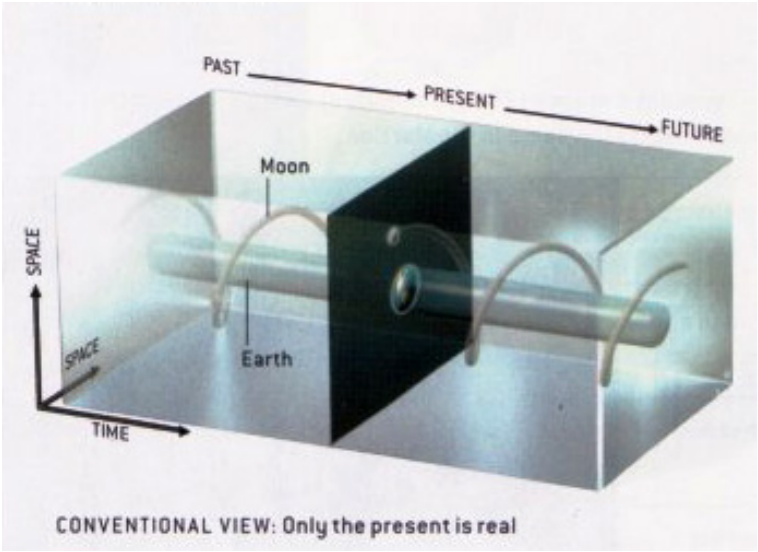
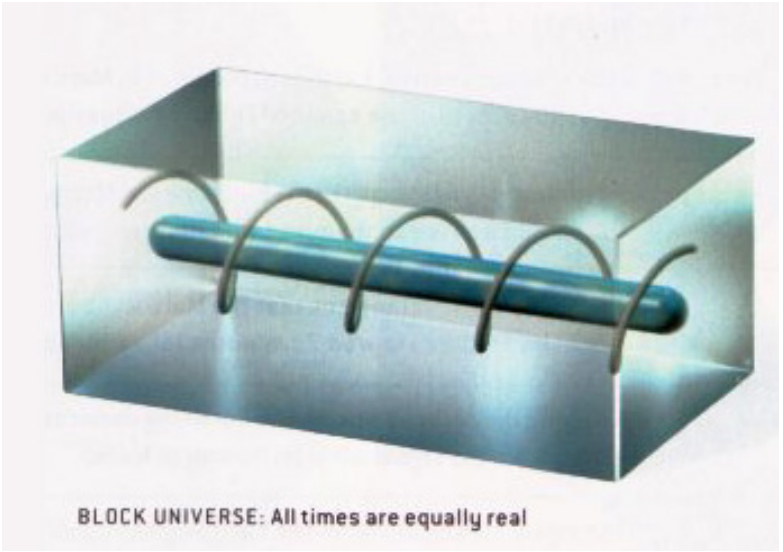
Time's Arrow and Eddington's Challenge

Huw Price

Centre for Time · University of Sydney

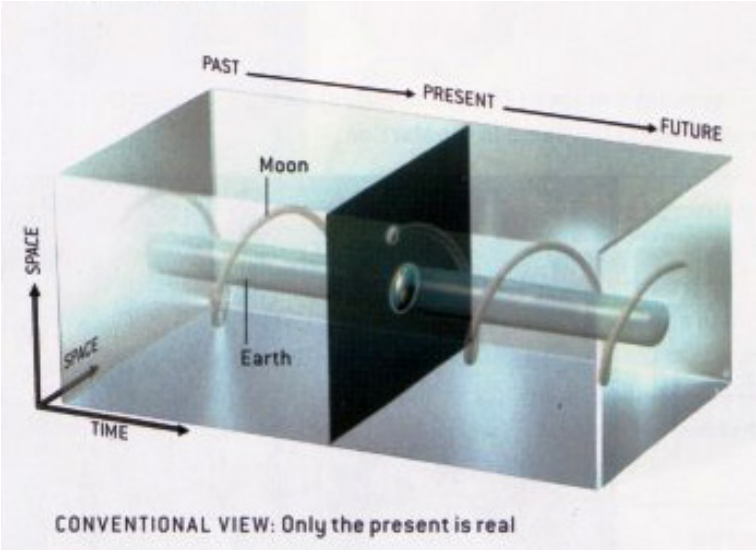
Two views of time





[Images: Scientific American/Bryan Christie Design]

The dynamic or 'passage' view



CONVENTIONAL VIEW: Only the present is real

This view treats one or more of these three elements as objectively real (even if missing from current physics):

1. A distinguished present moment.
2. An objective 'flow' of time ('becoming').
3. An objective direction of time.

This is said to be a minority view among physicists, but it has had – and still has – some distinguished champions.

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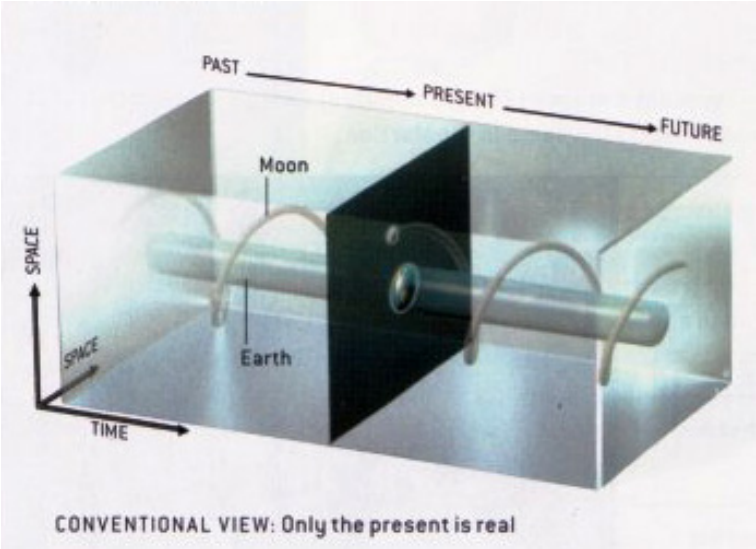

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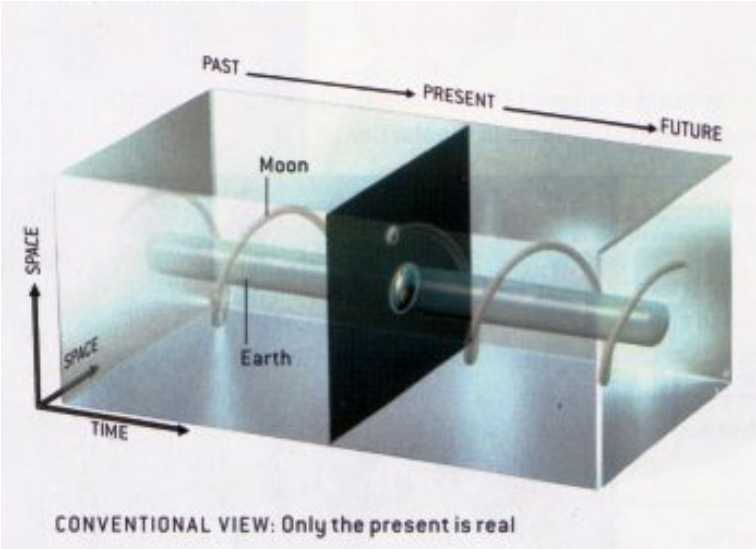

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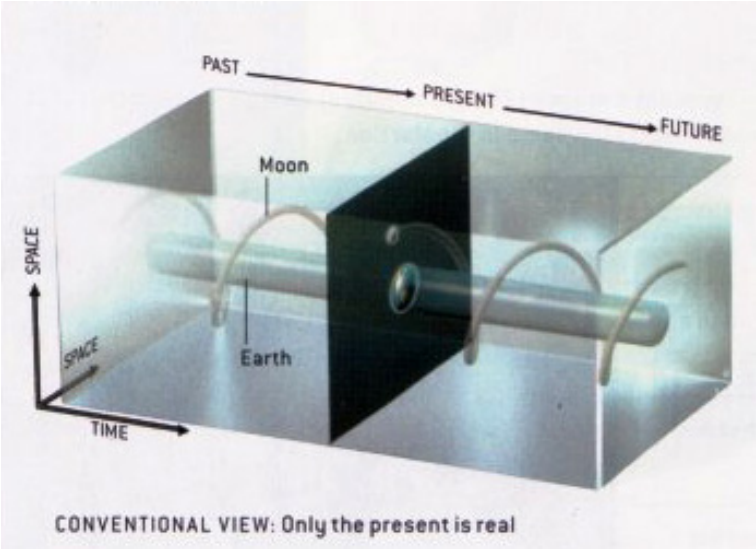

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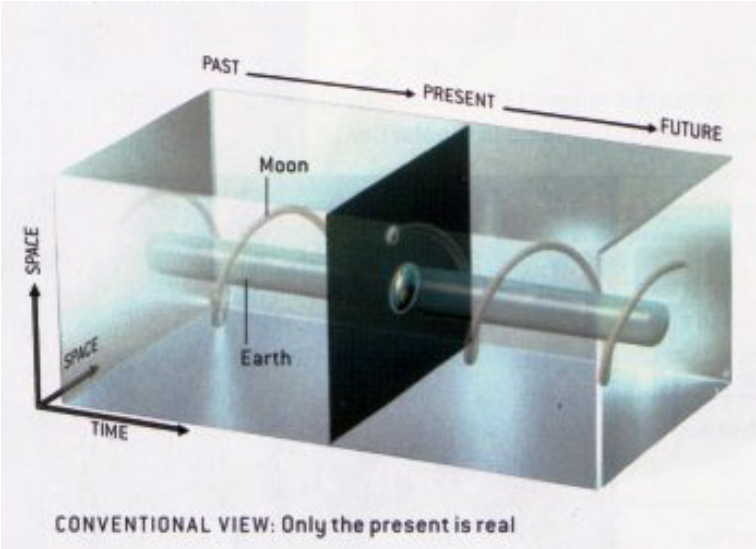

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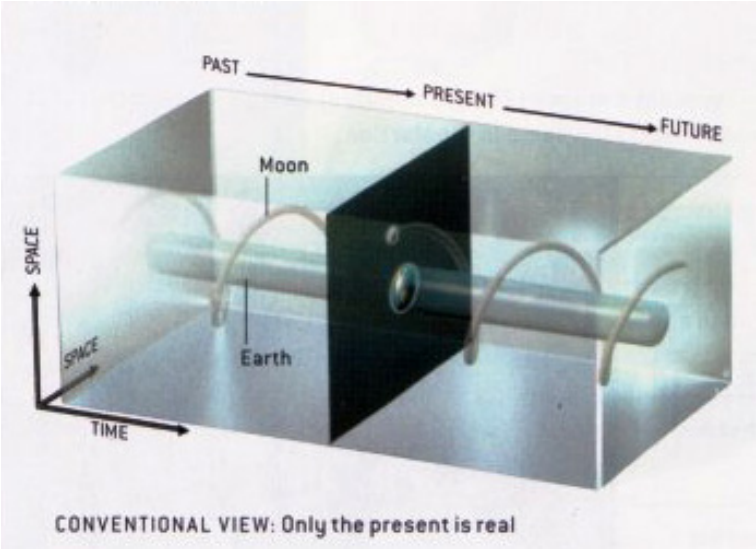

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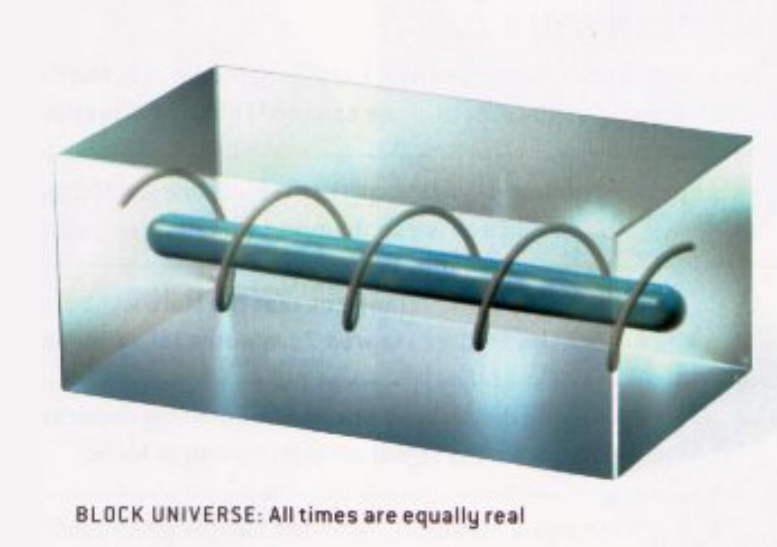
- Rejects all three distinct elements of (what it regards as) the 'subjective' view of time – as in these famous remarks . . .



