Some Key Questions on the Nature of Time

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What Parts of Time Are Real?

Some possible answers:

1. **Presentism:** Only the present is real.
2. **Possibilism:** Only the present and past are real.
3. **Eternalism:** Past, present and future are all real.

All of these (and their variants, to be discussed) present problems.

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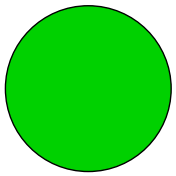

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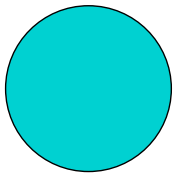

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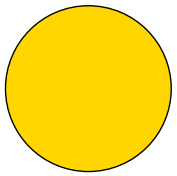

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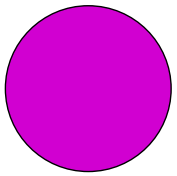

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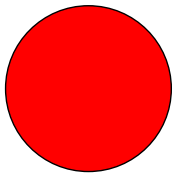

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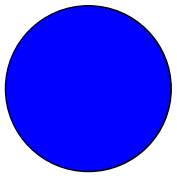

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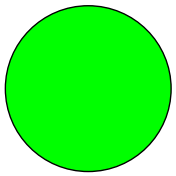

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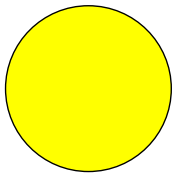

Presentism

For something to exist is for it to exist now.

For something to happen is for it to happen now.

The past only exists insofar as there exist present states of affairs which we can interpret as effects of what we call “past occurrences”.

The future only exists insofar as there exist present states of afairs which we can interpret as causes of what we call “future occurrences”

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Reality is a "block" with three dimensions of space and one of time, and is continuously growing along the time dimension by accreting extra layers — i.e., presents which immediately become past while retaining their reality.

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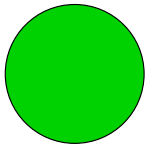

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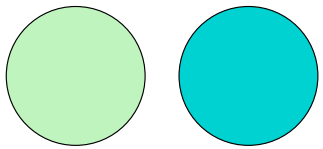

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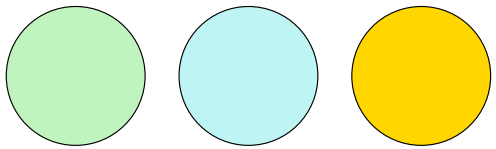

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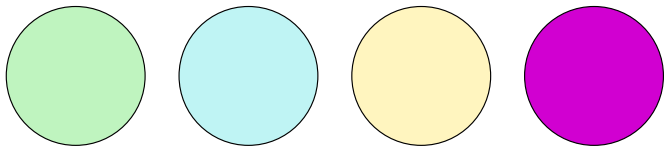

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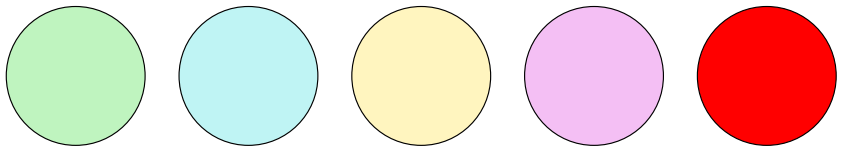

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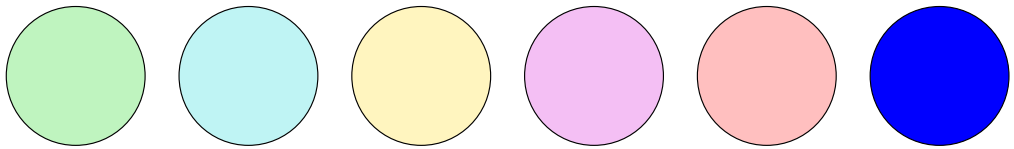

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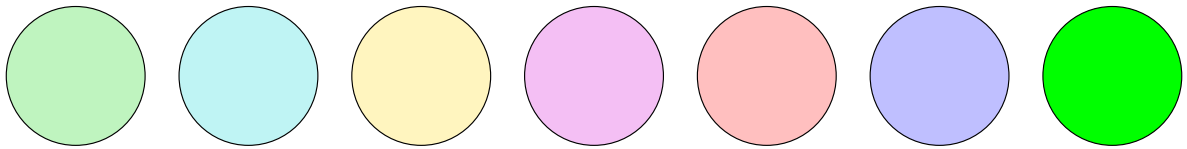

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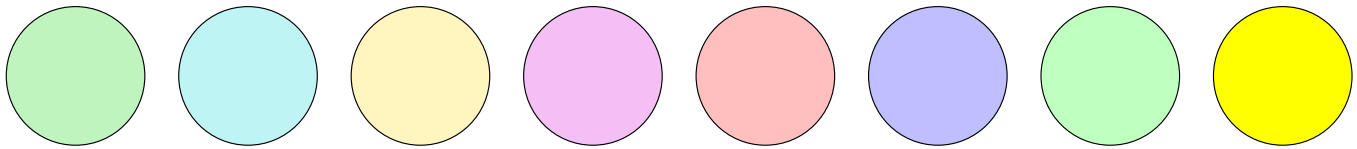

