Paradox

Now suppose that our world contains a "mirror" : a stationary object that reflects particles by inverting their velocity.

We will use the mirror to construct a version of the Grandfather Paradox in our toy world. The relevant scenario is depicted in Figure 1 below. 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.

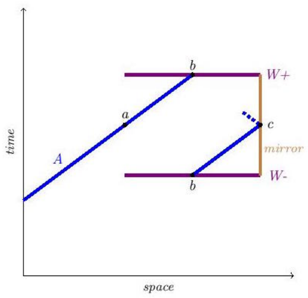

Figure 1. After passing through point a, and crossing through the wormhole at point b, particle A is reflected by a mirror at point c

But what happens next?

It is not clear that we could draw out A's trajectory in full without violating the dynamical laws of our toy model. Notice, in particular, that if we attempted to complete A's trajectory as depicted in Figure 2, particle A would be blocked from entering the wormhole region at point a by a future version of itself. (Not just that: it would be blocked from crossing point b on its way to the mirror by a later version of itself, and it would get blocked from crossing point b.

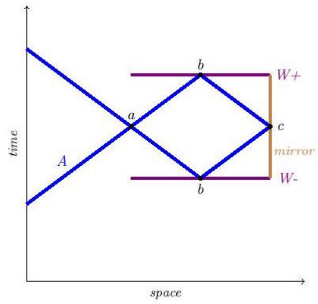

Figure 2. Particle A is prevented from entering the wormhole region by a future version of itself.

So does particle A of Figure 1 succeed in entering the wormhole region or not? If it does enter, it shouldn't have, since its entry should have been blocked by a future version of itself. And if it doesn't, it should have, since there is nothing to block it. In other words: the scenario depicted by Figure 1 is paradoxical, given the laws of our toy model.

Notice, however, that the laws do allow for a situation in which particle A starts out traveling on the "paradoxical path" of Figure 1 but is prevented from entering the wormhole region by a *different* particle. One way in which this can happen is as follows:

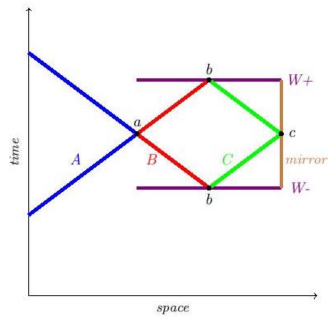

Figure 3. Particle A fails to enter the wormhole region, after colliding with particle B at spacetime point a. Particles B and C are each caught in a loop within the wormhole.

Note that Figure 3 is very much like Figure 2 above, but it represents a situation in which there are two additional particles living within the wormhole region and one of them blocks particle A from entering. (Think of this as analogous to a version of Bruno's story in which consistency is achieved because something blocks Bruno from carrying out his assassination attempt.)

Here is a more detailed description of the behavior of each of the particles in Figure 3:

- Particle A moves rightward until it reaches spacetime point a, where it collides with B and bounces off, moving leftward.
- Particle B is trapped in a loop. It departs spacetime point b at the time of W- moving leftward, until it collides with particle A at spacetime point a. It then bounces rightward until it reaches spacetime point b at the time of W+. Two things happen next. First,

particle B collides with particle C, and bounces off leftward. Second, B enters the wormhole, and jumps back in time.

- Particle C is also trapped in a loop. It departs spacetime point *b* at the time of *W*- moving rightward, until it collides with the mirror at spacetime point *c*. It then bounces leftward until it reaches spacetime point *b* at the time of *W*+. Two things happen next. First, particle C collides with particle B, and bounces off rightward. Second, C enters the wormhole, and jumps back in time.

Escaping Paradox

Figure 3 demonstrates that our toy model allows for consistent scenarios in which particle A starts out on the "paradoxical path" of Figure 1. But one might worry that there is something artificial about this way of escaping inconsistency. One might think it amounts to the postulation of a "pre-established harmony" whereby there happens to be an additional particle in just the right place to avert paradox.

Such harmony could certainly be imposed by restricting the range of admissible "initial conditions" of our toy model so as to allow for situations in which particle A starts out on a paradoxical path only when another particle is ready to block its entry to the wormhole region. But the resulting theory would be horribly unprincipled.

(It would be a bit like saying that we should allow for "initial conditions" whereby Bruno to go back in time in an attempt to kill Grandfather but only if the circumstances are such as to ensure that the assassination attempt would be derailed.)

When one thinks of the toy model in the right kind of way, however, there is no need for a postulation of pre-established harmony.

The trick is to be careful about how one characterizes one's worlds. 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.

On this way of thinking, 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 1 and then ask what happens when the dynamical laws are used to calculate the particle's spacetime trajectory. Instead, one draws a family of spacetime trajectories such as the one depicted in Figures 2 and 3, and one uses the laws to reach the conclusion that a world with those spacetime trajectories must contain three different objects (as in Figure 3).

This delivers a very satisfying result. We get a system of laws that allows for interesting forms of time travel and yet has a principled way of avoiding paradox.

Notice, moreover, that one is able to explain why there is no world in which particle A completes a "paradoxical path", and that the explanation is analogous to our earlier explanation of why one couldn't draw a figure that is both a circle and a square. Just like there is no distribution of ink-blots on a page that yields a figure that is both a circle and a square, so there is no lawful distribution of spacetime trajectories in our toy model that is both such that a particle is on a paradoxical path and such that there isn't another particle there to block it.

There is a final point I would like to emphasize before bringing our discussion of the toy model to a close. We have seen that our laws allow for the situation depicted in Figure 3, in which particle A starts out on a paradoxical path but is prevented from entering the wormhole region by another particle. It is essential to keep in mind that the presence of the additional particles in the wormhole is not *caused* by particle A's paradoxical path. The additional particles are not an "anti-paradox" mechanism that is activated by particles on paradoxical paths. What is going on is simply that there is no lawful distribution of spacetime trajectories that is both such that a particle is on a paradoxical path and such that there isn't another particle there to block it.

Problem 1

1 point possible (ungraded)

I noted earlier that the number of particles living in the wormhole region between *W*- and *W*+ is not settled by facts prior to the appearance of the wormhole.

For this reason, the situation depicted by Figure 3 is not the only way of restoring consistency to a situation in which particle A is the only particle that exists prior to the appearance of the wormhole, and is traveling at constant speed on a path that would (in the absence of collisions) lead to b via a.

Describe an additional resolution.

☐ Done

Submit

Discussion

Hide Discussion

Topic: Week 4 / Paradox

Add a Post

Show all posts | by recent activity

- Is there a paradox in Figure 3? — 2
  I originally thought I understood the arguments expressed by Figure 3 above, but after further th...
- Doesn't the "Toy Model" implies our definition of consistency is wrong? — 3
  Doesn't the Toy Model implies our definition of consistency is wrong? After introducing all th...
- One can not go forward or backward to visit one´s future or past self? — 2
  In figure 2 a past and future particle is present at the same time and this results in a paradox so t...
- On the "Toy Model" — 4
  A nice feature of the "Toy Model" is that due geometrical reasons we can demonstrate any partic...