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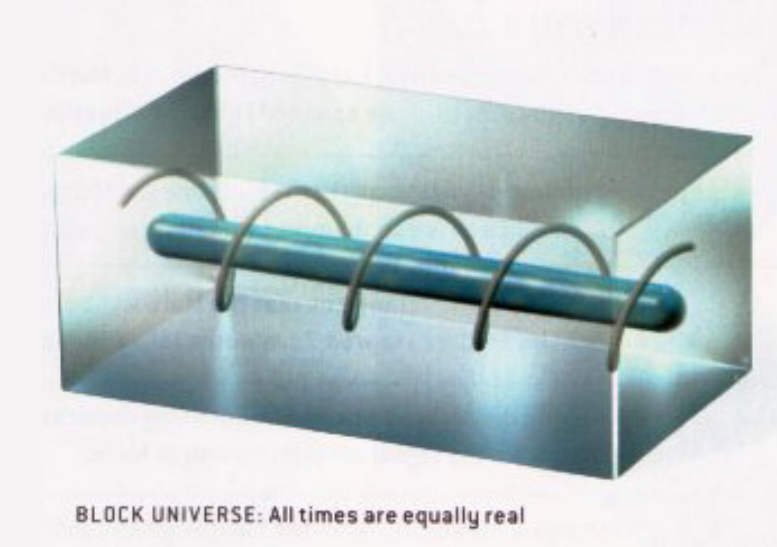
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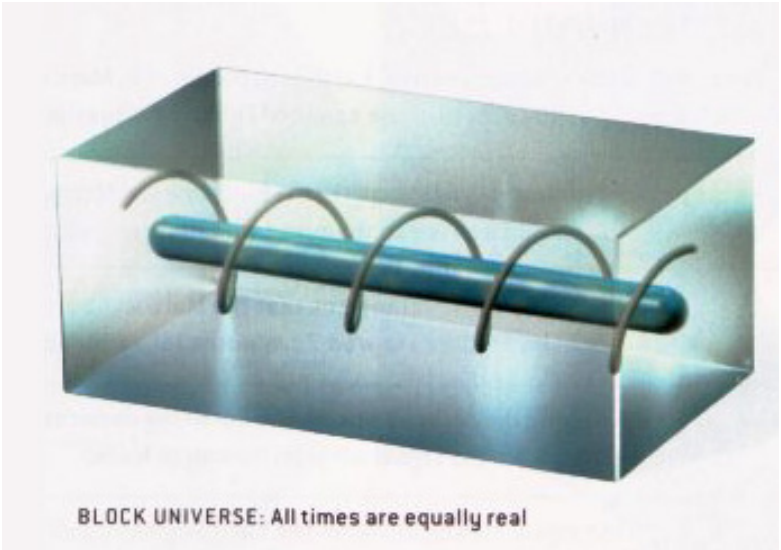

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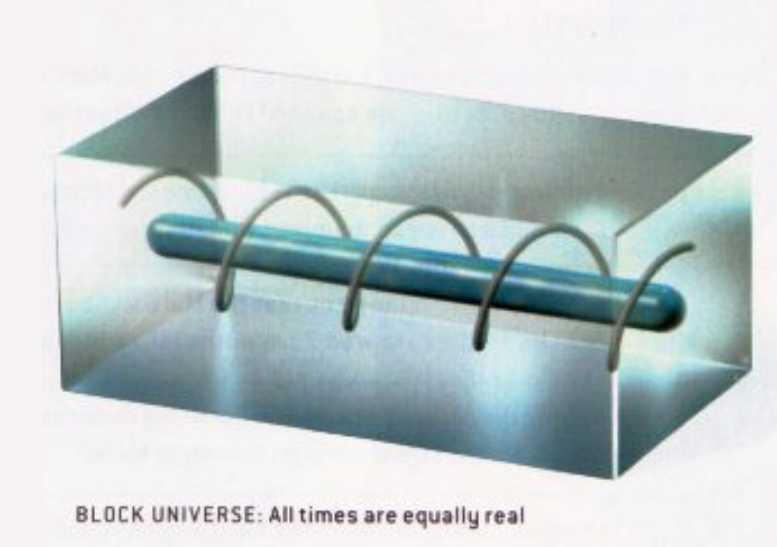

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2. Weyl: No objective passage

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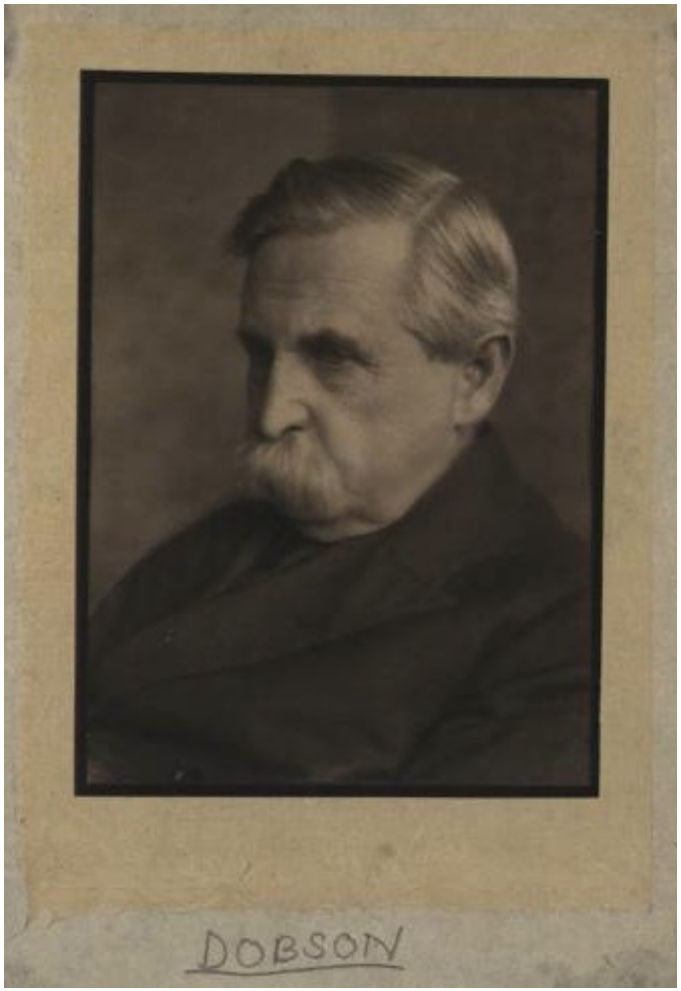

A word from the poets

TIME goes, you say? Ah no!
Alas, Time stays, we go.

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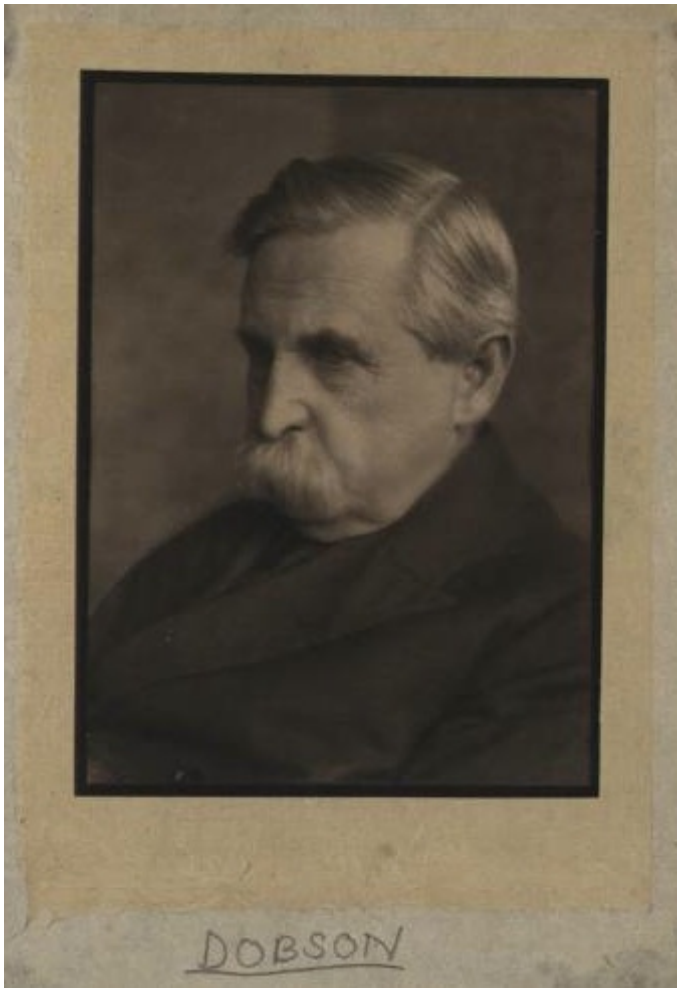

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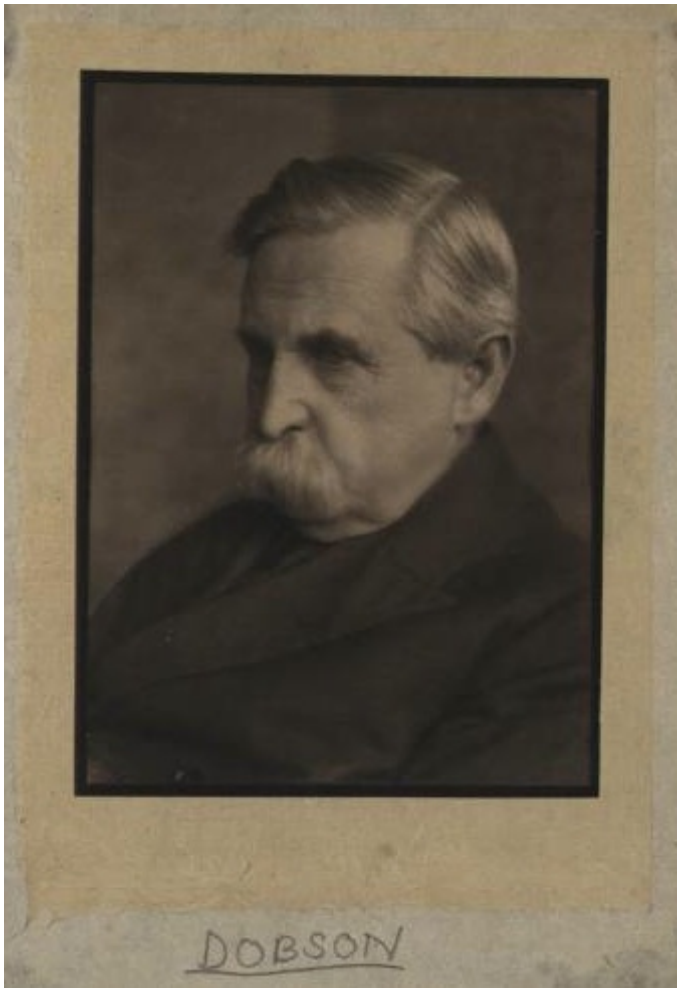

