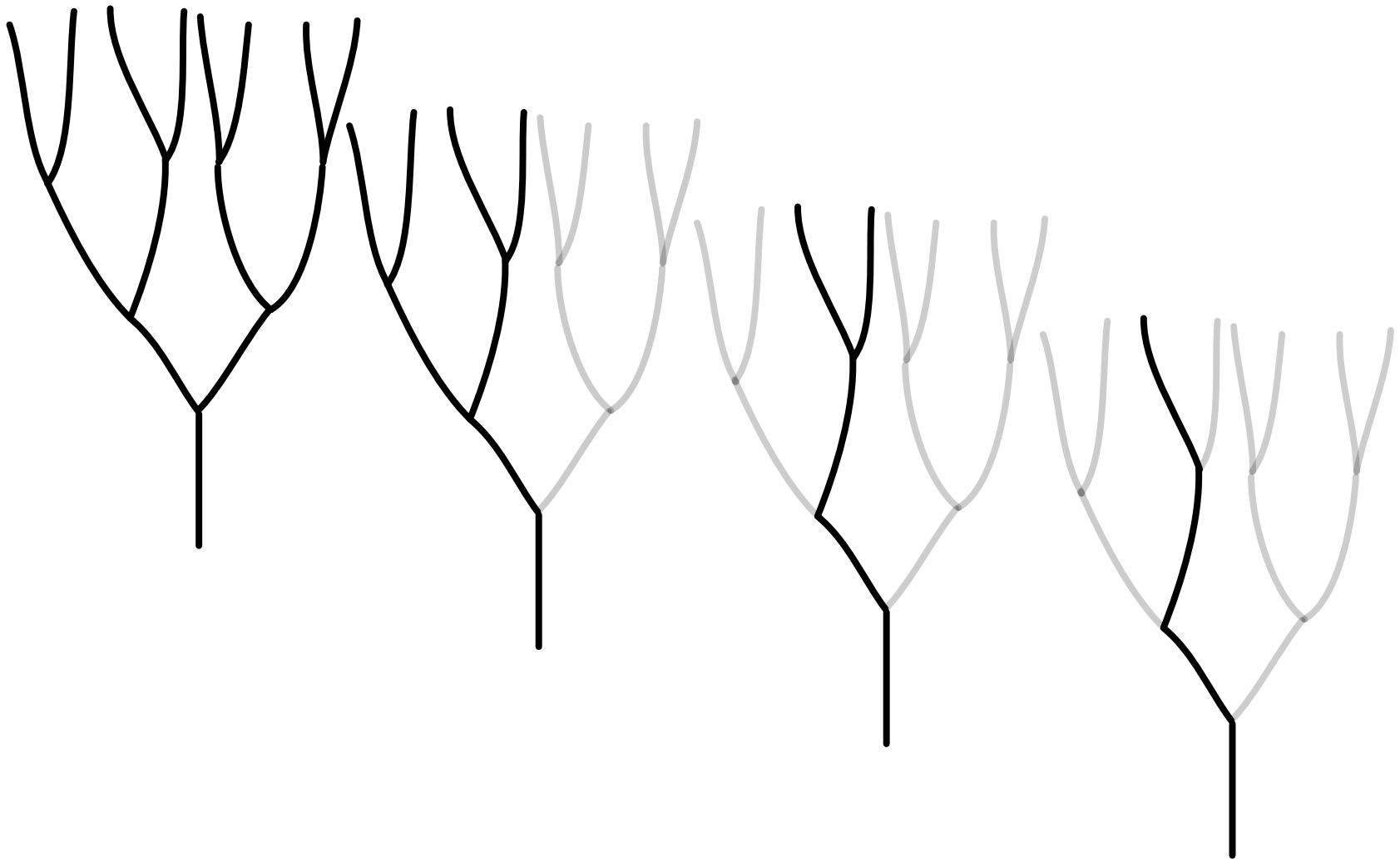

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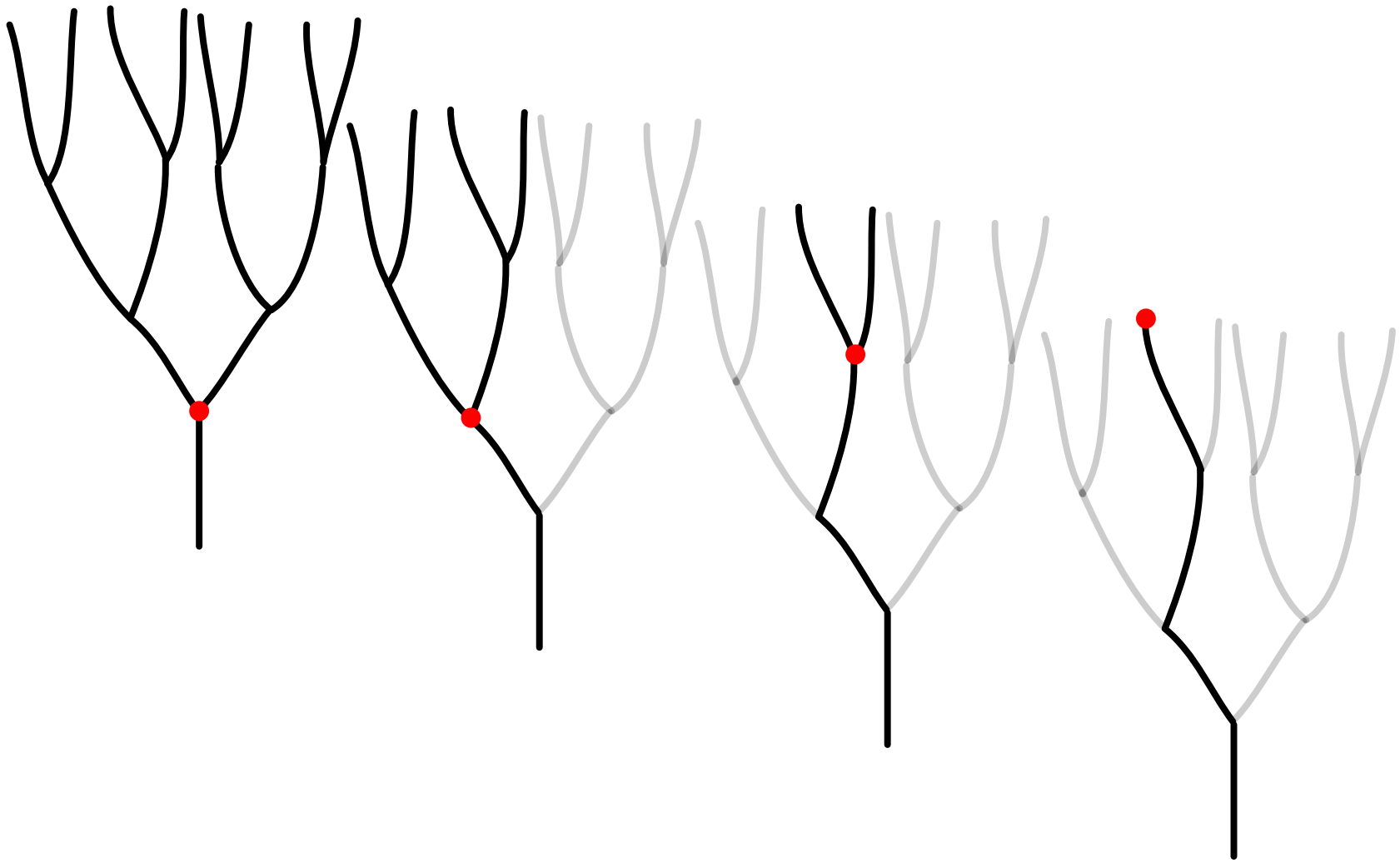