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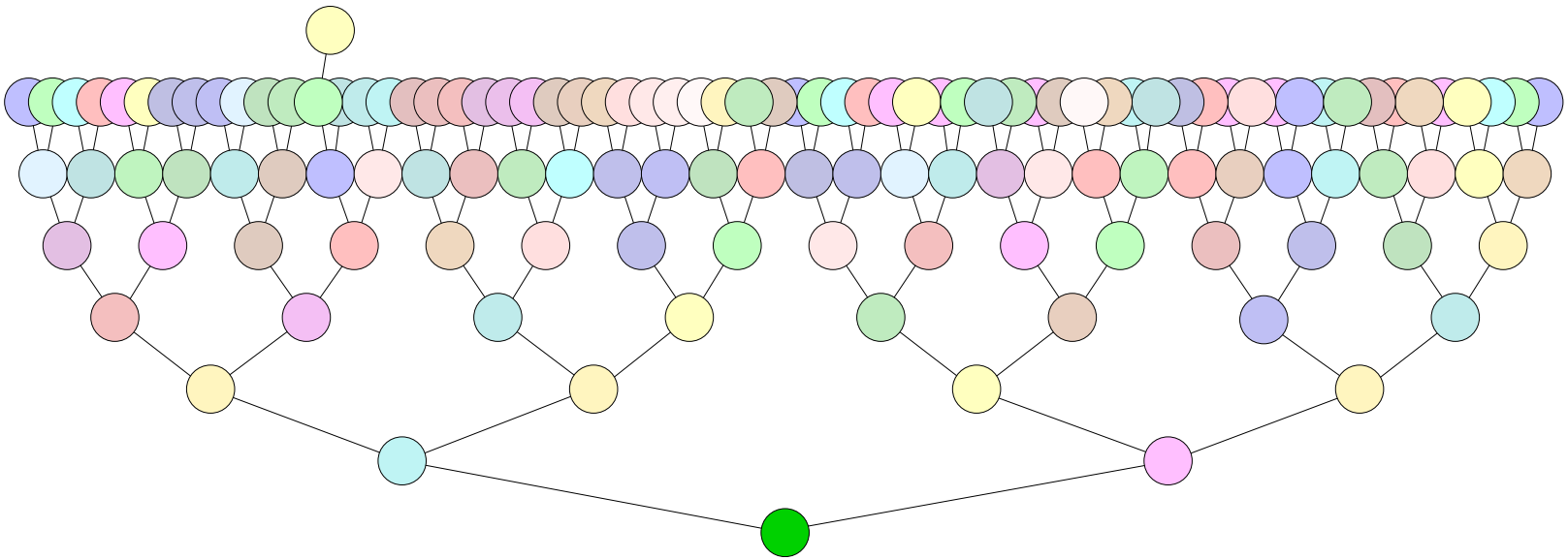

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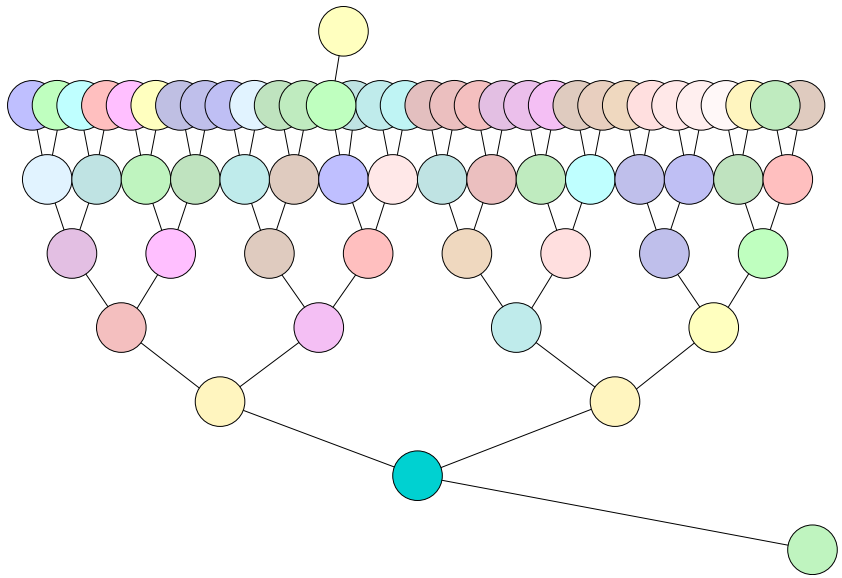

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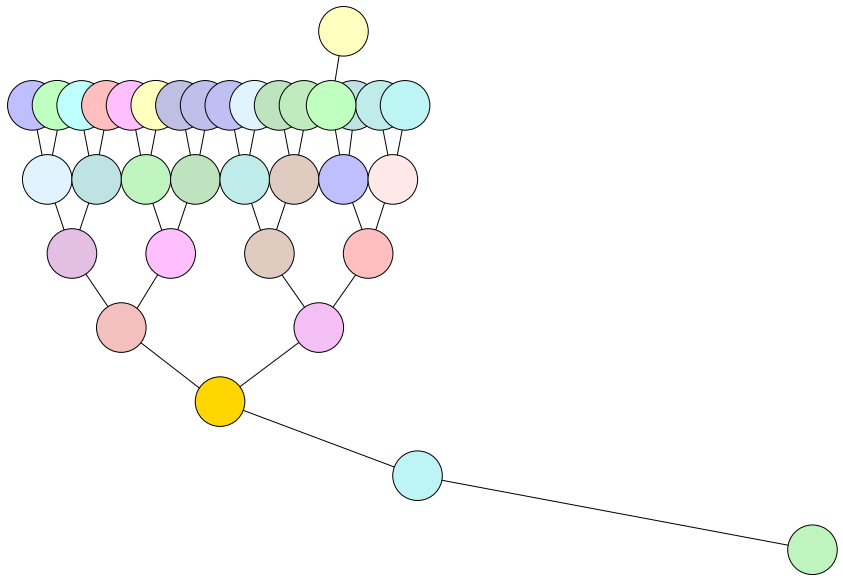

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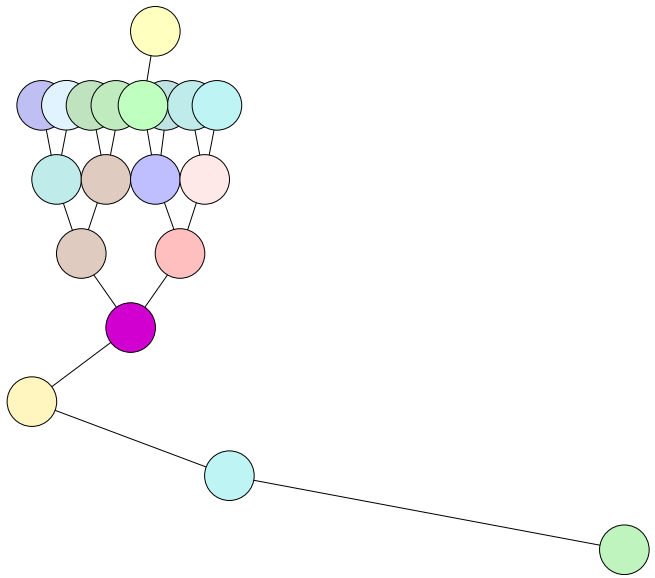