"Scant space have we for Art's delays"

WITH slower pen men used to write,
Of old, when 'letters' were 'polite';

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They knew not steam; electric light
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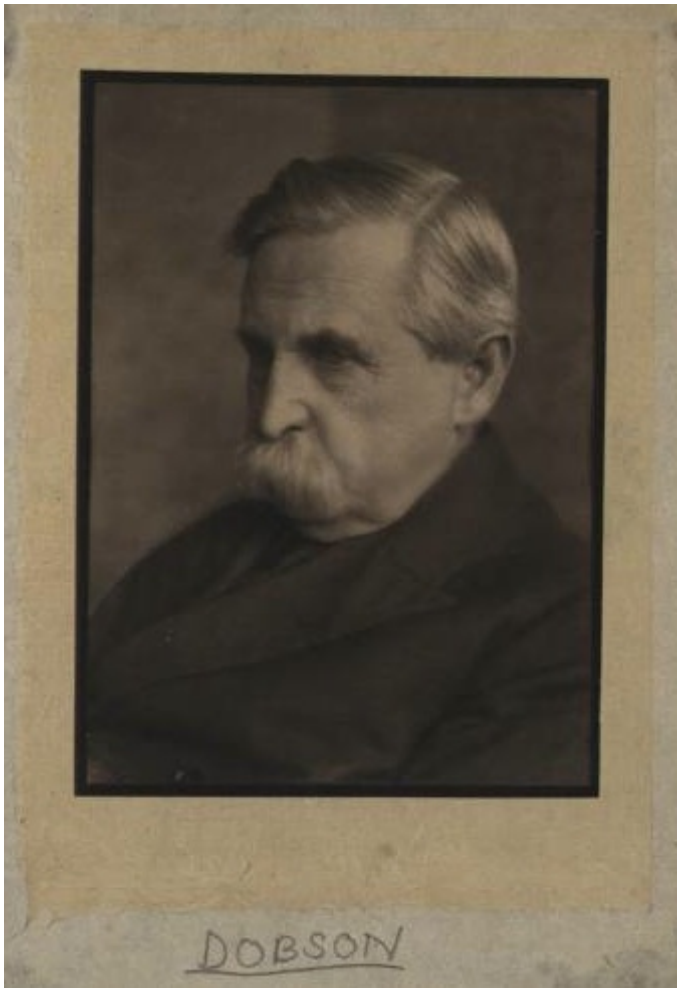
Too swiftly now the hours take flight!
What's read at morn is dead at night.



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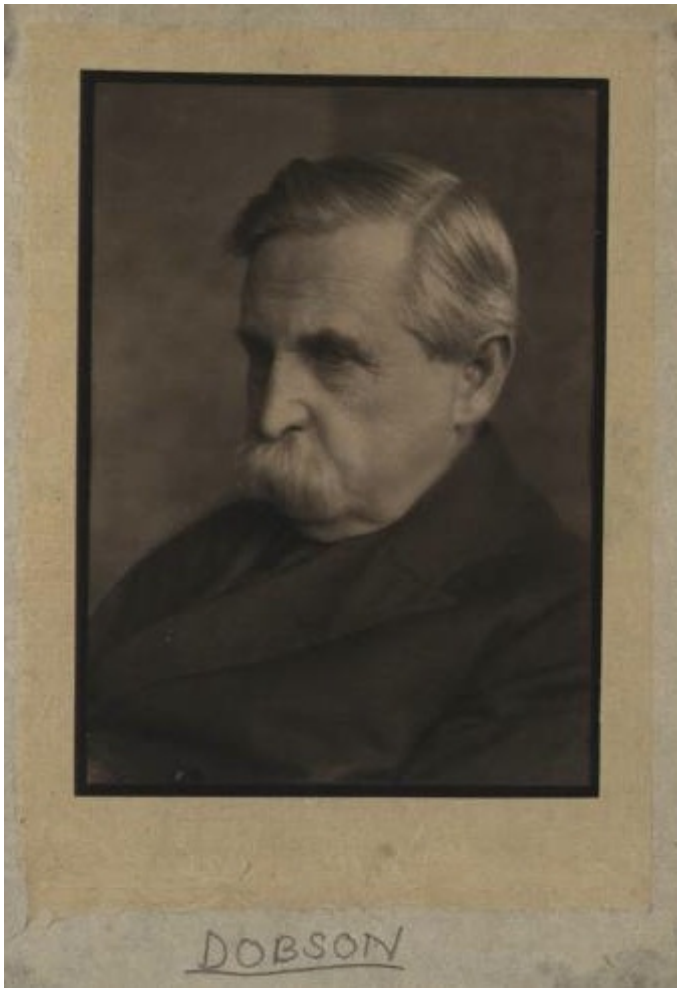

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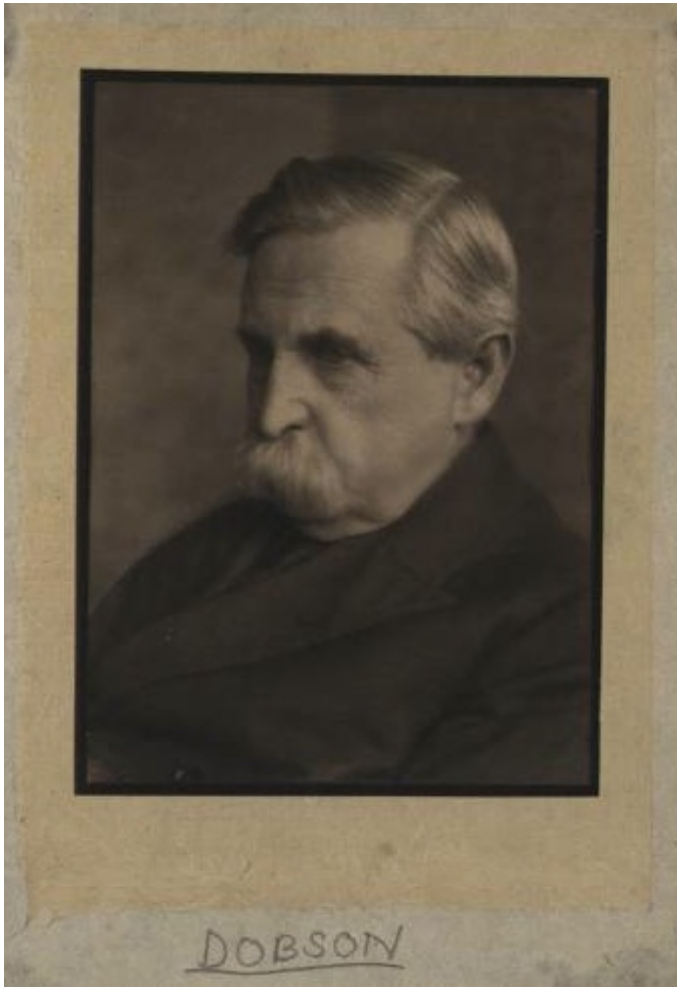

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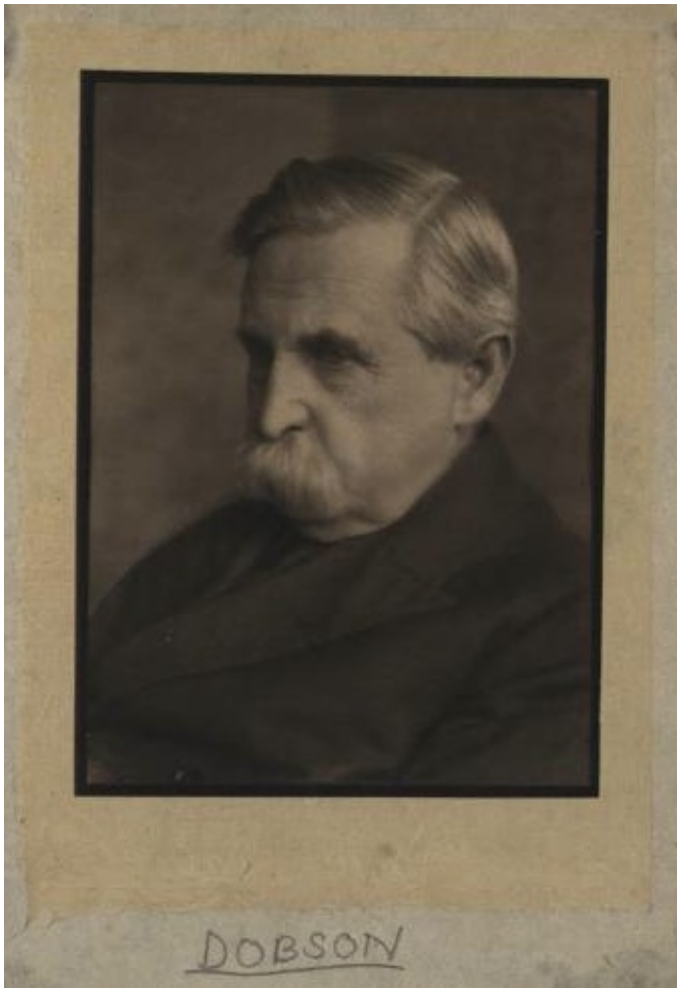

3. Boltzmann: No objective direction

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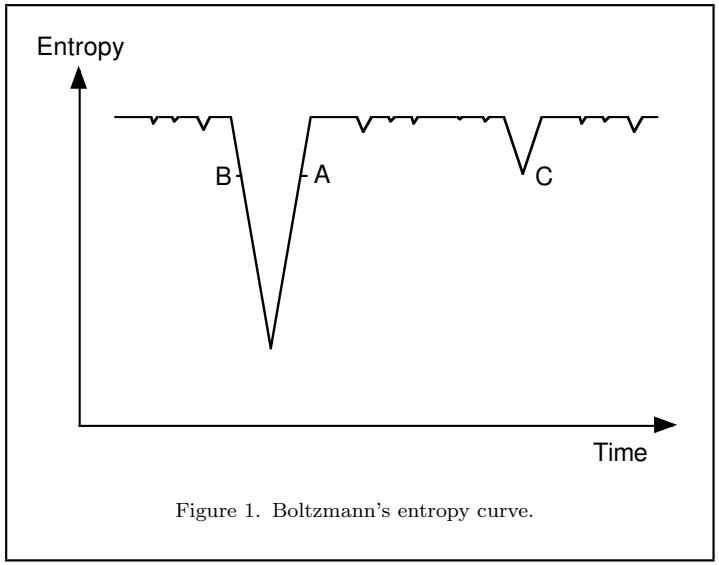

Figure 1. Boltzmann's entropy curve.