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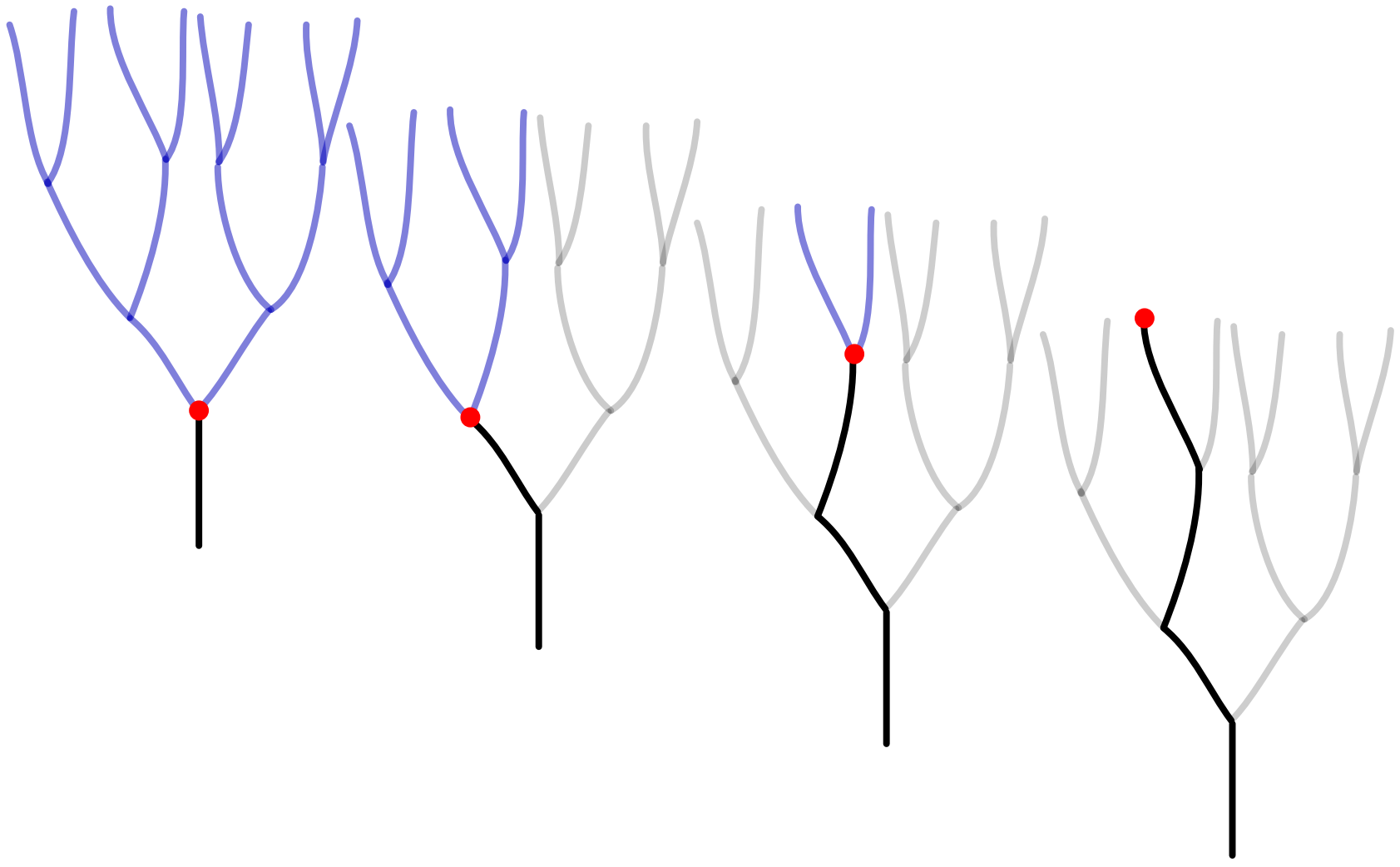
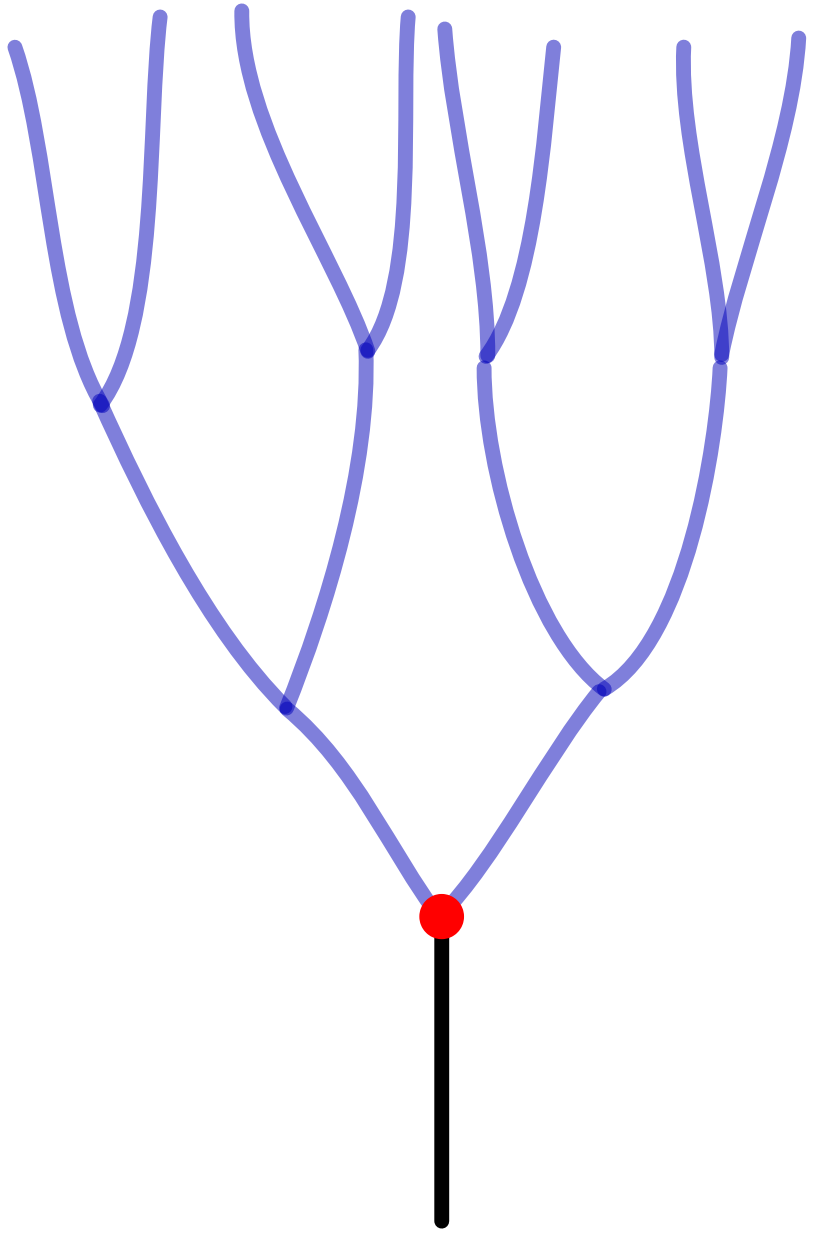