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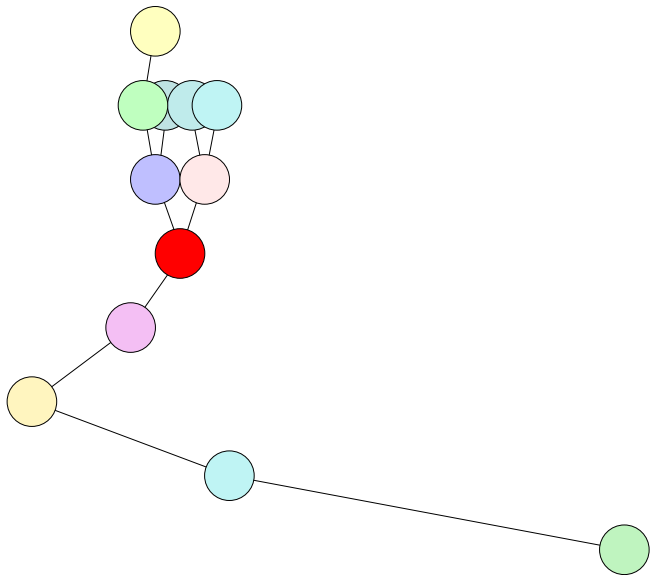

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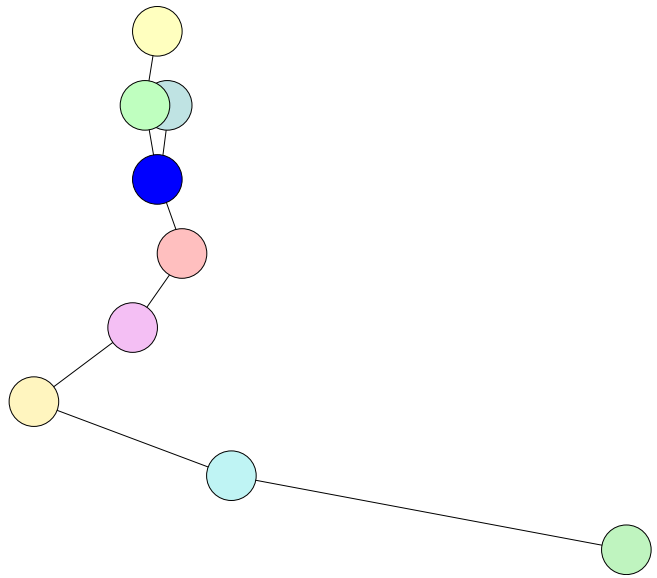

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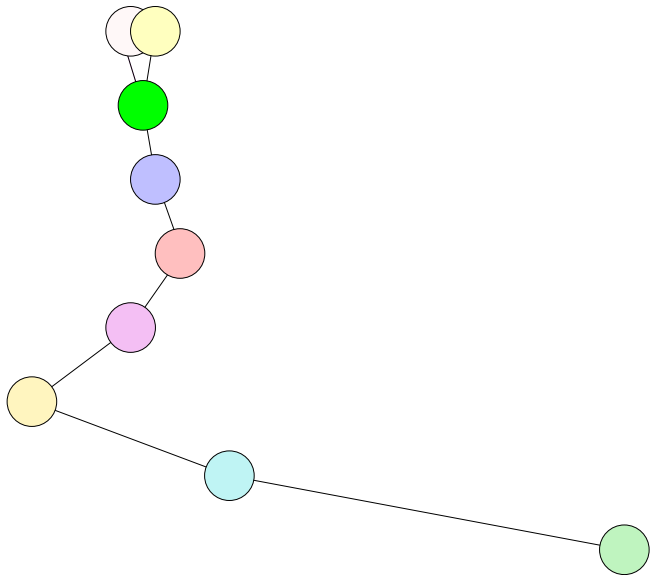

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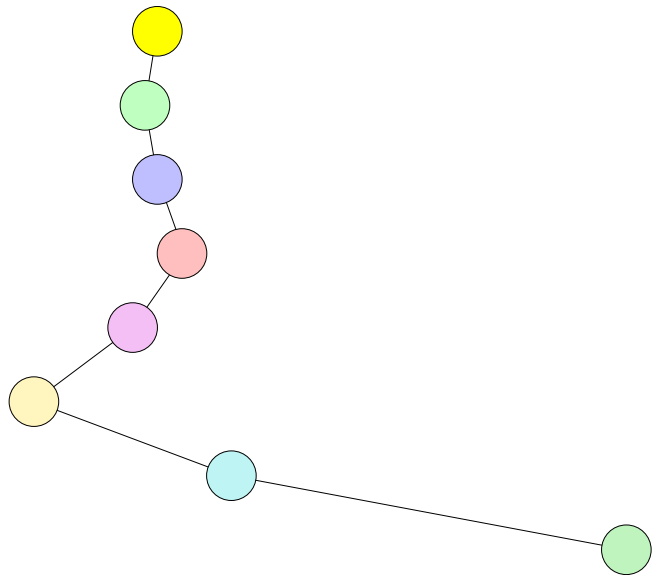

Eternalism I: The Moving Spotlight

Past, present, and future are all real, forming a complete "block universe". The passage of time consists of successive layers of the block being "illuminated", i.e., made present. Each layer starts off future, briefly becomes present (at the moment of illumination), and then becomes past, remaining past for ever more.