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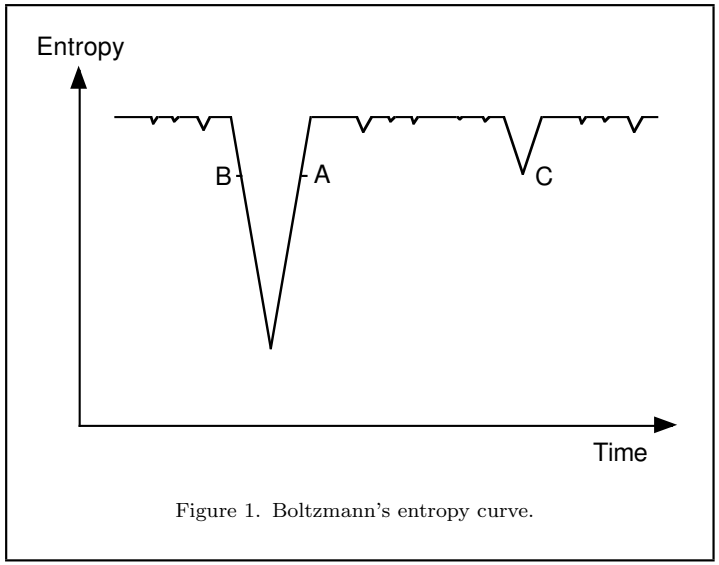

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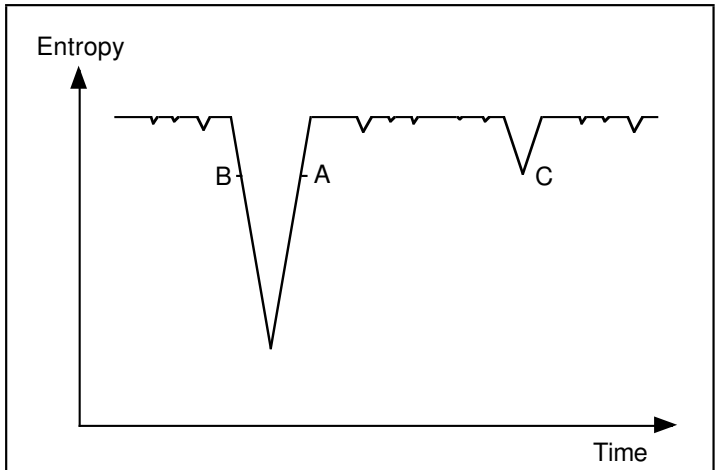

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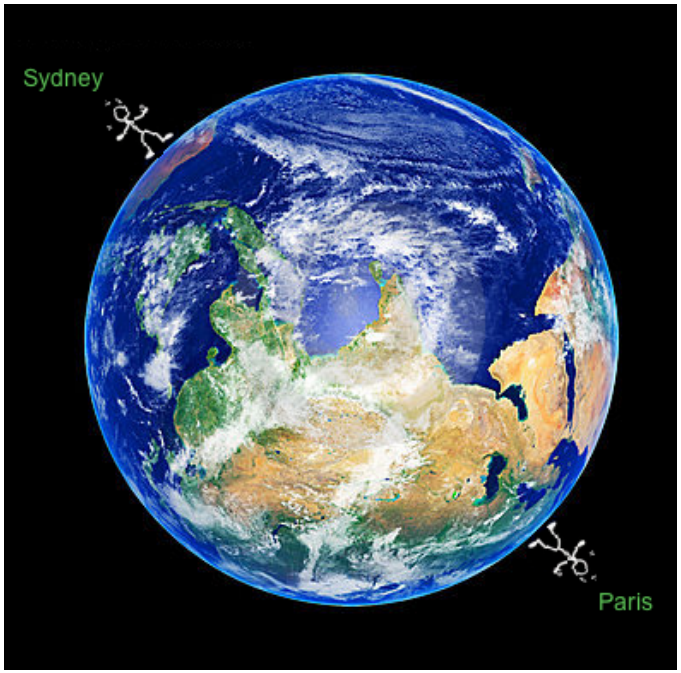
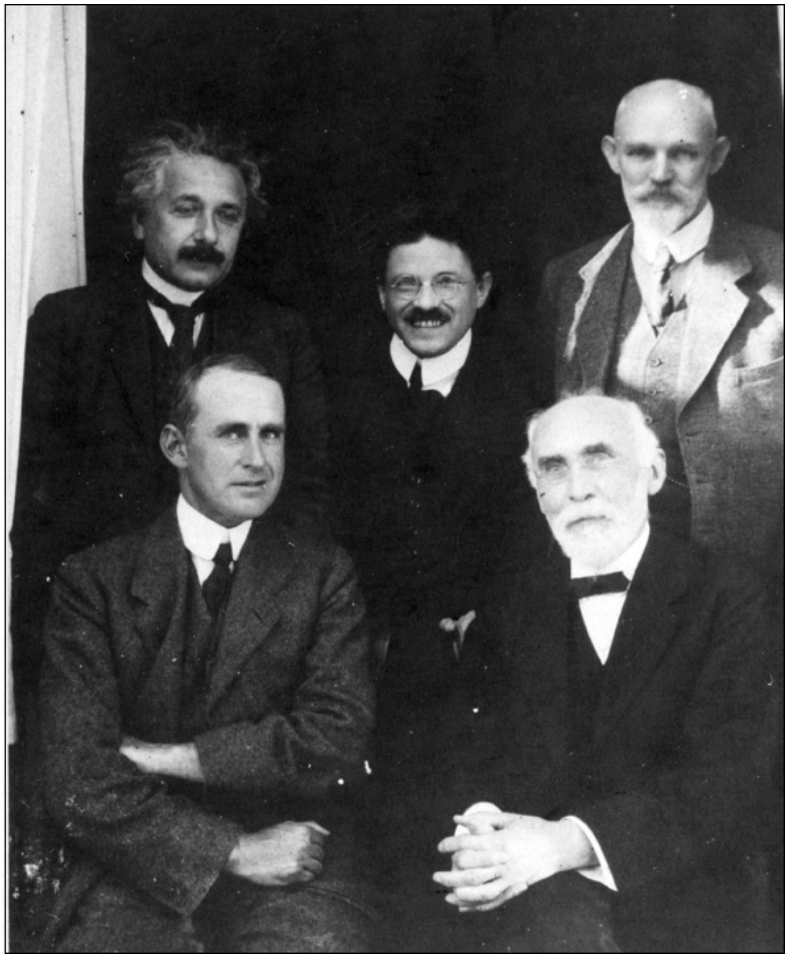


1. Two views of time

2. Eddington's Challenge
   - Remembering Eddington
   - Reversing the picture?
   - Meeting the challenge

3. Why it matters

"One of mankind's most reassuring cosmic thinkers" – TIME, 1944



Eddington (lower left) with Einstein, Ehrenfest, Lorentz and de Sitter. [Emilio Segrè Archives]

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'Eddington and Einstein', BBC 2008.

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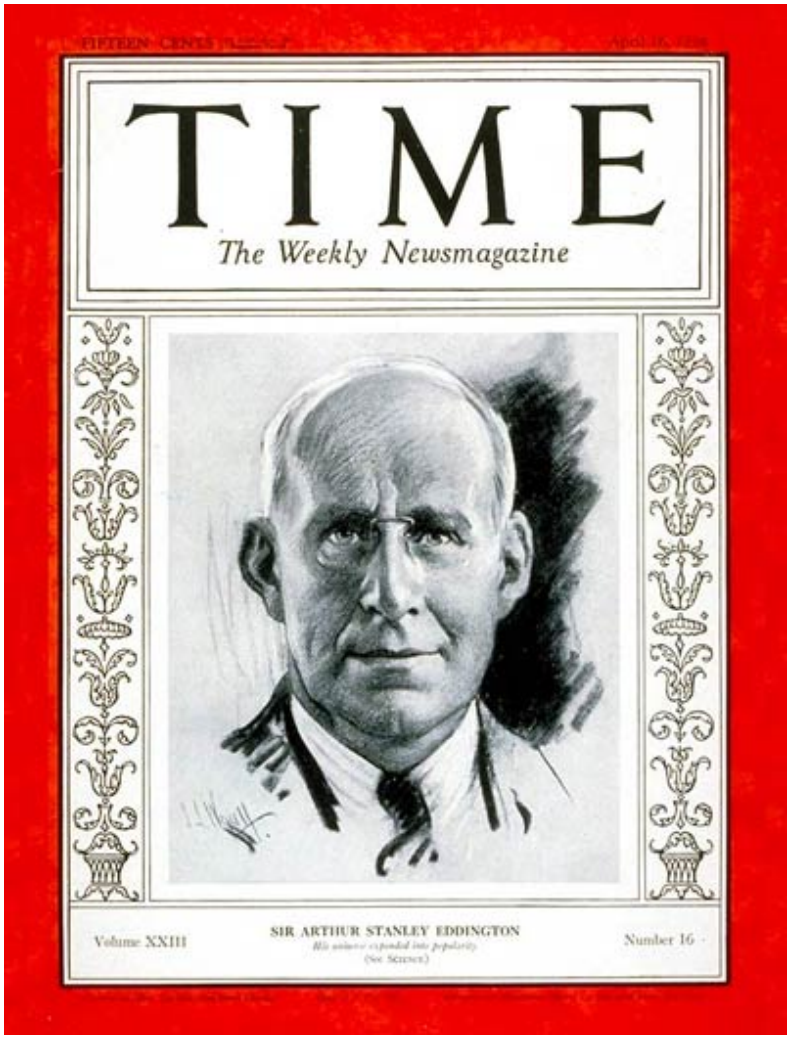

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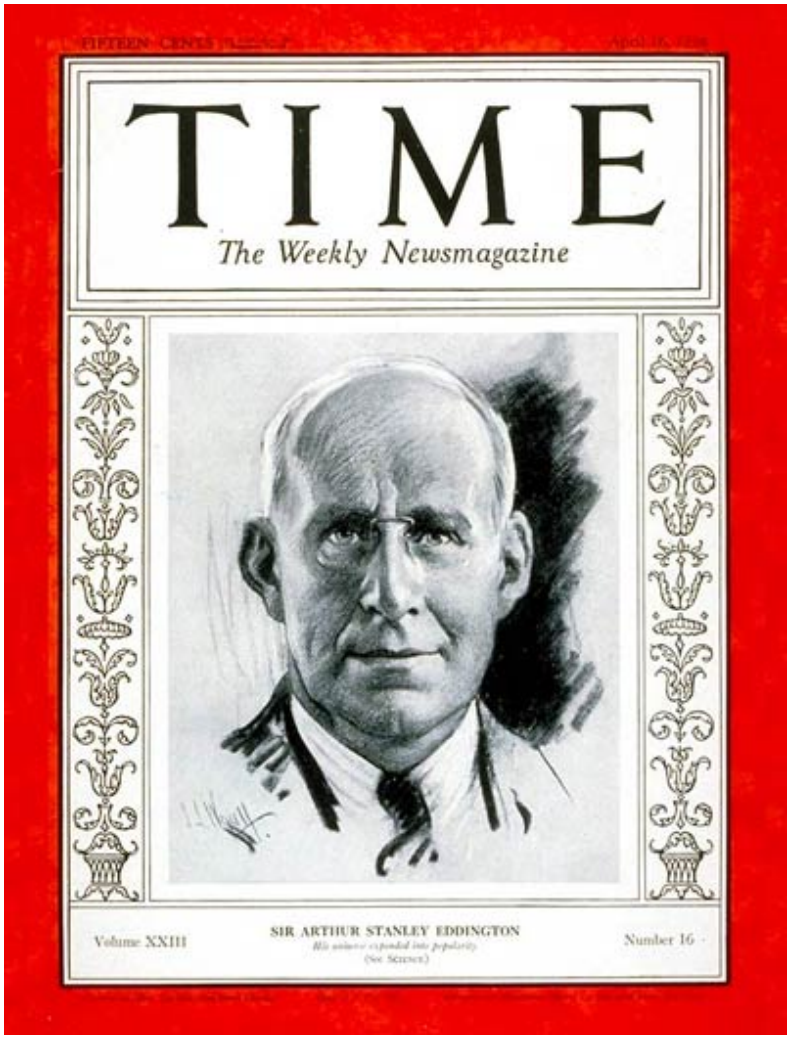