An A-theoretic Open Future: Replay



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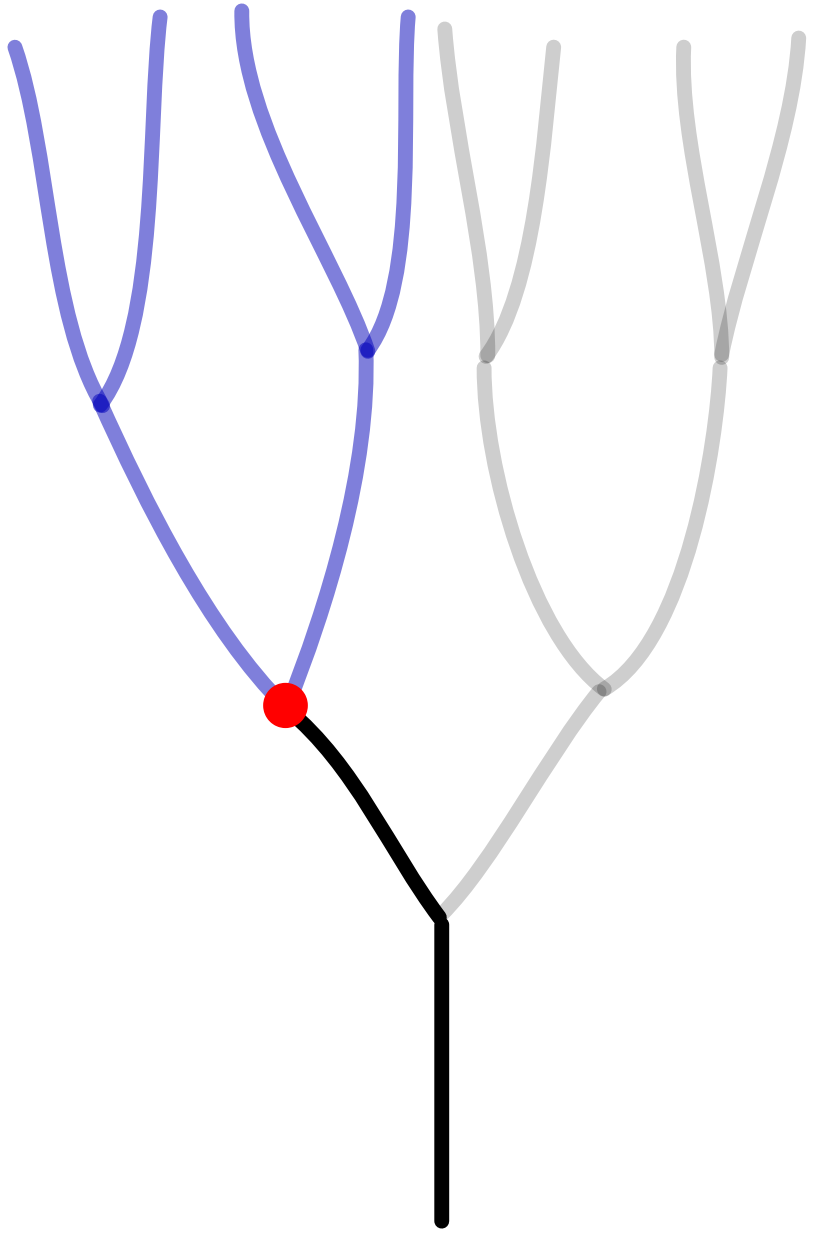