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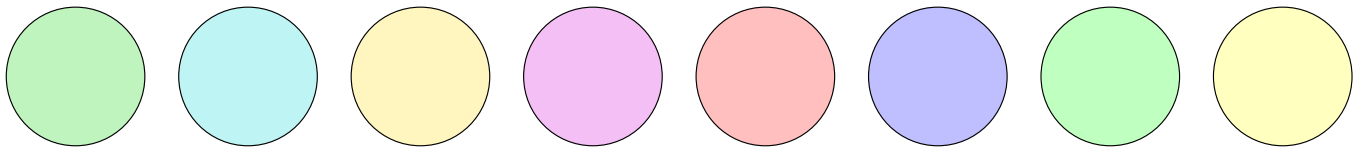

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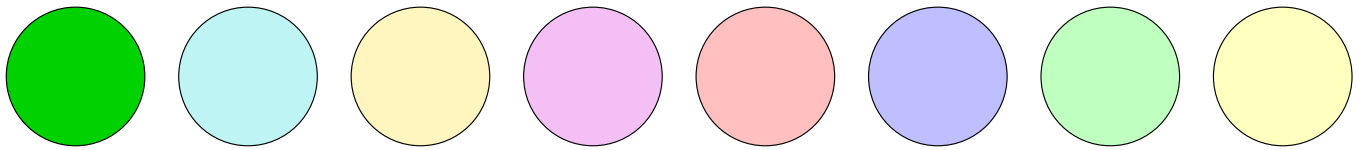

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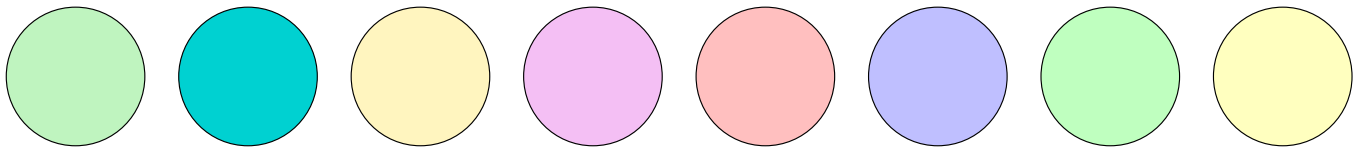

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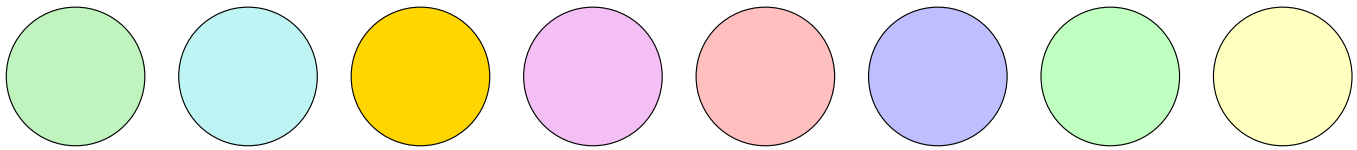

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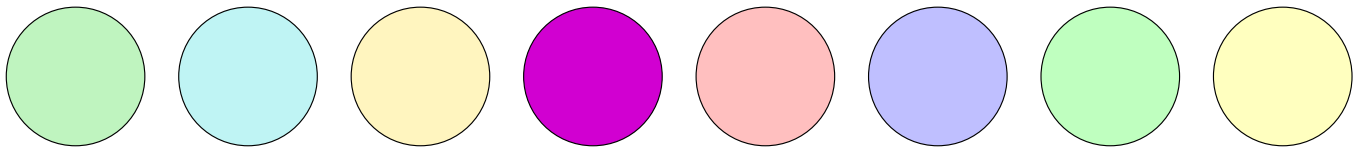

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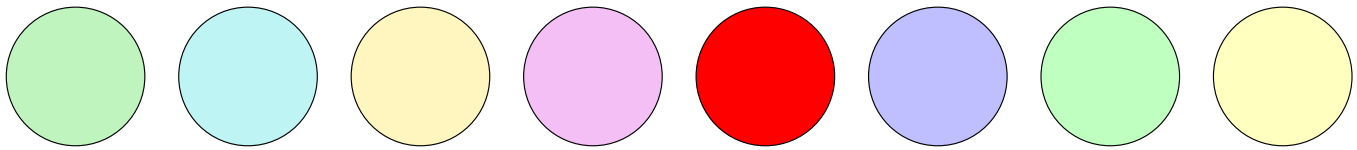

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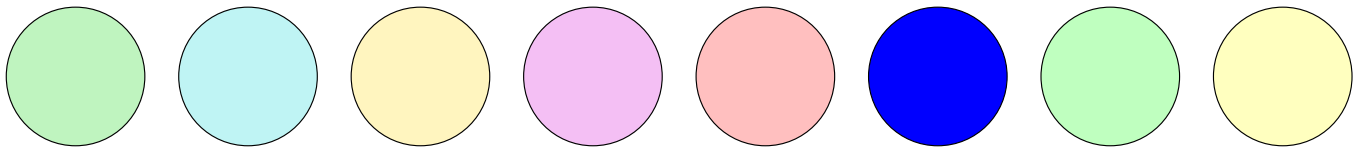

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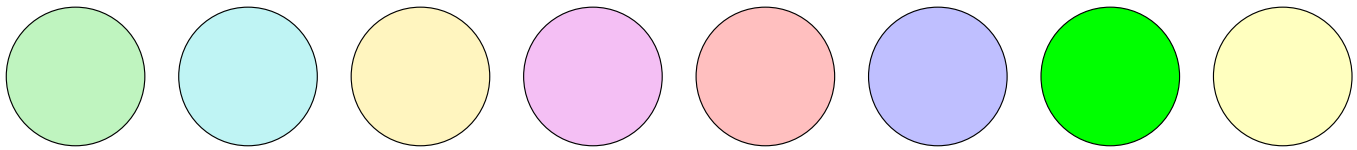

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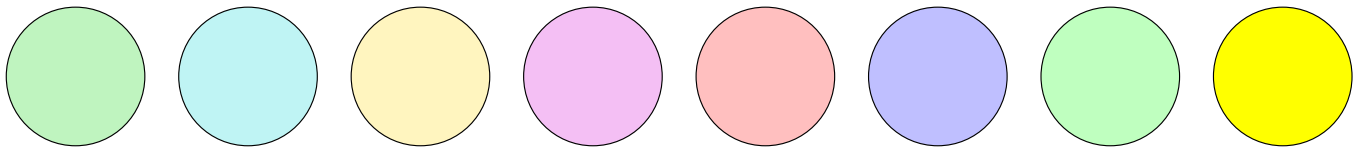