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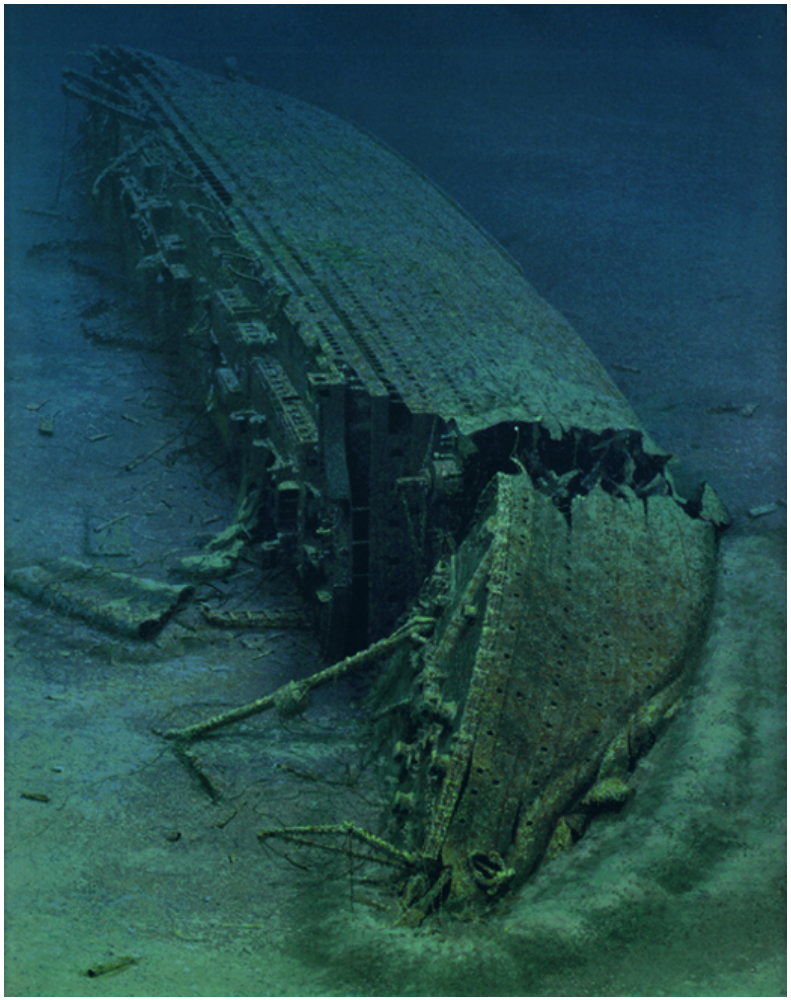

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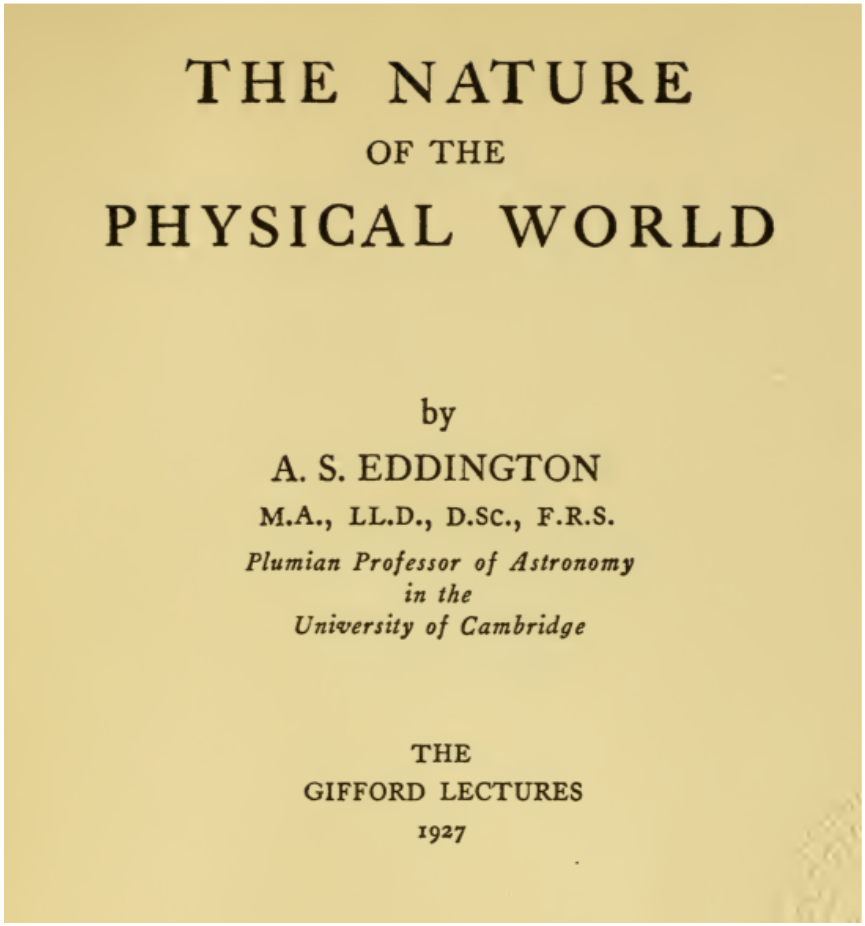
Sir Arthur Goes to Chicago

The origins of 'Time's Arrow'



THE NATURE
OF THE
PHYSICAL WORLD

by
A. S. EDDINGTON
M.A., LL.D., D.SC., F.R.S.
Plumian Professor of Astronomy
in the
University of Cambridge

THE
GIFFORD LECTURES
1927

The origins of 'Time's Arrow'

68 THE RUNNING-DOWN OF THE UNIVERSE

Time's Arrow. The great thing about time is that it goes on. But this is an aspect of it which the physicist sometimes seems inclined to neglect. In the four-dimensional world considered in the last chapter the events past and future lie spread out before us as in a map. The events are there in their proper spatial and temporal relation; but there is no indication that they undergo what has been described as "the formality of taking place", and the question of their doing or undoing does not arise. We see in the map the path from past to future or from future to past; but there is no signboard to indicate that it is a one-way street. Something must be added to the geometrical conceptions comprised in Minkowski's world before it becomes a complete picture of the world as we know it.

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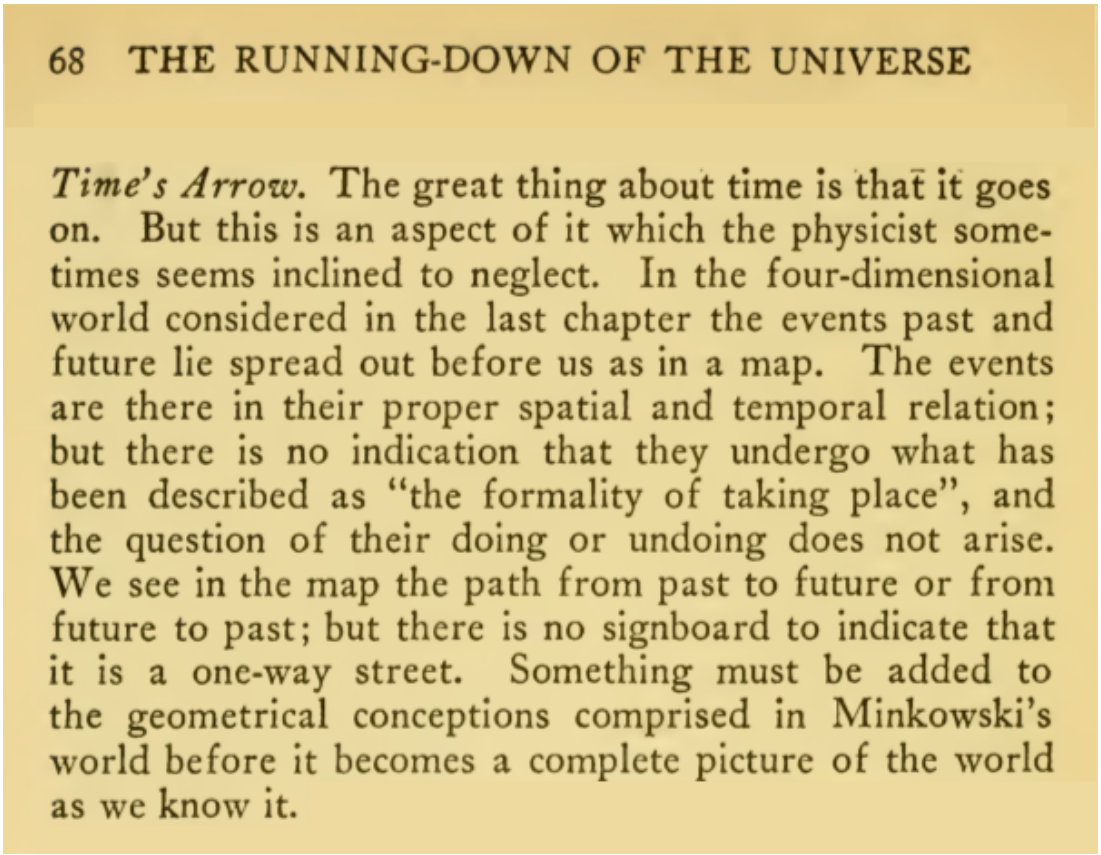

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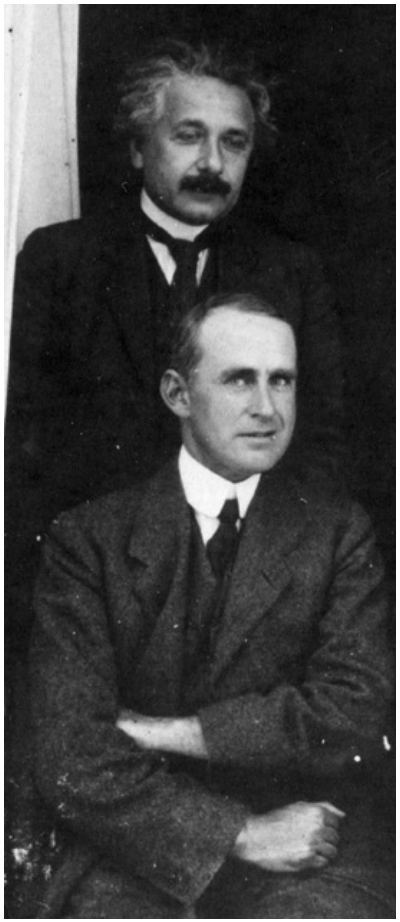
"[T]he second law of thermodynamics . . . opens up a new province of knowledge, the study of organization; and it is in connection with organization that **time-flow and a distinction between doing and undoing appear for the first time.**"

A 'private door' onto a one-way street?