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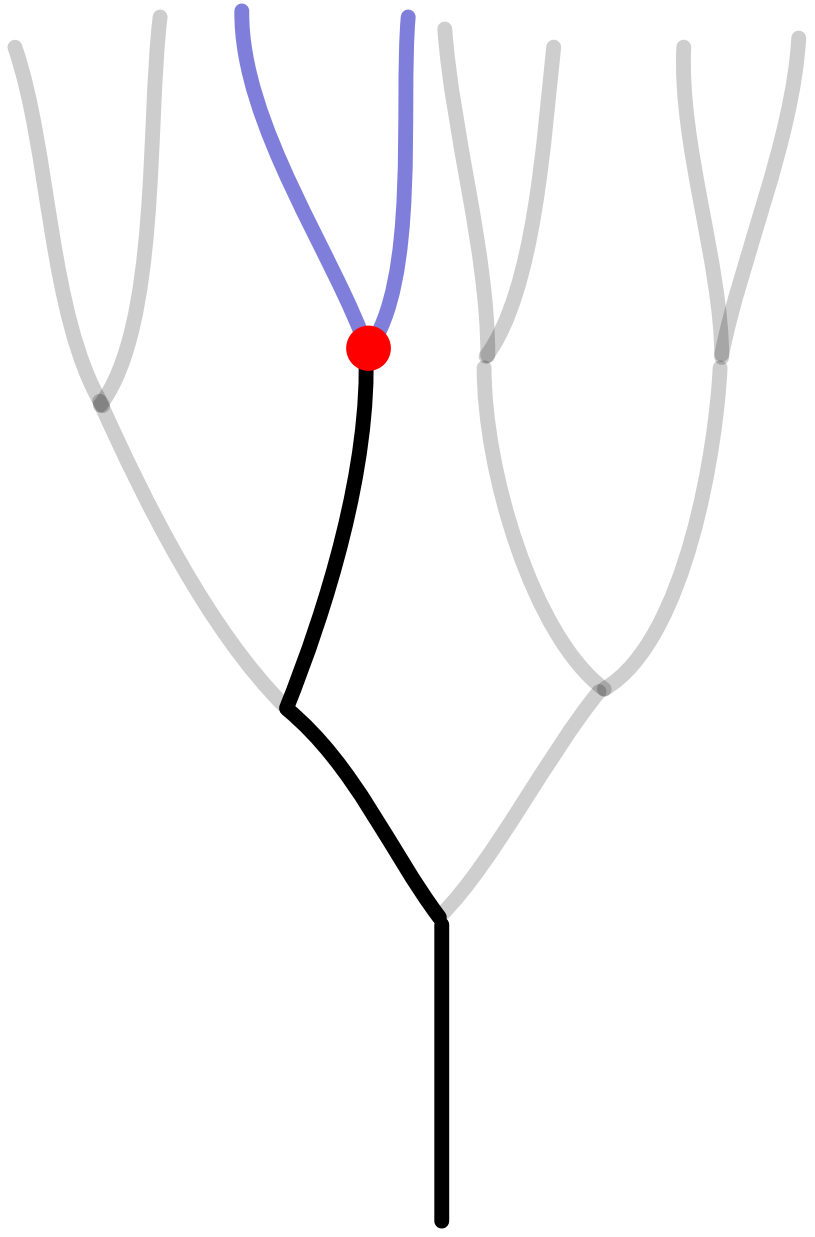

