Mad Genius or Rotten Apple? Exploring Time Travel Through Wormholes

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"They had to travel into the past to save the future"— *Timeline* (2003)

That's the tagline from the 2003 movie *Timeline.* The film itself was forgettable but it was based on a premise that has intrigued humanity for generations: time travel. In the movie, characters were able to identify a wormhole, which allowed time travel between present day and medieval France. I thought this was an interesting idea but I knew it bordered on ridiculous, so I decided to take a closer look at whether time travel through wormholes could indeed be possible.

First things first, what is a wormhole? Here is an easy way to picture wormholes without a Physics PhD: imagine that you fold a piece of paper so that one end hovers a couple of inches above the other end. Now punch a hole with a pen on the top part of the paper so the point of the pen reaches the lower part of the paper. Your pen now represents the wormhole. In principle, the wormhole could be used as a shortcut so that, from the point of view of observers outside of the wormhole, travel between the two points could appear to take place faster than the speed of light.

The essence of the idea was originally put forth in 1935 by Albert Einstein and Nathan Rosen, who suggested the possibility of "bridges" in the space-time continuum. Once I learned that Einstein had something to do with the concept behind wormholes, I actually felt that wormholes might not be so ridiculous after all. This so-called "Einstein-Rosen bridge" would essentially act as a tunnel connecting two distinct regions of space or time.

However, it was later realized that there is actually a black hole preventing passage from one side of this "bridge" to the other. Could the human body survive falling into a black hole? Not according to Neil de Grasse Tyson, director of the Hayden Planetarium at the American Museum of Natural History and author of the book *Death by Black Hole: And Other Cosmic Quandaries.* He says that it would be "the most spectacular way to die in space," where your body would be shredded into miniscule pieces by the force of gravity and then slowly spit back out (contrary to popular opinion, things eventually do come out of black holes bit by bit).

Even though the Einstein-Rosen bridge turns out to be black hole, this is the original idea that prompted physicists to search for genuine wormhole solutions to Einstein's theory of general relativity. However, they encountered what seems to be a universal problem: all wormhole solutions in general relativity seem to require the presence of "exotic matter" with negative energy, which prevents them from collapsing into a black hole. To date, all known matter has positive energy. However, in 1948, a Dutch scientist named Hendrick Casimir showed that a small attractive force exists in a vacuum between two uncharged plates. Although this is debatable, some scientists have proposed that this force is actually the result of negative energy.

In order for something to have negative energy, then it would essentially have negative mass. Looking at Einstein's equation $E=mc^2$, E denotes energy possessed by a certain amount of matter, m is the mass and c represents the speed of light; since the square of the speed of light cannot be negative, the mass must be negative in order for the energy to be negative. Some scientists have suggested that certain fluctuations near black holes may exhibit characteristics associated with negative mass.

Without the presence of negative mass/energy, a wormhole could only exist for a fraction of a second before collapsing into a black hole. In order for us to use wormholes for time travel, these bridges would probably have to be sustainable for a lot longer than that!

Let me end by mentioning that there are extensions of the theory of general relativity which contain wormhole solutions that don't require the presence of negative energy in order not to collapse. However, such theories tend to involve extra dimensions, and this opens up a whole new can of worms—or wormholes!

References

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