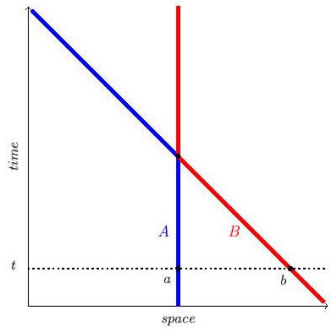
Indeterminacy

In the absence of wormholes, our world is fully deterministic.

In other words: one can use a specification of the positions and velocities of the world's particles at a given time to determine the positions and velocities of the world's particles at any other time. To see this, consider the following diagram:



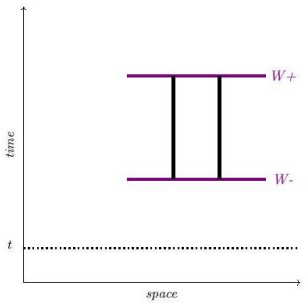
At time t, A is at rest and occupies spacetime point a, and B is traveling leftward with speed 1 and occupies spacetime position b. To determine the position and velocity of A and B at other times, we draw a straight line through each of a and b, at an angle corresponding to the velocity of the object at t.

As long as no collisions take place, the spacetime trajectory of a particle is given by the straight line that intersects its position at t; when a collision takes place, the spacetime trajectories of the two particles swap, with each continuing along the straight line corresponding to the trajectory of the other prior to the collision. The spacetime trajectory of a particle can then be used to determine its position and velocity at any given time.

The particle's position is given by the point at which the particle's spacetime trajectory intersects the horizontal line corresponding to the relevant time; the velocity is given by the angle of the particle's spacetime trajectory at that point.

Now for the interesting part: when a wormhole is introduced, determinism is lost.

Consider, for example, the wormhole in the following diagram:



At time t, no particles exist. If we had determinism, this would be all the information we would need to determine how things stand at every other time. In particular, we should be able to figure out how many particles exist in the wormhole region" (i.e.~the spacetime region between W- and W+).

But our laws do not determine an answer to this question. As far as the laws go, there could be no particles in the wormhole region, or one, or two, or any number whatsoever, as long as there aren't too many of them to fit into spacetime. (The diagram above depicts the case in which there are exactly two particles between W- and W+.)

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