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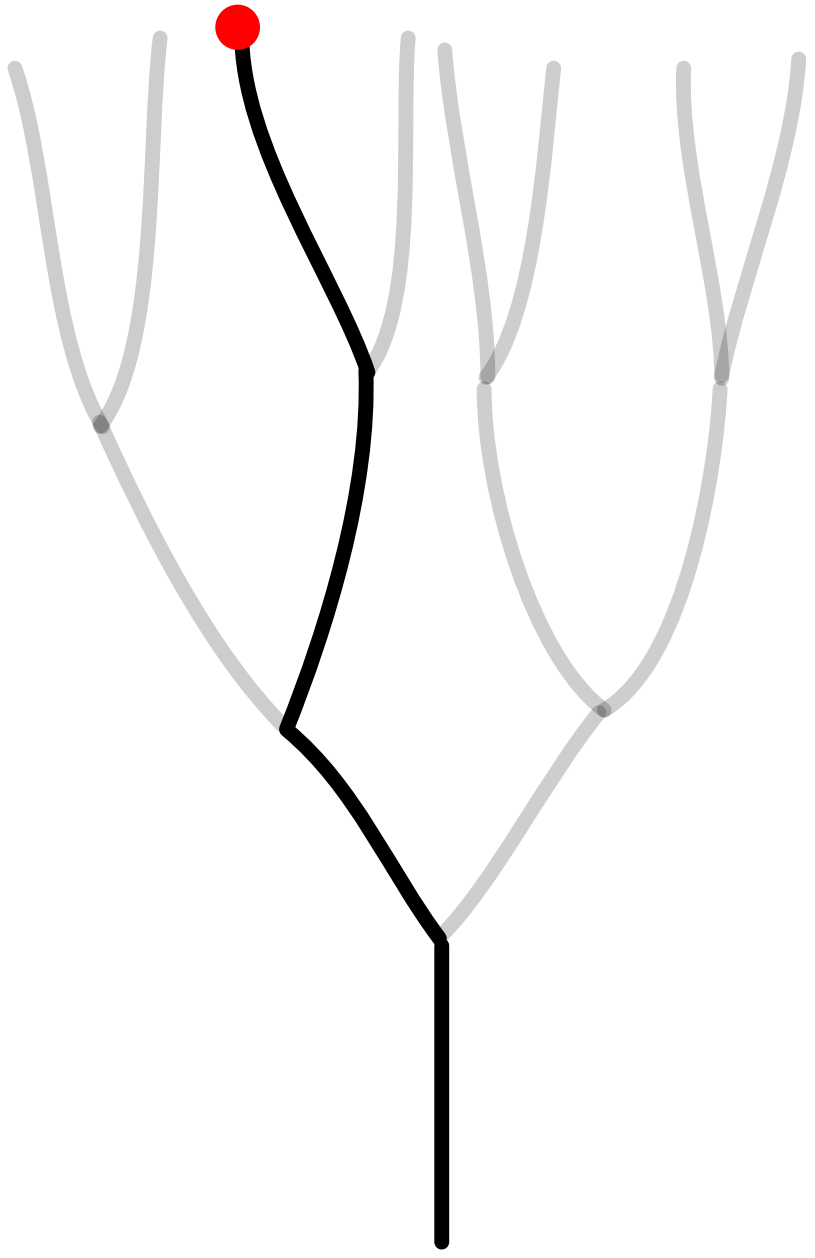

Interpreting the Model

The elements of the sequence are “shorthand” for the collection of tensed facts.

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Non-Standard Interpretation

- Each element of the sequence corresponds to the facts as of the relevant time.
- What *will be* true at $t' > t$, relative to t, need not be what *is* true relative to t'. What is true relative to t' is something that might be true relative to $t < t'$.

Outline

Motivation and Stage-Setting

Standard A Theory

Non-standard A Theory

Passage and the Open Future

Real Passage and Relativity

Relativistic Passage: Three Options

relativity $\Rightarrow$ the B Theory $\Rightarrow$ no objective passage

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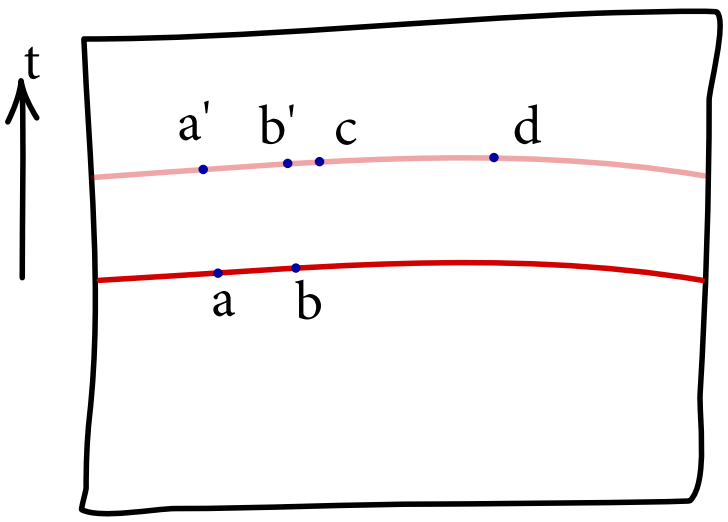

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- WILL (a', c and d are occurring)

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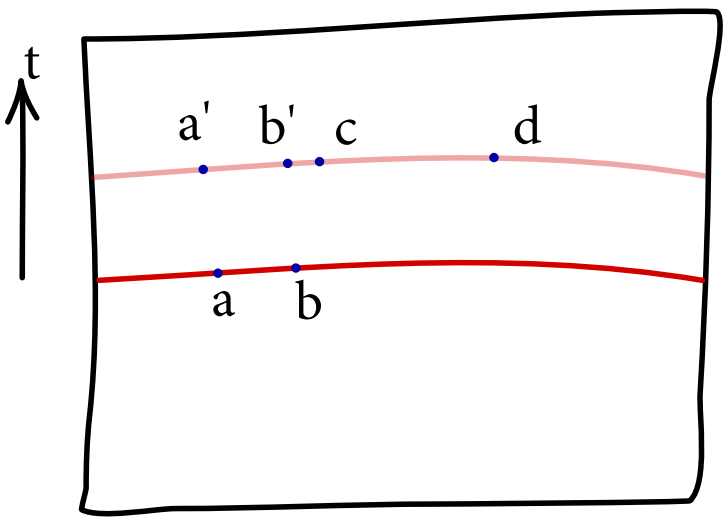

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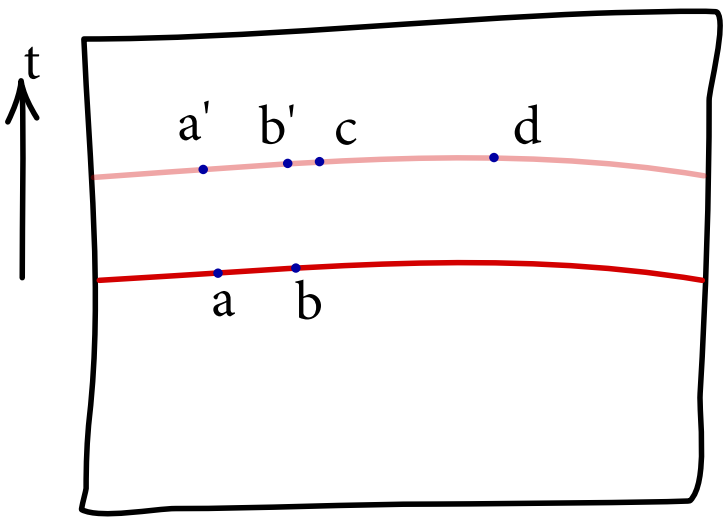