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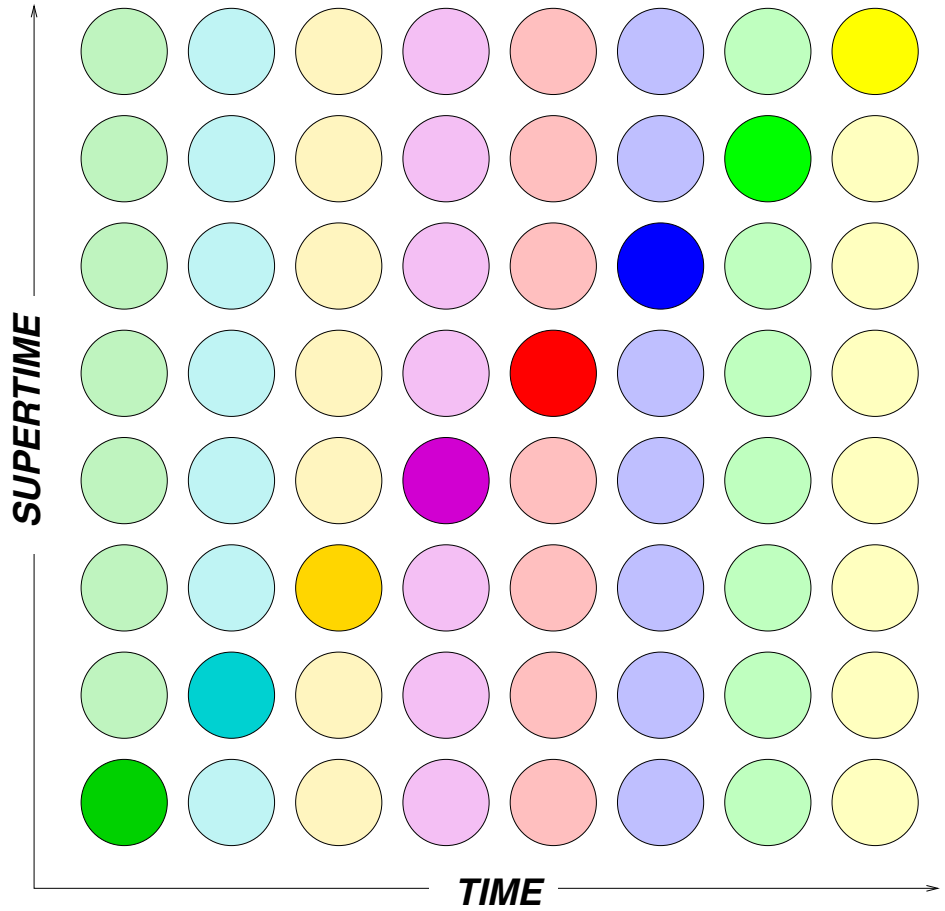

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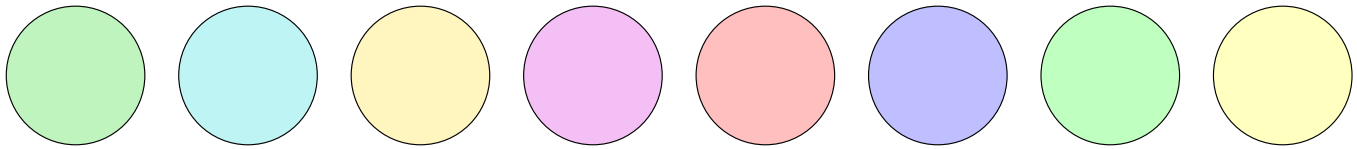

Change

Compare:

(1) It is moving.

(2) It has moved.

In (1), we ascribe a certain property — "movingness", or being in motion — to an object at the present time.

In (2), we assert that the object is in a different position now from where it was at some earlier time.

I shall call these two assertions *experiential* and *historical* respectively.

Experiential vs Historical Change

- Experiential change is change *in the process of happening*, ongoing in the present.
- Historical change is change as a *fait accompli*. It is characterised by the difference between a present state of affairs and a past state of affairs.

The "at-at" theory of motion and change

> *Motion consists merely in the occupation of different places at different times.*
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> (Bertrand Russell, 1903)

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Always be suspicious of the word "merely"!

(cf. P. B. Medawar on *nothing-buttery* — "always part of the minor symptomatology of the bogus".)

The Reality of Experiential Change

For a presentist, historical change must be dependent on experiential change. If something *has moved* this is because it has spent some time *moving*.

In the Growing Block theory too, it is natural to accord primacy to experiential change at the growing front of the block, with historical changes forming the "fossil record" of the present in the persisting past.

Instantaneous Change?

How can there be change *in the present*?

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Standard mathematical solution: A state of change at an instant is a limit of changes taking place over intervals converging on that instant, e.g.,

$$\text{velocity at } t = \lim_{\delta t \to 0} \left(\frac{\text{distance travelled over } (t - \delta t, t)}{\delta t} \right)$$

This makes the state of change at an instant depend on what holds at *other* instants rather than the other way round. It formalises the "static" at-at account of change.

The Duration of the Present

If

- There is change in the present, which exists solely by virtue of what is real at the present

and

- Change necessarily takes time

then it seems inescapable that

- The present has duration.

If the present is a knife-edge, it is rather a blunt one!

The Specious Present

The idea of the *psychologically experienced present* having duration seems natural: it is the "specious present" of William James. Its duration can be investigated experimentally — with different results for different sensory modalities.

But it is a presumption of both presentism and possibilism that the Present is an intrinsic feature of time as such, not dependent on empirical facts of human psychology.

If this "true present" is to be extended, it seems arbitrtary what duration we assign to it.

The Instant as a Mathematical Idealisation

- Bergson, James, Whitehead: The notion of a strictly durationless instant is a mathematical idealisation, which does not correspond to anything in physical reality.
- The idealised mathematical instant is an essential ingredient in the mathematical conception of the time-continuum, which comprises *a non-denumerable infinity of instants, isomorphic, with respect to ordering, with the set of real numbers* $\mathbb{R}$.