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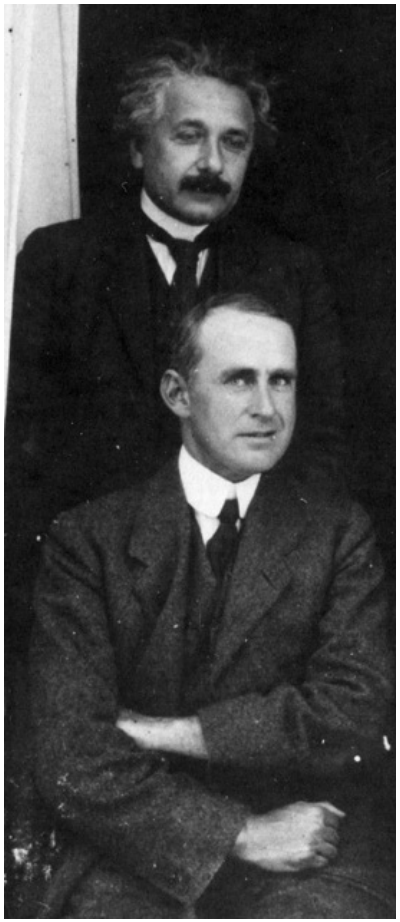

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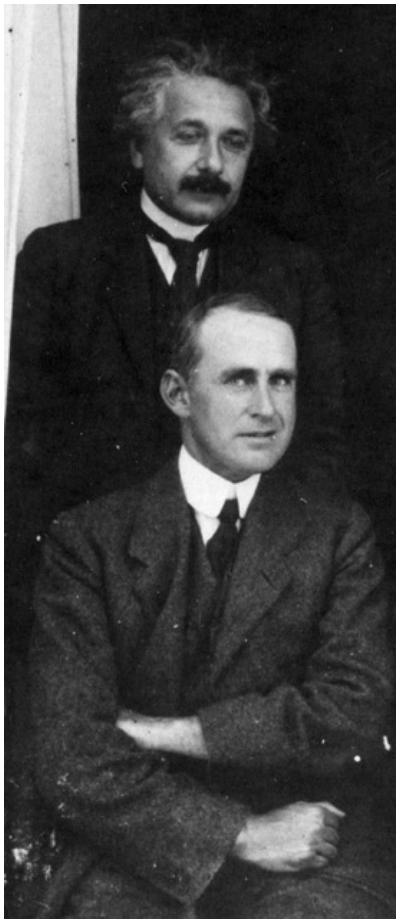

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Eddington's challenge to his opponents

"But is he [i.e., the physicist who renounces private doors] ready to forgo that knowledge of the going on of time which has reached us through the door, and content himself with the time inferred from sense-impressions which is emaciated of all dynamic quality?

No doubt some will reply that they are content; to these I would say—Then **show your good faith by reversing the dynamic quality of time** (which you may freely do if it has no importance in Nature), and, just for a change, give us a picture of the universe passing from the more random to the less random state . . ."

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1. Remember Boltzmann on 'up' and 'down'.
2. Suppose someone challenged the view that 'up' isn't objective, by saying "Just try living your life upside-down!"
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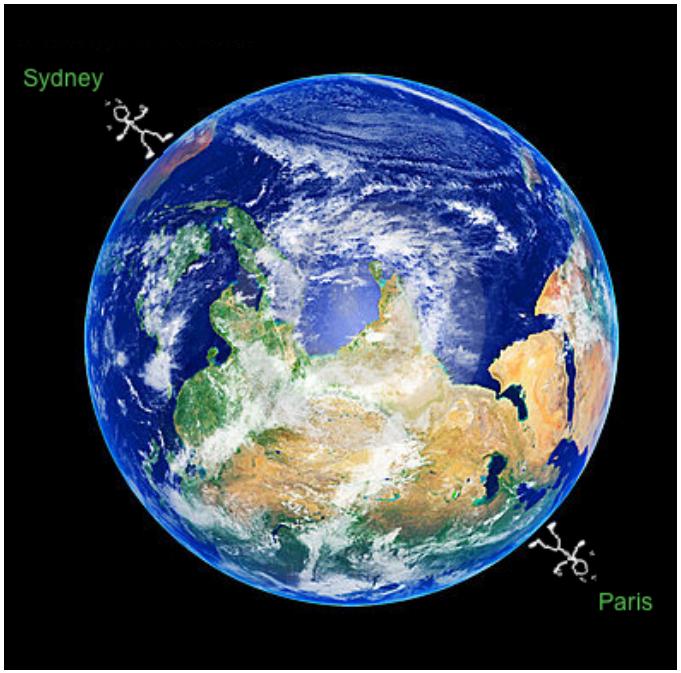

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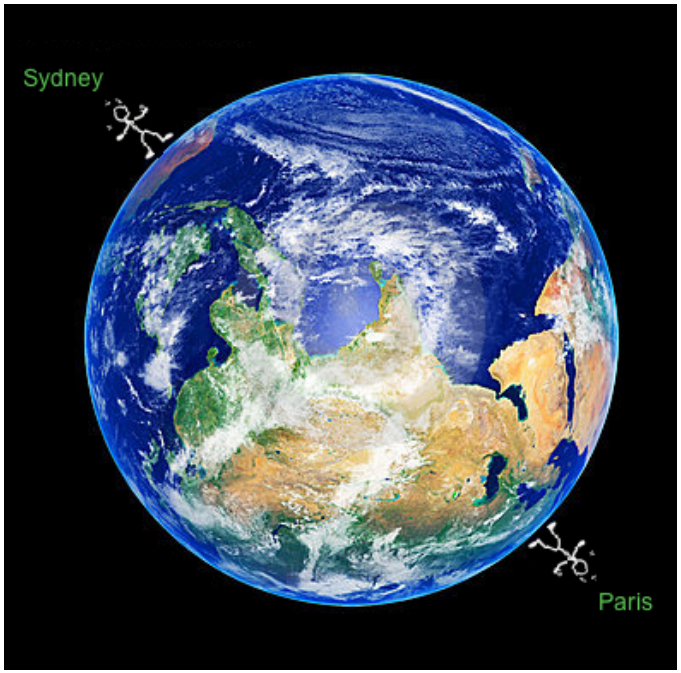

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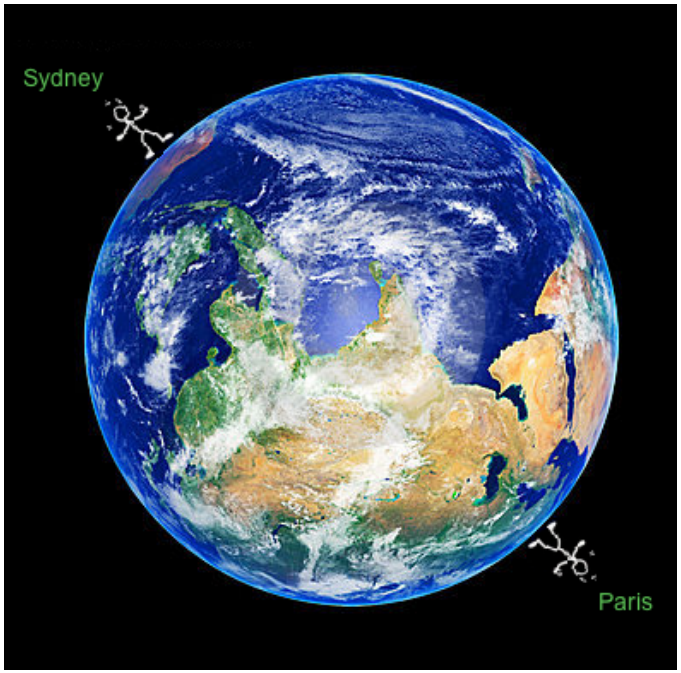

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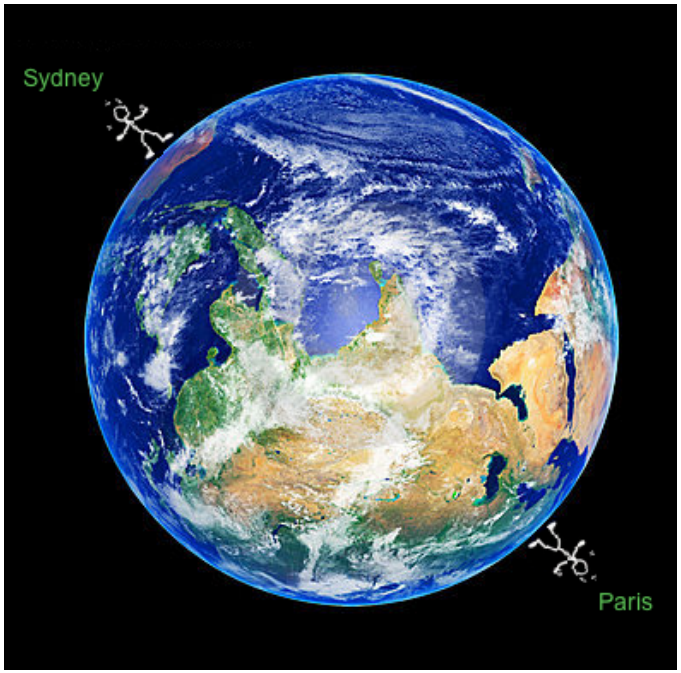

Applying this to the direction of time

Distinguish three cases:

1. Around here.
2. The very big.
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In our region (**very** broadly construed):

- Physics is dominated by special initial conditions.
- Here, Eddington is right: 'randomness' only works in one direction.
- The real puzzle is why it doesn't work towards the 'past' – and the answer seems to lie in cosmology.