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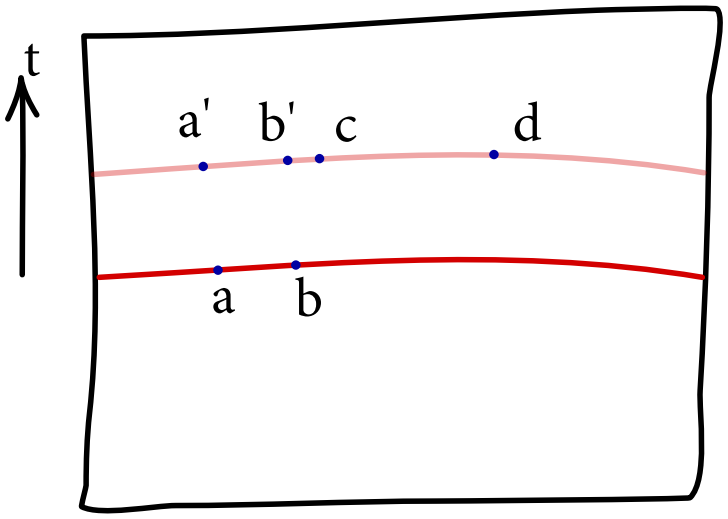
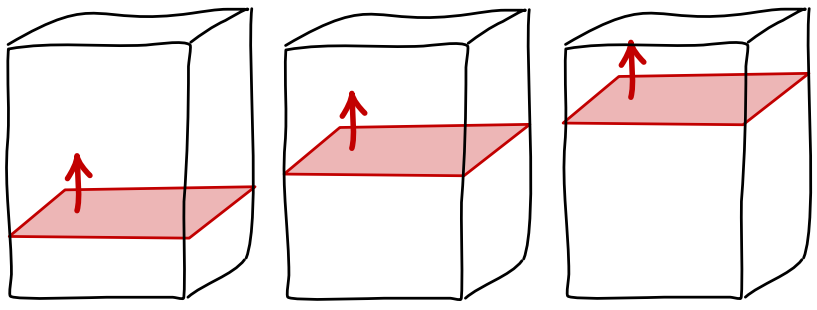


- a and b are occurring
- WILL (a', c and d are occurring)

- a' occurs five hours after a .
- c' occurs only a second after a.
- d occurs after a, but it occurs no finite amount of time after a and b. It occurs at some spatial distance it.

Without a Global Now



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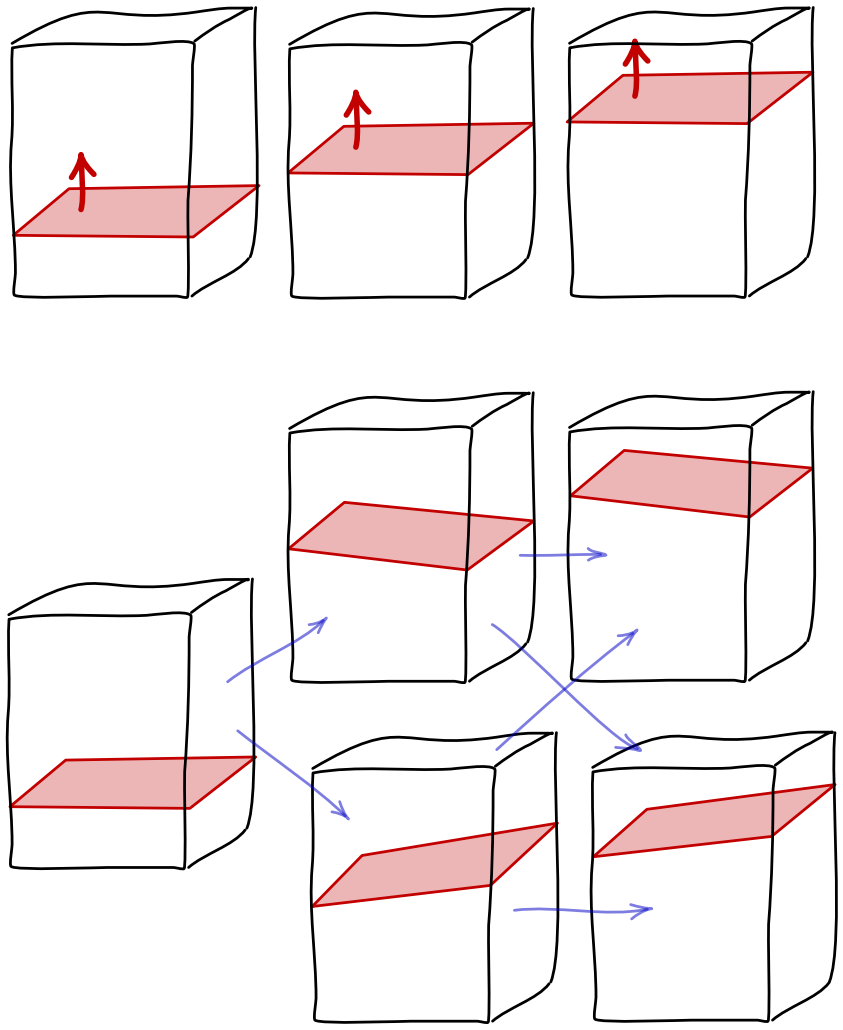