- Mathematicians generally think of the time-continuum as *constructed* from this set of instants. That leaves the puzzle of *where duration comes from*.
- Obvious answer: If two times correspond to the numbers x and y (where $x < y$) then the duration of the interval they span is $y - x$.
- But without a *prior* notion of duration, the assignment of numbers to times is arbitrary: There are infinitely-many order-preserving mappings from $\mathbb{R}$ onto itself which do not preserve duration — to know which one of these corresponds to the "real" time order, we have to know the durations in advance.

Instrinsic Duration

- An alternative picture: Duration is an irreducible property of time, not derived from relationships amongst instants.
- An instant is an idealisation of the notion of a *potential division* of time.
- Divisions in time are marked by events: either "sufficiently short" events (*a lightning flash, the clang of a bell*) or boundaries between states (*onset of motion of a body, a moving pointer's coming into coincidence with a mark*).
- It is impossible, even in principle, ever to narrow down such divisions to durationless instants.

The Present is Extended

- From the foregoing we conclude that *all parts of time are extended*, even those we customarily think of as instants ("on the dot of noon").
- All we can say is that with respect to a particular temporal resolution (or "time granularity") we can regard them as indivisible: Although they are really divisible, we lack the discriminatory ability to divide them.
- If *all* parts of time have duration, then the present, if it exists and is part of time, has duration too.
- This leaves room for ongoing change in the present.

A Counterargument

"The only time that can be called present is an instant, if we can conceive of such, that cannot be divided even into the most minute fractions, and a point of time as small as this passes so rapidly from the future to the past that its duration is without length. For if its duration were prolonged, it could be divided into past and future. When it is present it has no duration."

St Augustine, *Confessions*, Book XI, 15

A modern version of Augustine's argument

"Assuming time to be infinitely divisible, the present can have no duration at all, for if it did, we could divide it into parts, and some parts would be earlier than others. But something that is present cannot be earlier than anything else that is also present! So the present cannot have earlier and later parts, which is to say that it can have no duration."

Robin Le Poidevin, *Travels in Four Dimensions* (2003), p.156

The Argument Formalised

1.	Any duration can be divided into parts.	(Stated premise)
2.	The present is a duration.	(Assumption to be refuted)
3.	If a duration is divided into parts, some of those parts are earlier than others.	(Unstated assumption)
4.	The present has parts some of which are earlier than others.	(2, 3)
5.	If A is earlier than B then A and B cannot both be present (i.e., parts of the present).	(Unstated assumption)
6.	The present cannot have parts some of which are earlier than others.	(5)
7.	The present has no duration	(2 refuted: contradiction 4+6)

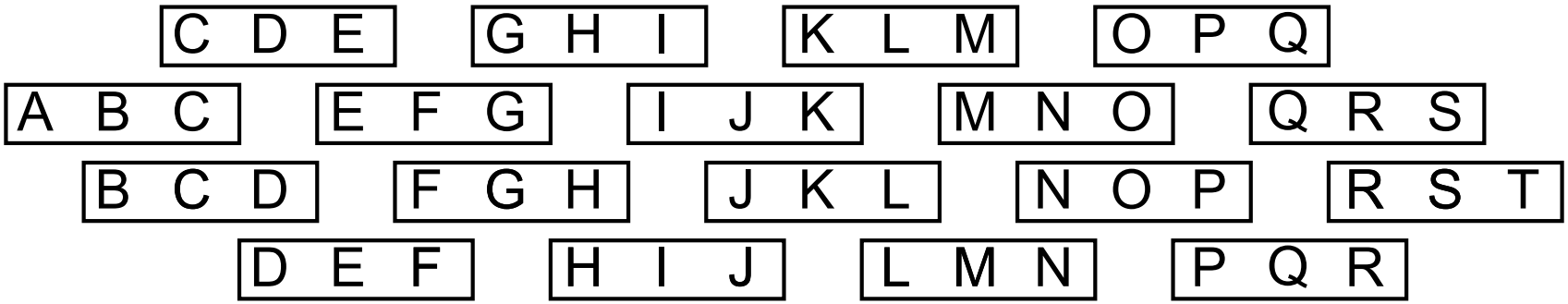
The Contradiction Defused I

- Both unstated assumptions use the term "earlier than". How should this be defined?
- First attempt: "X is earlier than Y" means "X is past when Y is present".
- Disambiguation:
  - "X is *strongly earlier* than Y" means "X is past whenever Y is present".
  - "X is *weakly earlier* than Y" means "X is past at some time that Y is present".

The Contradiction Defused II

- Assumption 3 ("If a duration is divided into parts, some of those parts are earlier than others") is reasonable if "earlier" is read as "at least weakly earlier".
- Assumption 5 ("If A is earlier than B then A and B cannot both be present") is reasonable if "earlier" means "strongly earlier", but *not* if it means "weakly earlier".
- Hence the argument establishes that (4) the present has parts some of which are weakly earlier than others, and (6) the present cannot have parts some of which are strongly earlier than others.
- There is no contradiction!

Weak and Strong Succession



The boxes represent (a selection of) presents;
A, B, C, ... are "events".

Each event is weakly earlier than the next two in the series, and strongly earlier than all the later ones.

- B and C can be present together (as in the presents ABC and BCD), but B can also be past when C is present (as in the present CDE) — so B is weakly earlier than C.
- B is past whenever E is present, so B is strongly earlier than E.

The View from Special Relativity

The central premise of the Special Theory of Relativity (STR) is that *the greatest speed at which any causal influence can be propagated across space is the speed of light (c), and it is the same for all observers, whatever their state of motion.*

From this, it follows that:

- Observers in relative motion will assign different lengths to spatial and temporal intervals, and different velocities to anything moving slower than light
- But all observers will assign the same value to the *spatio-temporal separation* between two events.