> "We are thus driven to admit anti-chance; and apparently the best thing we can do with it is to sweep it up into a heap at the beginning of time." (Eddington, 1931)

But this leaves two other scales to consider:

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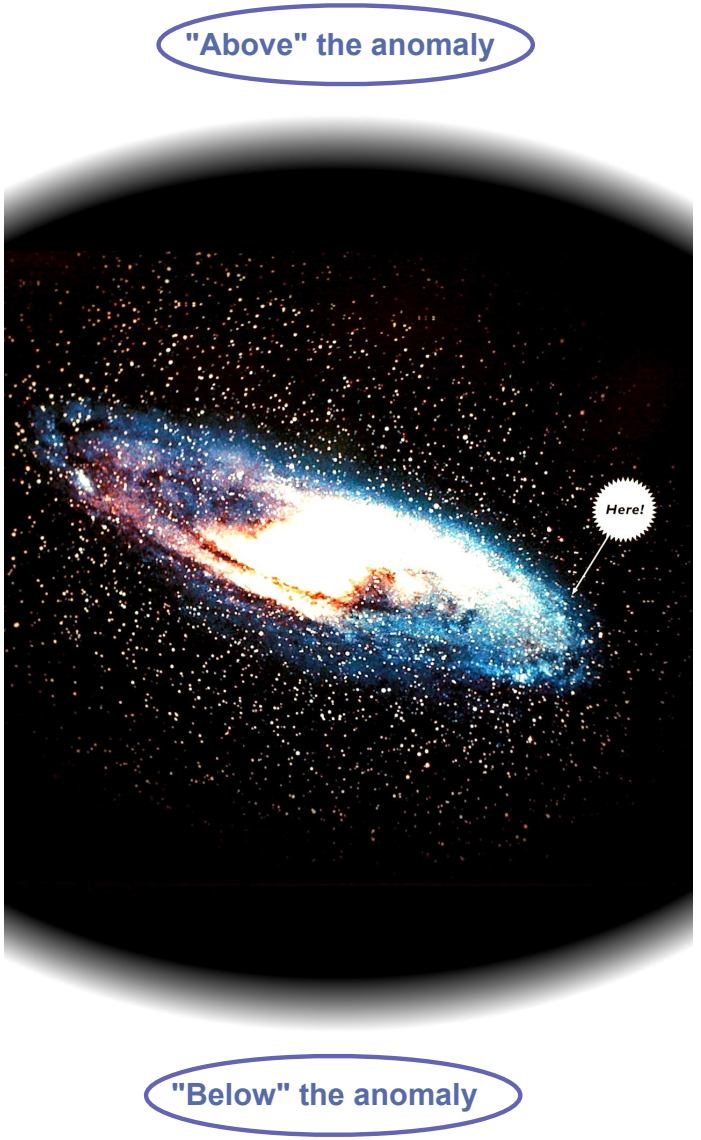

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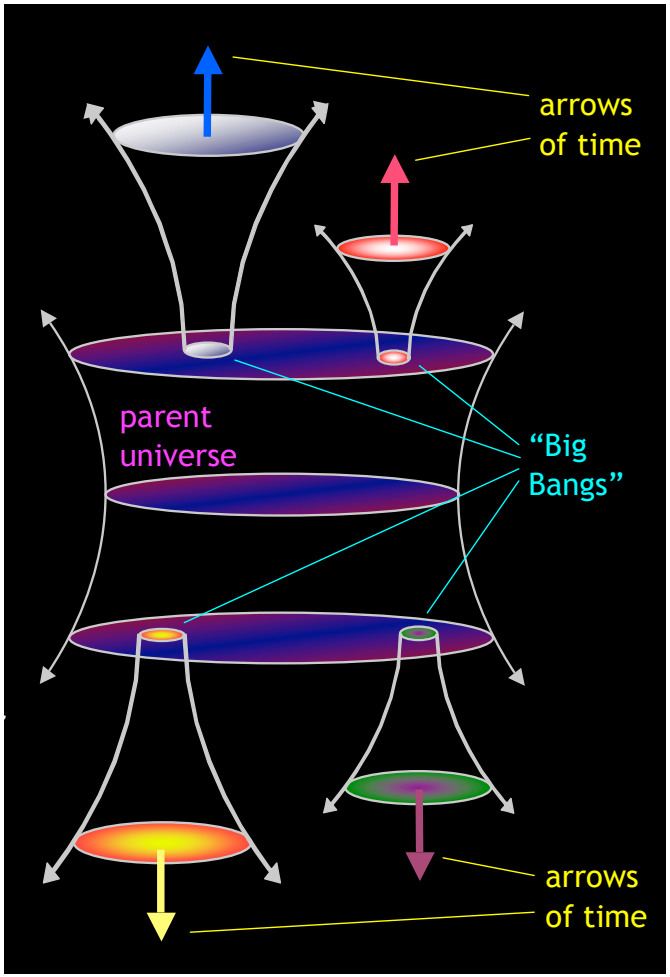

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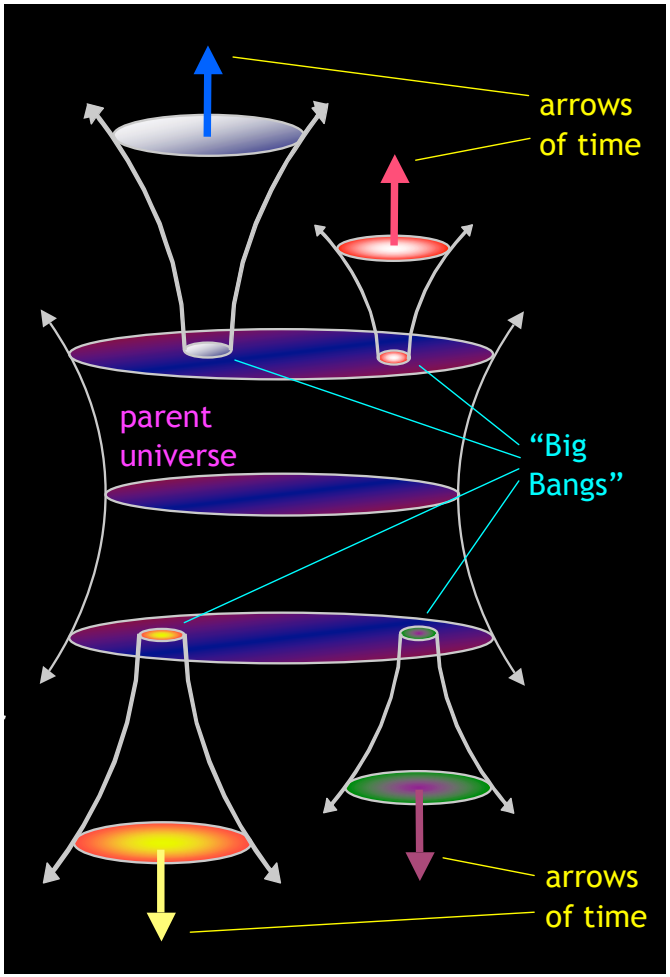

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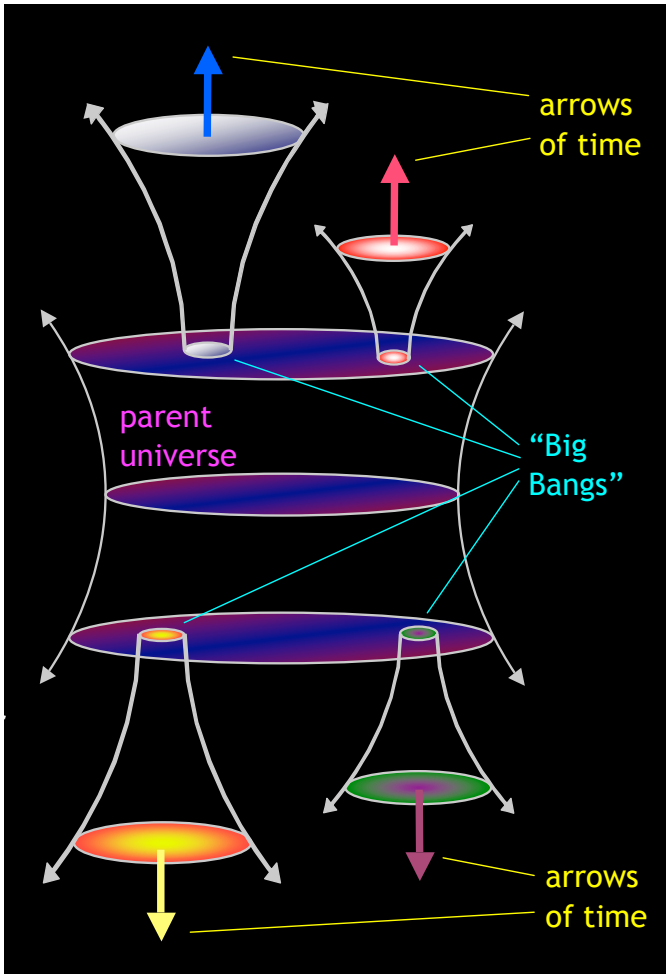

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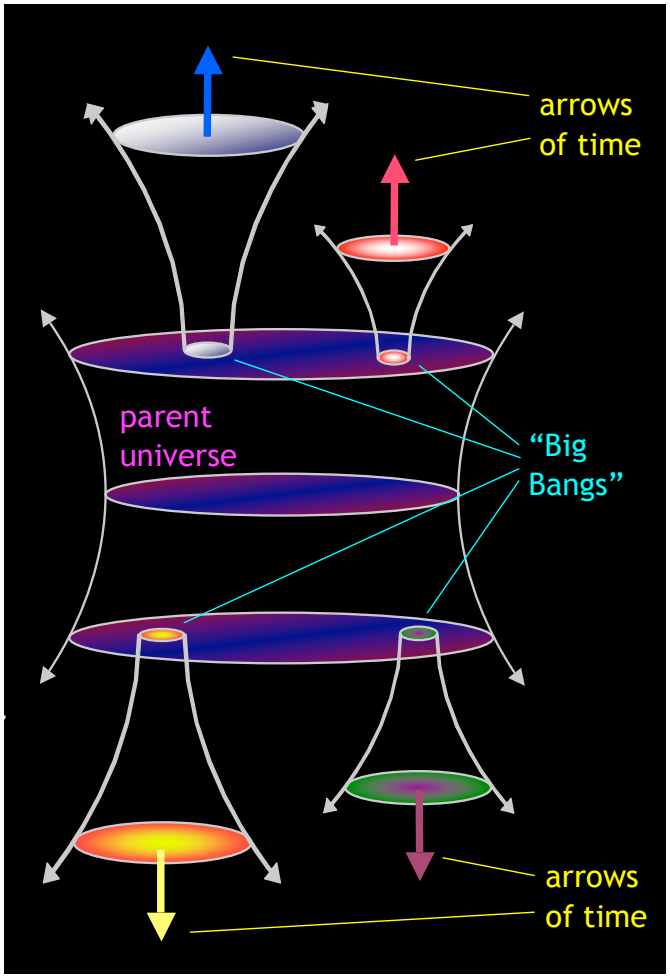

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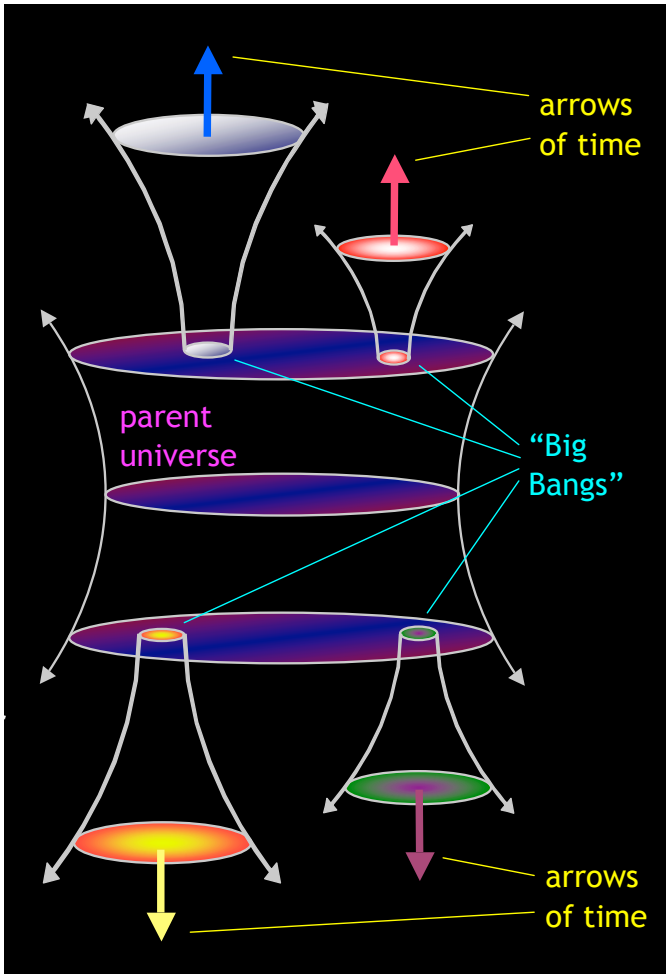