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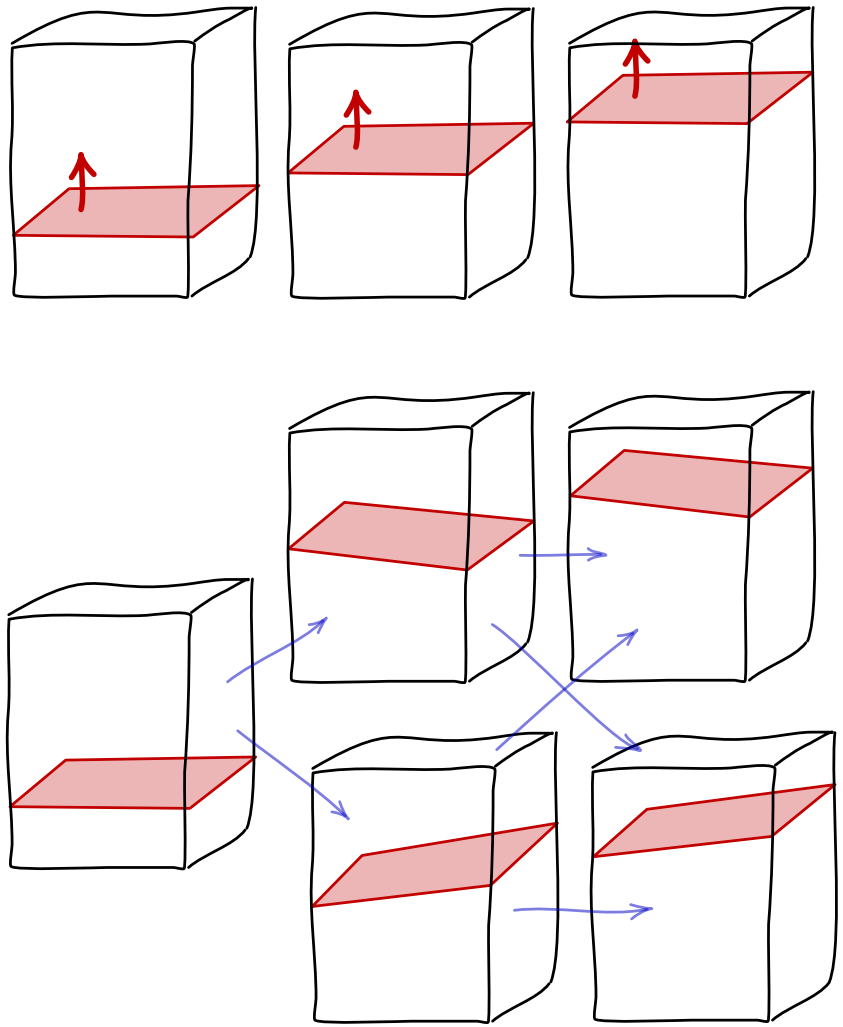

The elements of the model are now only partially ordered.

Skow's Relativistic Moving Spotlight

The non-relativistic case

If p and q are points in supertime, and p is r units Later than q, then the time that is NOW from the perspective of p is r units later than the time that is NOW from the perspective of q. (Skow, 2009, 671–2)

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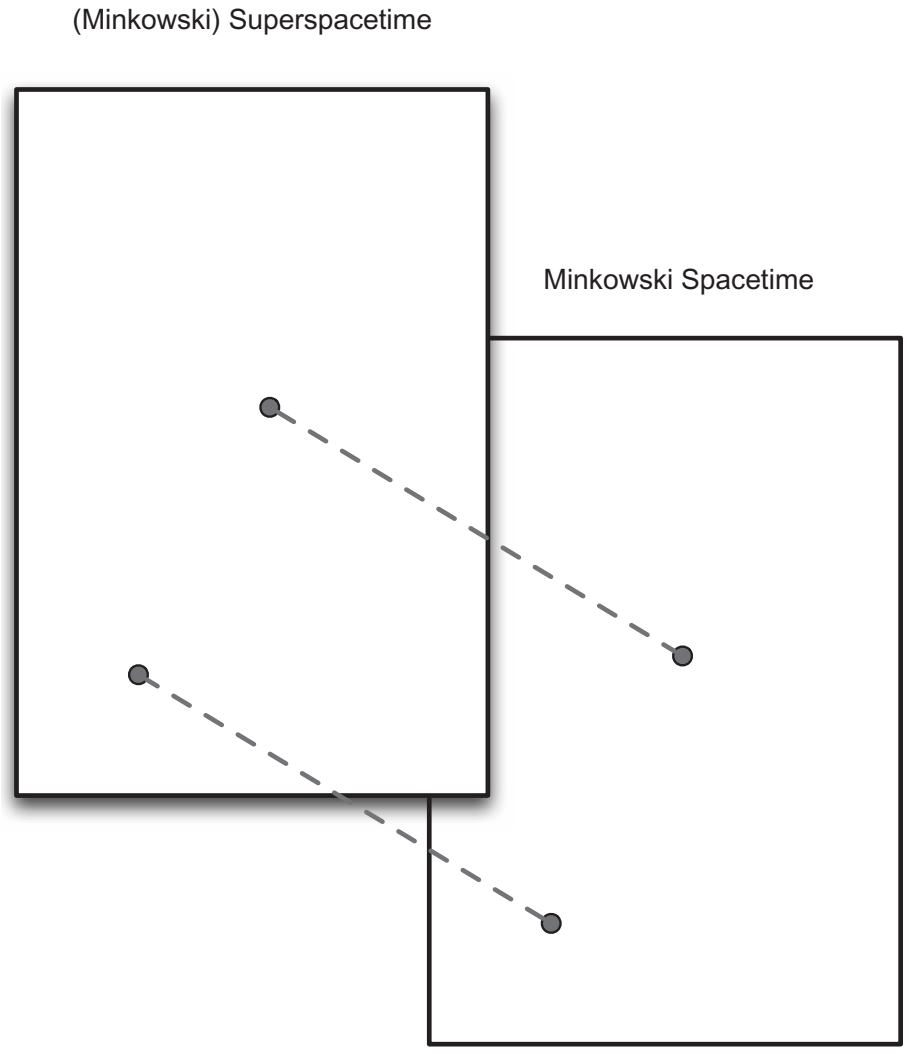
With Minkowski spacetime…

If p and q are points in supertime, and p is r units Later than q, then the BLANK-1 from the perspective of p is BLANK-2 than the BLANK-1 from the perspective of q.