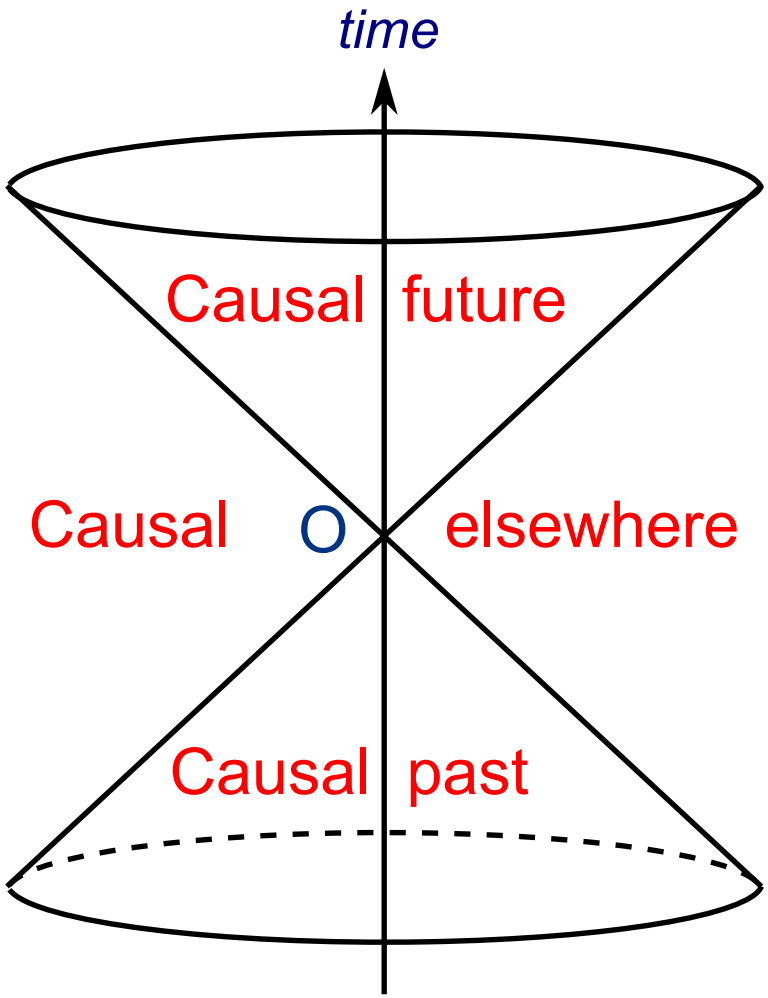
Spatio-temporal Separation

If observers O_1 and O_2 assign to two events spatial and temporal distances $\delta x_1, \delta t_1$ and $\delta x_2, \delta t_2$ respectively, then the invariant squared space-time distance between the events is

$$\delta s^2 = \delta x_1^2 - c^2 \delta t_1^2 = \delta x_2^2 - c^2 \delta t_2^2.$$

- If $\delta s^2 > 0$, the separation between the events is **spacelike**. No causal influence can pass either way between the events.
- If $\delta s^2 = 0$, the separation is **lightlike**. A light signal could pass from the earlier event to the later.
- If $\delta s^2 < 0$, the separation is **timelike**. A slower-than-light signal (or a moving body) could pass from the earlier to the later.

The Light-cone



At space-time point O one can identify a **light-cone**.

The surface, interior, and exterior of the cone comprise all points whose space-time separation from O is respectively lightlike, timelike, and spacelike.

The light-cone divides all of space time into the **causal past**, the **causal future**, and the **causal elsewhere**.

The Relativistic Present?

From the standpoint of an observer at space-time location O and in a particular state of unaccelerated motion, which space-time points should count as present?

1. Only O. [Stein, 1968; Čapek, 1975]
2. Those points which, in the observer's reference frame, are assigned the same time-coordinate as O [This will differ between different observers at O].
3. The points on the surface of the backward-pointing lobe of the light-cone at O. [Godfrey-Smith, 1979; Hinchliff, 2000]
4. The points in some "simultaneity surface" through O, comprising a maximal set of points, including O, such that the separation between any two of them is space-like. [Lango, 1969; Rakić, 1997; Bourne, 2006]

The Relativistic Present?

All of these proposals are problematic:

1. "Only O" — so no two observers are co-present, we can only see each other's past.
2. "Same time-coordinate" — co-located observers in relative motion have different presents.
3. "Surface of light-cone" — *co-present with* becomes an asymmetric relation.
4. "Simultaneity surface". Which of the many candidate surfaces is the true present cannot be determined by physics.

Alternatively: Past, present and future are purely subjective notions; all space-time points are equally real [Rietdijk, 1966; Putnam, 1967] $\Longrightarrow$ Eternalism.

"We're all in this together!"

