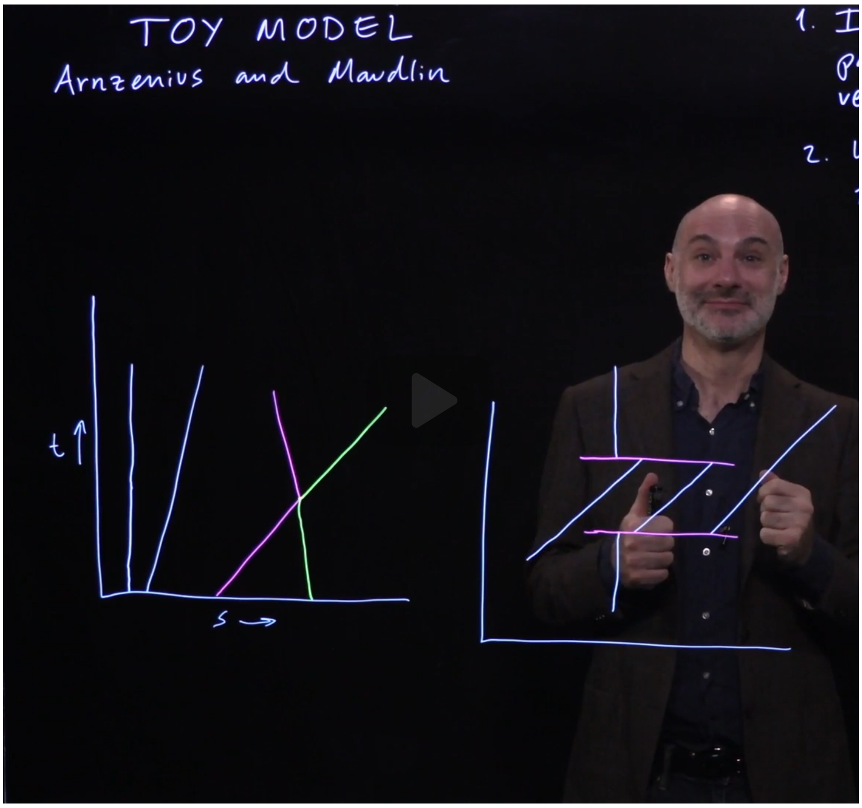
A toy model

A Toy Model



counterfactual question,
what

would have happened had Bruno aim slightly differently

and shot so that he would have killed our grandfather,

then our setup is powerless to say

what would happen in that counterfactual situation.

16:40 / 16:40 1.50x

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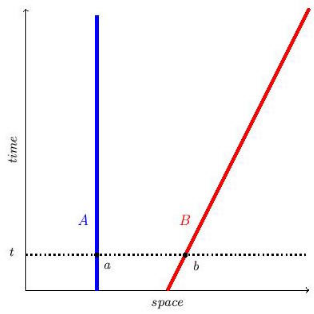
The system of laws I would like to discuss is due to philosophers Frank Arntzenius and Tim Maudlin. It governs a world with two dimensions: a temporal dimension and a single spatial dimension.

We will represent our world's spacetime using two-dimensional diagrams like this one:



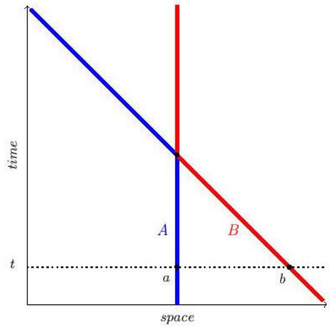
The x-axis of the diagram represents spatial change. The y-axis represents temporal change, with earlier times closer to the origin. Events that take place at time t correspond to points on the dotted line.

Particle A's location at t is labeled "a", and particle B's position at time t is labeled "b". A is at rest, so its spatiotemporal trajectory is represented as a perfectly vertical line; B is moving rightward at constant speed, so its spatiotemporal trajectory is represented by a diagonal line. (Slower speeds are represented by steeper diagonals.)

We shall assume that our particles obey two exceedingly simple dynamical laws:

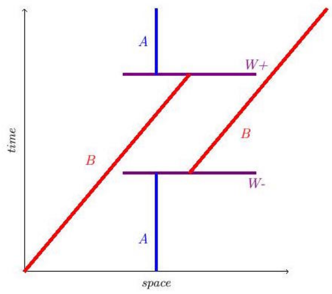
Law 1
In the absence of collisions, particles that are at rest remain at rest, and particles moving at constant speed will continue to move at constant speed.
(This is our version of Newton's First Law of motion. We represent it in our diagrams by ensuring that the spatiotemporal trajectory of a freely moving particle is always a straight line, as in the figure above.)

Law 2
When particles collide, they exchange velocities.
(This is our version of Newton's Third Law of motion. We represent it in our diagrams by ensuring that the spatiotemporal trajectories of colliding particles always form an "X", as in the figure below.)



Wormholes

Now imagine that our world contains a **wormhole**, which causes different regions of our diagram to represent the same region of spacetime, as in the following diagram:



The crucial feature of the diagram is that the spacetime points on line *W*- is identified with the spacetime points on line *W*+. This identification has two consequences:

1. When a particle approaches line *W*- from below, it continues its upward trajectory from line *W*+, with no change in velocity. (See object A in diagram above.)