> *BLANK-1 holds the place for the kind of region that is "lit up" from perspectives in supertime, and BLANK-2 holds the place for the relation that those regions stand in. But there appears to be no way to fill in these blanks. (Skow, 2009, 672)*

Skow's "solution"

- Replace supertime with Minkowski superspacetime
- From the perspective of a point in superspacetime just a single point of spacetime is "lit up"



The “Motion” of the Present

If p and q are points in superspacetime that are Timelike related, and p is to the Future of q (that is, lies in the Future Light Cone of q), then the point that is PRESENT from the perspective of p is timelike related to and to the future of the point that is PRESENT from the perspective of q.

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Just as, as one moved from Earlier to Later points in supertime, one saw the NOW move from earlier to later times, so as one moves from Earlier to Later points along any Timelike curve in superspacetime, one will see the PRESENT move from earlier to later points along a corresponding timelike curve in spacetime. (675)

Skow's Interpretation of the Model

The non-relativistic case involved:

- An absolute fact about which time is NOW
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"what is the literal truth behind the superspacetime metaphor? I am not sure I really need to answer this question. . . I think it may be possible to spell out the literal truth behind the superspacetime metaphor. It could be done using complicated primitive tense-like operators that are adapted to the structure of relativistic spacetime. But I do not think it is worth going through in detail how it all would work, because I think the presentation of the theory using superspacetime is easier to understand." (673–4)

Interpreting the Model II

A standard A-theoretic interpretation:

- In the classical case, the absolute facts included a fact about which time was *the* NOW.
  - Is there an *absolute* fact about which spacetime point is *the* PRESENT? What's special about *us* (spatially speaking)?

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  - Spacetime points in our elsewhere, were never and will never be present. But they will be such that they (then) once were present.

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A non-standard interpretation looks more promising…

- except for a "passage of space" problem.

Relativity and The Open Future

'Predictive' probabilism: the future, like the past, is now in reality entirely fixed and determined even though the basic laws are probabilistic and not deterministic

Ontological probabilism: the basic laws are probabilistic *and the future is now in reality open with many ontologically real alternative possibilities*

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I have argued. . . that special relativity is perfectly compatible (in general) with "ontological probabilism" (Stein, 1991, 164)

For an event—a man considering, for example—at a space-time point a, those events, and only those, have already become (real or determinate), which occur at points in the topological closure of the past of a. (Stein, 1968, 14)

Branching Spacetimes

- Belnap generalized the branching time frameworks used in tense logic:
  - (global) instants $\rightarrow$ point events.
- Just as classical branching time models have a natural "block multiverse" interpretation, so do branching spacetimes models.

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1. We want a relativistic analogue of the pre-relativistic model of the open-future views of passage
2. We want a relativistic analogues of the stories to accompanied the model

Elements of BST

- **Our World** (OW) – a set of (possible) point events
- A non-trivial partial order on OW, $e \leq e'$
  - e is in the causal past of e'
  - e' is in a possible future of e
- **histories** are maximal (upward) directed subsets of OW. (For any two events in a history, that history contains an event with both in its past.)
- **spacelike separated** = incomparable *and* compatible (= have a common upper bound).
- Postulates
  1. $\leq$ is dense
  2. every lower-bounded chain has an infimum (a greatest lower bound) and, if upper-bounded, a supremum (a least upper bound) in each history containing it
  3. OW has no maximal elements
  4. If E is a lower-bounded chain in $h_1 \setminus h_2$, then some lower bound of E is maximal in $h_1 \cap h_2$ (the "**Prior Choice Principle**")

A-Theoretic BST Models

- Given a BST model W and a history $h \subseteq W$, one can single out privileged sets of histories on which subsethood is a partial order.
  - $\{H_{(e)} : e \in h\}$
  - $\{H_E : E$ is a maximal spacelike-related set of events in $h\}$
- These are natural analogues of the elements (the "snapshots") in our A-theoretic branching-time model of passage

In Earman-style notation:

- $\mathcal{B}(OW, h) = \langle \{H_{(e)} : e \in h\}, \precsim \rangle$, where $\precsim$ is now defined via: $H_{(e)} \precsim H_{(e')}$ iff $H_{(e')} \subseteq H_{(e)}$.

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Consider the model $\mathcal{B}(OW, h) = \langle \{H_{(e)} : e \in h\}, \precsim \rangle$. A "standard" A-theoretic interpretation is not viable for now familiar reasons so:

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- each element of $\{H_{(e)} : e \in h\}$ represents the facts that hold as of some spacetime point.
- These facts display a particular pattern of indeterminacy:
  - As of some point p, what happens outside of p's casual past is indeterminate.
  - as of every point, including all points outside of p's causal past, what happens at that point is determinate.
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  - as of every point, including all points outside of p's causal past, what happens at that point is determinate.
- The perspectival facts are not inter-deducible, but mesh in the obvious ways.
- The model is inequivalent to:
  - a single BST model
  - its implicit preferred history
  - a BST model that includes a "thin red line"

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What kind of fact is represented by such sequences of perspectives anyway?

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