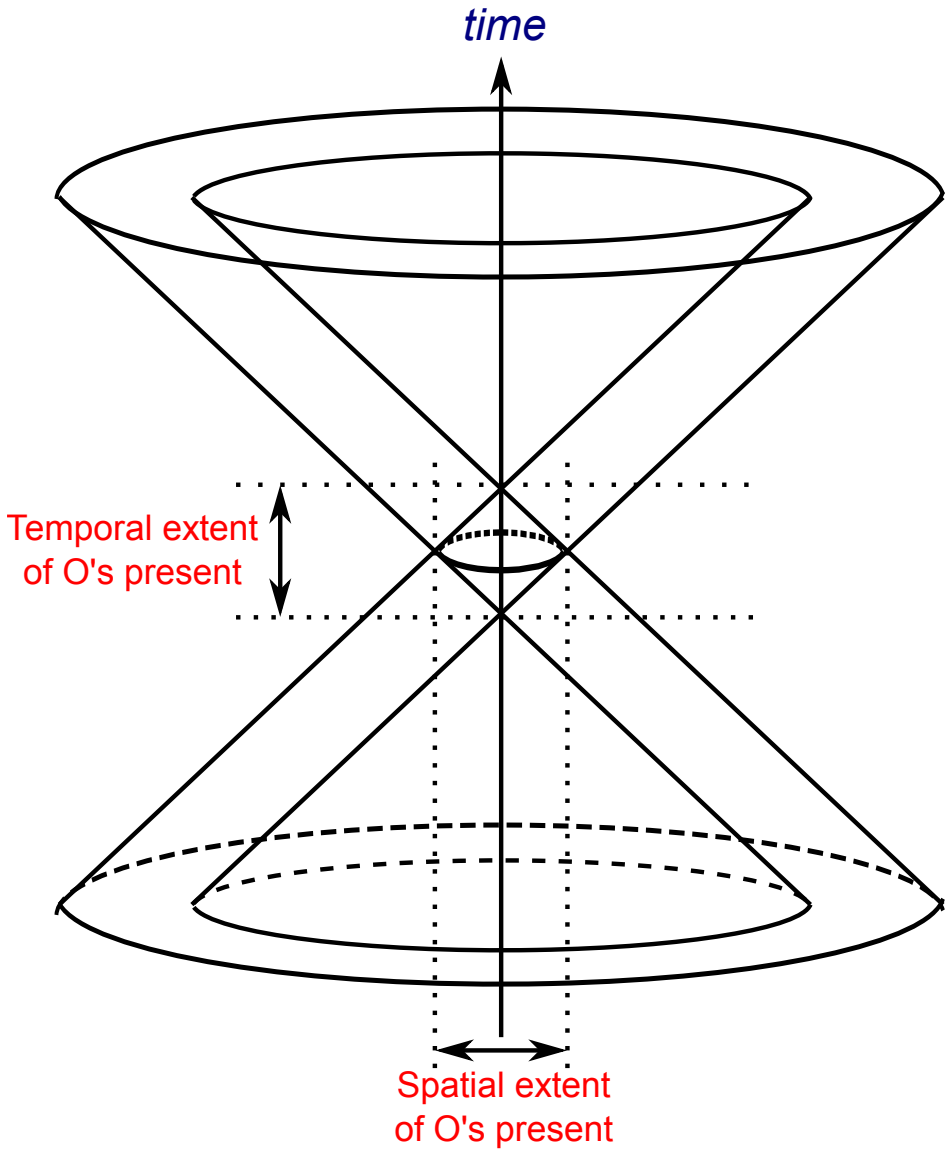
How can we capture the intuition that we are all "moving through time" together — that we share a common present?

Based on a (non-relativistic) suggestion of Butterfield (1984) and Callender (2008), I suggest that

> *My present has a* spatial *extent determined by the limits of a two-way exchange of signals within the* temporal *duration of my specious present.*

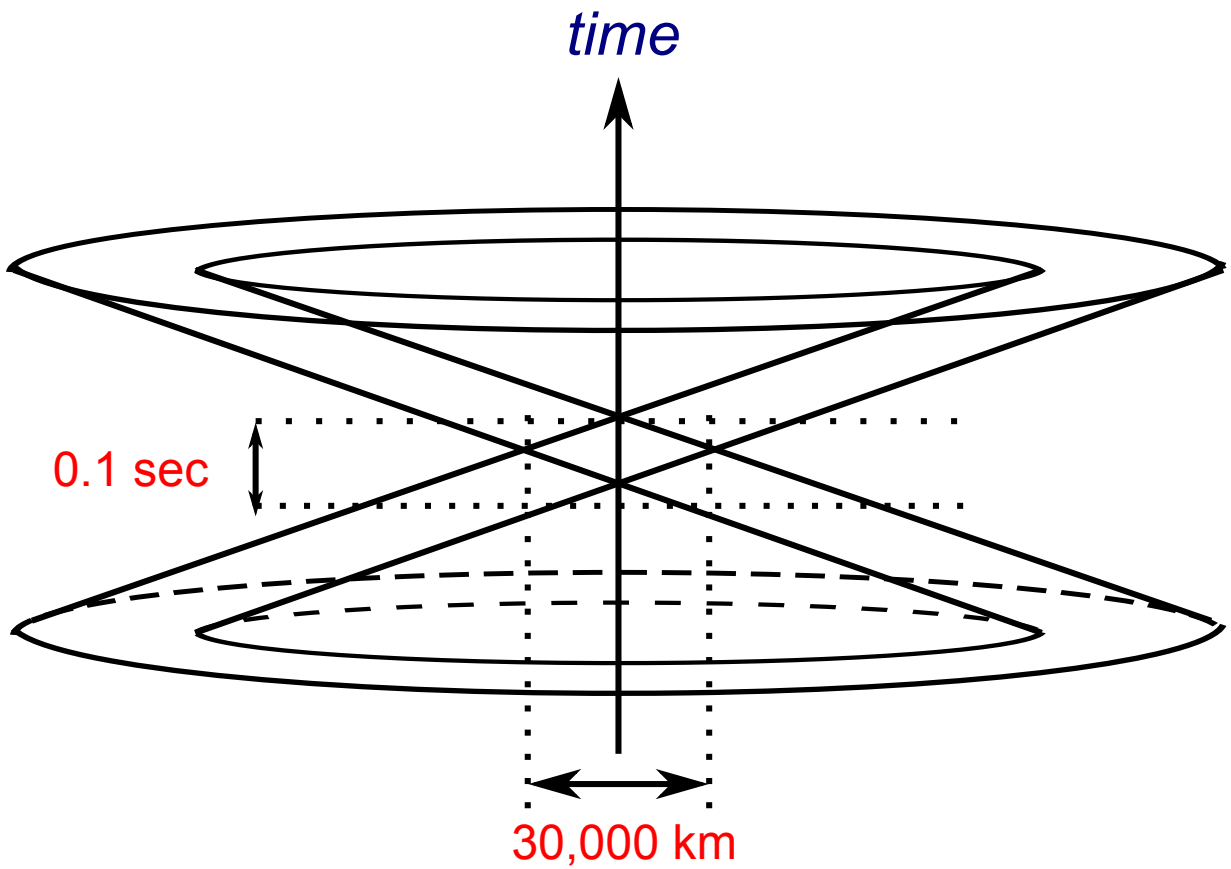
We're in it together when our spatio-temporal presents overlap, enabling mutual communication in a shared present.

The Relativistic Spatio-temporal Present



The extent of the present

The speed of light is close to 300,000 km/sec. If my specious present has a duration of, say, 0.1 seconds, then it has a spatial extent of 30,000 km — more than enough to overlap with the presents of everyone on earth.



Thank you for listening!

ANY QUESTIONS?