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A Quick Summary on Wormholes and Whether They Will Ever Be Feasible

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ABSTRACT

Wormholes could potentially be a method of transport utilised by an advanced civilization if the laws of physics were to allow. In this article we delve into what makes a wormhole and the various types of them and as to whether humanity would ever be able attain them.

Introduction

Wormholes are often considered an unattainable aspect of science fiction literature due to their violation of the null energy condition. The premise of a wormhole arose in 1915 alongside Einstein's general theory of relativity. With objects being able to stretch and warp space-time, if the flat sheet of space-time was bent in the right way, a wormhole could connect two very distant points in the universe. Evidently, problems arise from this, due to one being able to travel distances faster than the speed of light. Therefore, the majority of the research on this topic is theoretical.

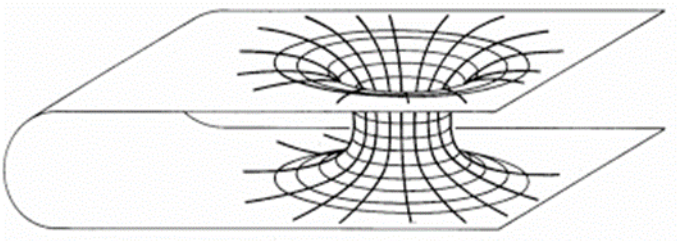

Figure 1. A wormhole connecting two distant regions of space-time.

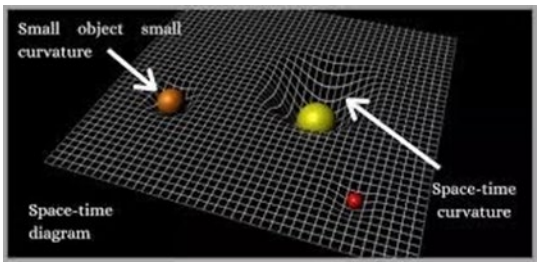

Figure 1. Different objects shown warping space-time.

Einstein-Rosen Bridges

The first kind of wormholes to be theorized were Einstein-Rosen Bridges. With this model, it is believed that the singularity at the centre of a black hole isn't actually a singularity, but in fact a thoroughfare to an infinite parallel universe. With each observed black hole, there would be a universe formed simultaneously along with it. Accordingly, our "own universe may be the interior of a black hole existing inside another universe". Another possibility is that the other side of the event horizon would look akin to our universe, however, time would be running backwards. Due to this, objects would be spewed out of the other end of the wormhole through a phenomenon known as a white hole. Unfortunately, these wormholes cannot be traversed under any circumstances as it would take an infinite amount of time to cross over to the other universe and the wormhole squeezes shut in the middle. If attempted to be crossed, a human would certainly not become the matter being spat out of the other side, but would only die. Therefore, to find a traversable wormhole, we would need a different model.

String Theory Wormholes

If string theory, or one of its variations, correctly describes our universe, then we may fortunately have countless wormholes already lurking around the universe, waiting to be discovered. Cosmic strings, first theorised by Tom W. B. Kibble in 1976, are objects that may have formed in the early universe. These cosmic strings would have been threaded through traversable wormholes created at the Planck Length scale. During the very first instants of the big bang, the ends of these cosmic strings and by extension, wormholes, would have been pulled light years apart, scattering them throughout the universe. This would mean that a wormhole could be closer than we realise. However, string theory is yet to predict any experiments and remains predominantly theoretical.

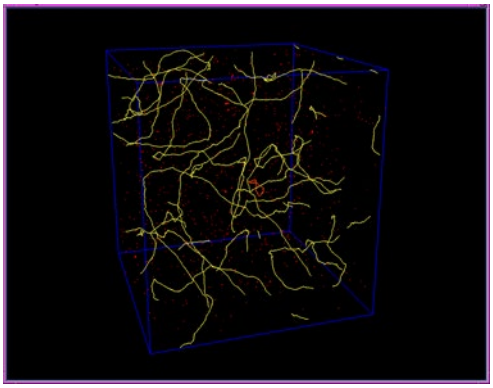

Figure 3. Simulation of a cosmic string network. Long strings are represented in yellow and cosmic string loops are shown in red.

Due to wormholes and black holes looking extremely similar when observed theoretically, many physicists have been led to believe that supermassive black holes, such as Sagittarius A* at the centre of the milky way, are actually wormholes. It would obviously be extremely difficult to travel that distance to find out, but we could also try and create man-made wormholes. For these to be useful, there are a few properties we would want a wormhole to have. It would need to connect two distant points in space-time, not contain an event horizon, preventing two-way travel, and it would have to be sufficiently large so it would not kill any human travellers. The greatest problem would actually be keeping the wormhole open. This is due to gravity trying to pinch the wormhole closed, cutting the bridge and leaving only two black holes at either end. Therefore, no matter what type of wormhole we have, the wormhole will try to close unless it has something propping it open. With string theory wormholes, the cosmic string fulfils this role, however, when considering man-made wormholes, we would need a different substance, one theorised but not found yet.

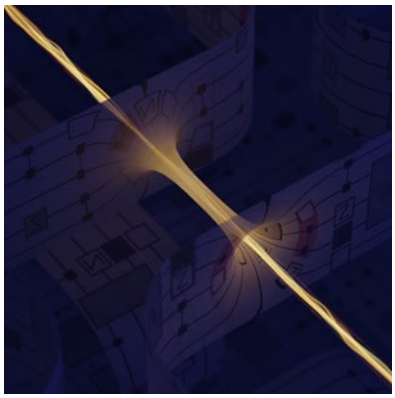

Figure 2. Example of a wormhole being propped open by a cosmic string.

Exotic matter is a substance that has properties unlike anything found on earth. One such property that would be useful is a substance with negative mass. Positive mass, making up everything we know of in the universe, is attractive because of gravity. However, negative mass would be gravitationally repulsive and therefore be able to prop open our wormholes. We are already able to manipulate quantum fluctuations in empty space, which are constantly creating pairs of particles and antiparticles that are annihilated an instant later. The vacuum of space is simmering with these occurrences and an effect similar to the negative mass we are searching for can already be produced.

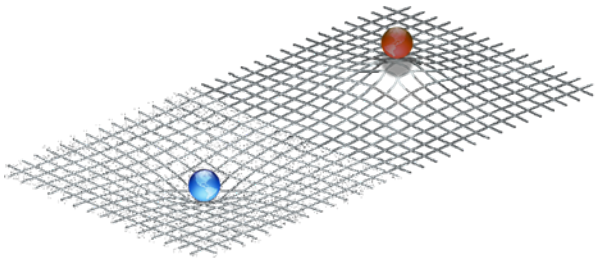

Figure 3: The Janus model, where positive mass would create a well in space-time, and negative mass would create a hill.

Conclusion

Wormholes however have an integral problem tied to their very nature. As mentioned in the introduction. By violating the null energy condition and travelling distances faster than the speed of light, the universe and laws of physics are broken, potentially creating time travel paradoxes and violating the causal structure of our universe. Hence, many scientists think that not only does this make wormholes impossible to make, it is also impossible for any naturally occurring wormholes to exist at all. Therefore, for the time-being, wormholes can only exist on paper in the form of equations.

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