   In other words: when an object enters *W*- from below, it leaps forward in time by exiting the wormhole at the corresponding point on *W*+.

2. When a particle approaches line *W*+ from below, it continues its upward trajectory from line *W*-, with no change in velocity. (See object B in the diagram above.)

   In other words: when an object enters *W*+ from below, it leaps backwards in time by exiting the wormhole at the corresponding point on *W*-.

Our toy physical model is now in place. Let us use it to illustrate some surprising consequences of time travel, as it occurs in this setting.

Discussion

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Are particles b,c causal loops?

discussion posted a day ago by **ericcoker1974**

In prior lectures we learned about the person that went back into the past to give their younger self the information needed to build a time machine, so while not logically inconsistent, this story has a problematic question : where did the information to build a time machine come from?

I've always thought about these causal loops as information created out of nothing... which seems to violate maybe not logical laws, but evolutionary ones (how do you get something as complex as the knowledge without having a simpler predecessor?)

So, in this toy universe, they eliminate the logical inconsistency of the grandfather paradox but they replace it with an causal loop that is instantiated not in information, but in actual toy particles! Which is very cool and brain-twisty. "Where did the knowledge to build a time machine come from" is turned into "where did particles b and c come from?" Bringing it back to the real world, the grandfather paradox may be solved not by allowing logical inconsistency, but then having to ask the question "where did the bullet that collided into Bruno's bullet, stopping it from hitting his grandfather, come from?" Which, while not logically inconsistent, is still pretty vexing.

But maybe not... why are we ok with not asking where the bullet from Bruno's gun (or particle a) came from? Well, you say, we have this physics theory called the big bang, that once started, set off this chain of events with particle a ending up where it was.... we have no such theory for the mystery bullet that stopped bruno's bullet (particles b/c). But we have no explanatory framework from the big bang either. Well, maybe the inflationary multiverse or membranes colliding or some other such untestable theory... but then where did that come from? It's turtles all the way down even for our everyday, seemingly explicable reality.

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1 response

Jimbof
about 9 hours ago

Along with your comments, It is interestion to notice how, if we build a similar solution with only one additional particle "B" (see figure 3 some pages ahead and remove particle "C" from it), we avoid the logical inconsistency in point "a" but we get a new one at W- "b", as there the particle "B" would be moving left and right at the very same spacetime point.

However, the funny thing is to consider how both alternatives, the one with particles "B" and "C" and the one with only "B" would be perceived by particle "A". For us looking from outside the Toy Model we see in both cases there's a causal problem, but... What does "A" see?

In my opinion and as I've explained in another post, "A" would requiere some sort of field theory on the wormhole system, including the existence of a "wormhole boson" as mediating particle, and a wave function expression describing the interaction between "A" particles and "wormhole" particles. In such a way "A" could have an explanation on how any particle approaching the wormhole system interacts with the field associated to said system, and how those wormhole particles are in a quantum state which is determined only when an interaction with (any) "A" occurs.

In other words, "A" would need to develop a quantum field theory of some kind in order to explain what it perceives. And from "A" POV, neither a causal problem nor a logical inconsistency problem arises at all!

Is this similar to the case where we only have particle "A"? IMHO it depends on what happens to "A" when it interacts with the wormhole.

These considerations make me think about an alternative "logical inconsistence definition" for the case we are dealing with time travel with only the particle "A" involved. If you are interested I may post it in my thread... if i find the time :-P

I read your post about the POV of A and I like it. It made me think of Edwin Abbott's flatland and how he could have made the world of the linelanders so much more interesting with wormholes! And yes, it does appear that removing particle C causes the same problem.

Reading some of your other posts...I think we are both trying to get our heads around the same problem... and just framing them slightly differently. I'm framing them as logical inconsistency turns into causal loops, while your thinking about this in terms of the definition of logical inconsistency. That is the beauty of logic and language (the combination of which, when put into a rigorous system, we call mathematics)... you can use the tools cut up problems in different ways and try different solutions, but any solution you come up with needs to be generalizable (is that a word?) to any framing. This is why the toy model is interesting and the concerns about the details of it (like what is the mirror, is it a quantum or deterministic world... etc.) that have been posted elsewhere are far less interesting to me. The main point is you can set up a simplified version of the Grandfather paradox, completely take free will and conscious beings out of the picture, and still have the same fundamental problem.

Do you agree? Or is there something I'm missing in your concern with the logical inconsistency framing you see?

posted about 7 hours ago by **ericcoker1974**

I do agree with you Eric.

My main issue at this point is that casual problems arising from logical inconsistencies may be addressed by developing "non time travel related" theories, so it would look like, as time travels seems to generate always some logical inconsistency, we could conclude it is not possible and there's always an alternative "classic" way of thinking on it.

But the real reason not making it possible would be a consistency definition developed for a general purpose case, where we may think of time and its related events as written in stone with fire, non-mutable and constant, while we haven't consider maybe we need to adapt said definition to the purpose of analyzing, more deeply, what time travel is about from a phylosophical POV.

posted about 3 hours ago by **Jimbof**

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