Time Travel

1 Time Travel

Our working definition: to travel in time is for there to be a discrepancy between:

1. the start-time and end-time of one's journey, and

2. the duration of the journey from the perspective of one's own perspective.

2 Inconsistent Time Travel Stories

For a time travel story to be consistent is for it to never make conflicting statements about what the world of the story is like at a given time.

- For instance, *Back to the Future* is an inconsistent time travel story:

What we're told	**When we're told**
In 1985, George is unhappy	beginning of film
In 1985, George is happy	end of film

2.1 Caveat: No "Changing Timeline" Stories

"Changing Timeline" stories rely on two different senses of time:

1. an ordinary notion of time, which is used to describes changes *within* a given timeline;

2. a non-ordinary sense of time, which is used to describe "changes" in the timeline itself.

But: is the second sense really intelligible?

2.2 Caveat: No World Travel Stories

One can make some inconsistent time travel stories consistent by interpreting them as world travel stories.

But: that just means that we've changed the subject.

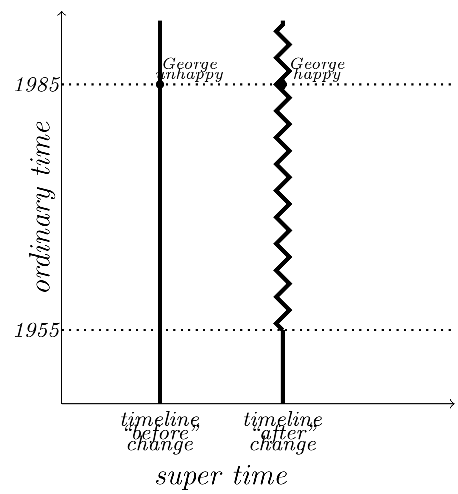


Figure 1: A change in George's timeline. The straight lines represent events as they "originally" occurred. The jagged line represents events as they occur "after" the change.

3 The Grandfather Paradox

You travel back in time to kill your grandfather, who is yet to have any children. You have a loaded gun at point-blank range.

- If you succeed, Grandfather will never have any children. So you'll never be born, which contradicts the setup of the story.
- If you don't succeed, what stops you?

Some reasons you might think the Grandfather Paradox is interesting:

1. It shows that the concept of time travel is incoherent.
2. It raises questions about whether the laws of physics could rule out paradoxical time travel in a principled way, without banning it altogether.
3. It shows that time travel is incompatible with free will.

(For what it's worth: I think these reasons are all mistaken.)

4 A Toy Model[1]

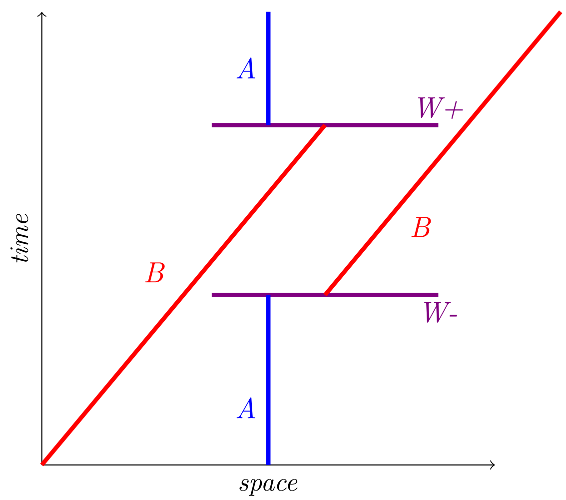
The particles of our world live on two dimensions and obey the following laws:

Law 1 In the absence of collisions, a particle's velocity remains constant.

Law 2 When two particles collide, they exchange velocities. (There are no collisions involving more than two particles.)

4.1 Wormholes

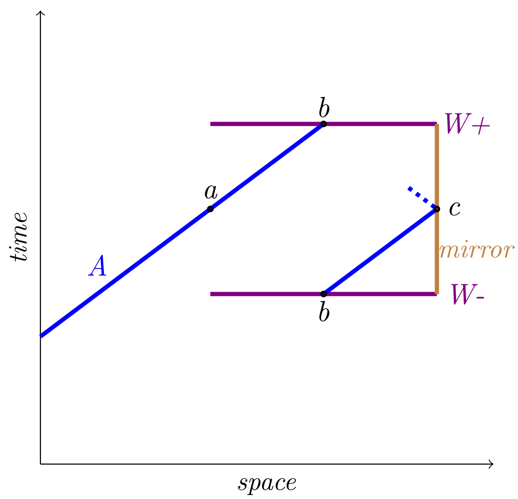
Our laws are consistent with wormholes. For instance:



In this diagram, the points represented by W- are identified with the points represented by W+. A jumps to the future when its spacetime trajectory reaches a point at which the wormhole is active; B jumps to the past when its spacetime trajectory reaches a spacetime point at which the wormhole is active.

[1] The model is due to philosophers Frank Arntzenius and Tim Maudlin.

4.2 A Toy Version of Grandfather's Paradox



Particle A is on a "paradoxical path". It travels rightward, passes through spacetime point a and enters the wormhole at spacetime point b, jumping to the past. It exits the wormhole and continues its rightward trajectory until it reaches the mirror at spacetime point c. But what happens next?

4.3 An answer to the toy paradox

- One does not characterize a world by *first* deciding how many particles the world is to contain (and assigning them each a position and velocity at a time), and *then* using the dynamical laws to calculate the spacetime trajectories of these particles.

- Instead, one characterizes a world by *first* drawing a family of spacetime trajectories that conform to the dynamical laws and *then* using the laws to determine how many particles the resulting world must contain.

- So: it is a mistake to think that one can characterize a world by stipulating that it is to contain a single particle traveling as in figure **??** and then ask what happens when the dynamical laws are used to calculate the particle's spacetime trajectory.