Time travel? Maybe

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Imagine that you're a science-fiction writer on a tight schedule. You'd like to play in the vast expanses of the universe, but you have too much scientific integrity to conjure up a warp drive or a DeLorean out of thin air. You're also concerned that your audience would get bored in the thousands of years that it would take for a spaceship to realistically travel the distances between stars. What you really need is a wormhole -- a shortcut through time and space. Best of all, unlike most science-fiction tropes, wormholes might very well be real.

Seventy-five years ago, Albert Einstein and his collaborator, Nathan Rosen, submitted a paper to the *Physical Review* with the goal of unifying gravity and electromagnetism. Although they failed to discover a theory of everything, they did something arguably more much important: By creating the first theoretical model of a wormhole, Einstein and Rosen allowed science-fiction writers -- including Arthur C. Clarke, Madeleine L'Engle and the writers of "Babylon 5" and "Doctor Who" -- to explore vast stretches of space and time in the blink of an eye.

From the outside, an Einstein-Rosen bridge, as wormholes were originally known, looks a lot like its cousin, the black hole. And I risk having my official Physics Badge revoked if I don't tell you, ideally in a spooky voice, that "nothing can escape from a black hole -- not even light."

Einstein and Rosen made a very bold supposition: What if a traveler fell into the mouth of something that looked like a black hole, but rather

than being crushed by a singularity at the center of a black hole, instead emerged from another mouth, potentially many light-years from where he or she started? This isn't as crazy as it sounds. Einstein's theory of general relativity -- our current working model for how gravity and space work -- has been confirmed with countless experiments. And, as ad hoc as it sounds, an Einstein-Rosen bridge is a perfectly valid solution to the equations of general relativity.

And it's not just a shortcut through space. In 1988, Caltech physicist Kip Thorne also showed something else: If you can build a wormhole, you can also turn it into a time machine. By dragging one of the mouths of the wormhole around space at nearly the speed of light, we can create a two-way tunnel connecting two points in time. Even better, you don't need to worry about mucking up history. A time machine built from the laws of general relativity is necessarily self-consistent, and thus your history will remain safely as you left it.

However, Einstein's original concept had a few flaws. For one thing, going through an Einstein-Rosen bridge, later theorists have concluded, would have to be a one-way trip, since one mouth always serves as the entrance and the other the exit. An even bigger problem with the wormhole Einstein envisioned was found in 1962, when John Archibald Wheeler demonstrated that an Einstein-Rosen bridge would collapse before anything, even a beam of light, could travel through.

Fortunately, wormhole design has improved considerably in the last 75 years. In 1988, Thorne and his students took up the problem of traversable wormholes, in large part because of a plea from his friend Carl Sagan, who was then working on the novel "Contact." Thorne found that it was theoretically possible to construct models of wormholes, but they would require the existence of as-yet-undiscovered "exotic matter" -- strange stuff that has less than zero mass -- to keep them open. Unlike Einstein-Rosen bridges, Thorne's model was bi-directional and, more

important, stable.

This all might seem like good news, but the fine print on wormholes is pretty daunting when you get into it. For one thing, we've never discovered anything like the exotic matter needed to prop wormholes open, and for another, we're not sure how we -- or even a supercivilization -- could punch a hole through the universe to create one in the first place. Furthermore, the idea of time travel is so anathema to many respectable physicists that some, including Stephen Hawking, have proposed a "chronology protection conjecture," basically insisting that physics must somehow outlaw time machines in order to keep "the universe safe for historians."

Theoretical physicists have the luxury of being able to invent things that don't, or perhaps can't, exist. In the three-quarters of a century since Einstein thought up wormholes, we haven't come close to observing one, though we've gotten some fantastic science fiction in the bargain. It may be that in science fact, if we want to explore the galaxy, it would be much easier to do so without trying to rip up the fabric of space-time in the process.

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ABOUT THE WRITER

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