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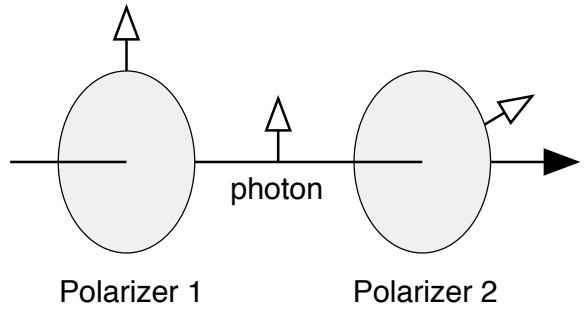

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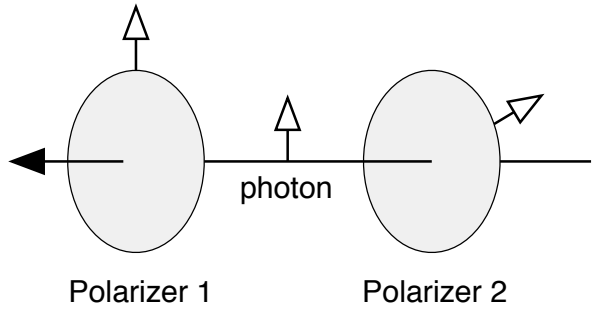

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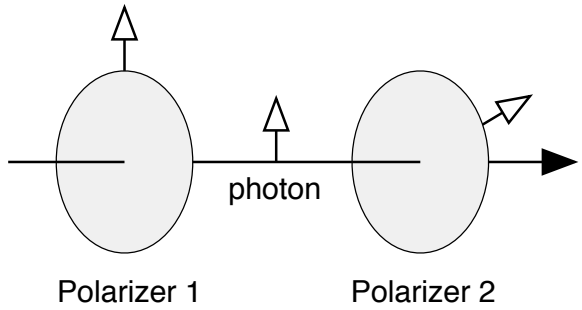

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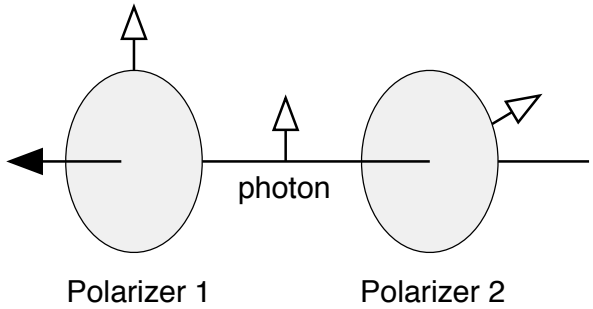

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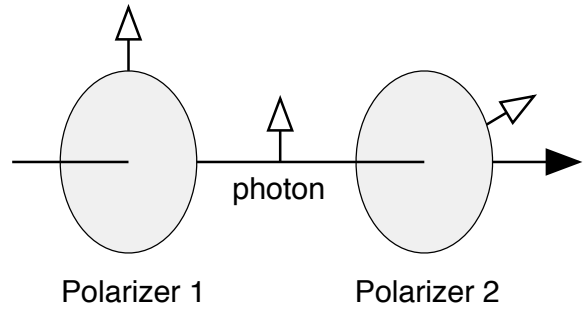

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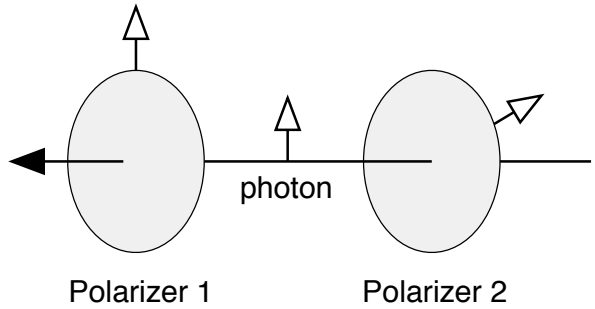

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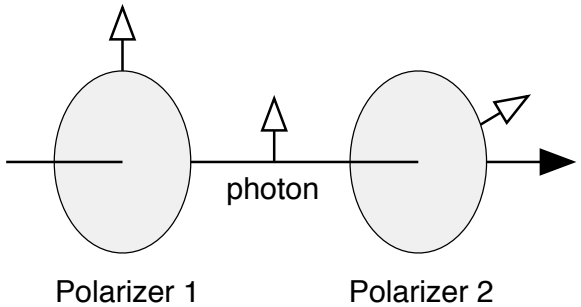

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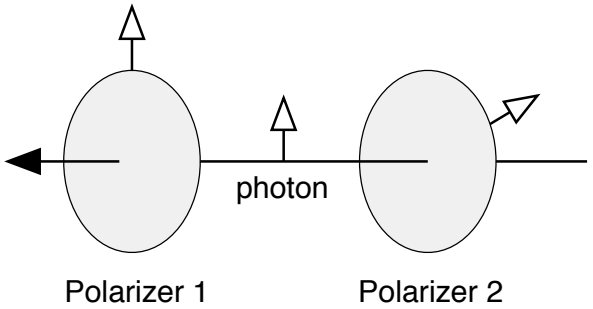

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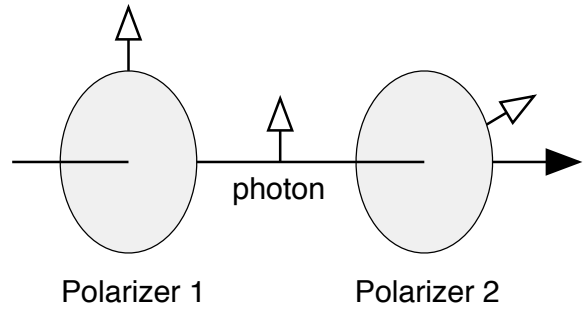

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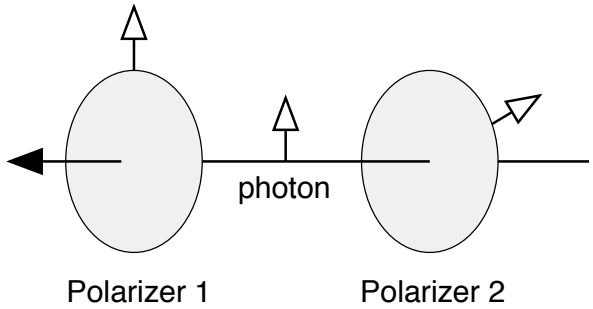

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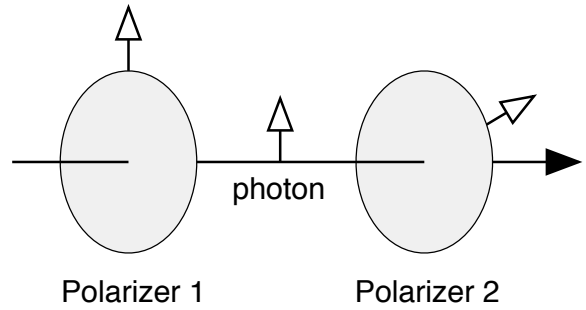

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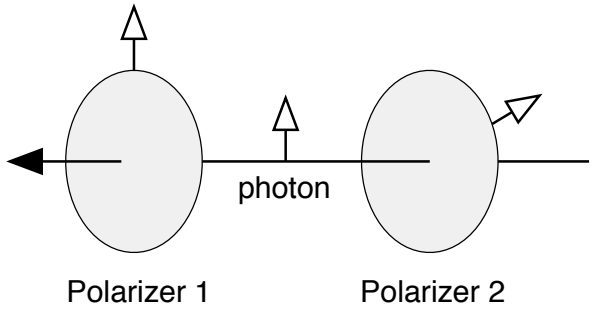

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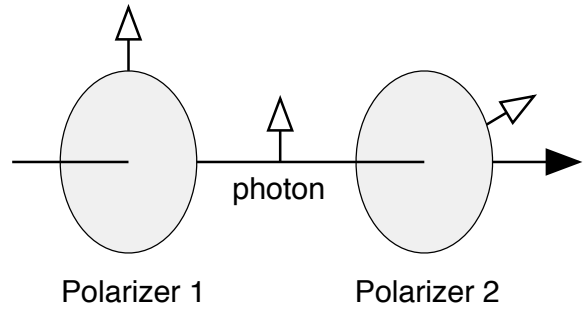

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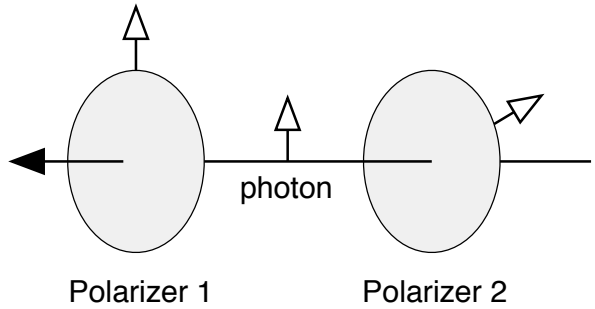

Disallowed

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- Distinguishing 'objective' from 'subjective' – i.e., **what's in the world**, from **what comes from us** – is one of the defining projects both of physics and philosophy.
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- (Three key ingredients: direction, 'flow', and the status of the 'now'.)
- My view: Physics is in transition – (mostly) committed to the view that these are not objective, but not yet comfortable with the consequences of that.
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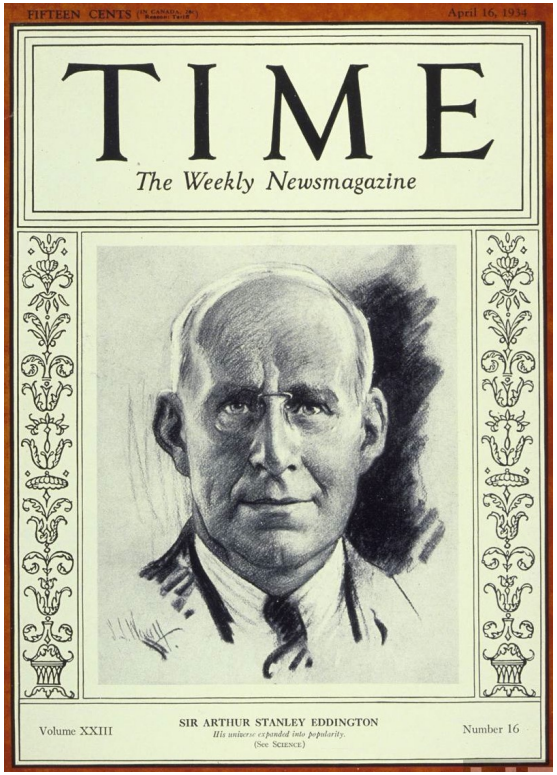

"One of mankind's most reassuring cosmic thinkers . . . he discoursed on his cosmic subject with a wit and clarity rare among scientists."

– TIME, December 4, 1944.

The End