Lecture 6: Wormholes and Time Travel

This week’s topic is also another intriguing topic and it borders on science fiction. Wormholes are the general name for some kind of bridge between two universes or between two different locations of our universe.

They are further subdivided into Permanent and Transient wormholes. The permanent and transient wormholes are subdivided into inter-universe and intra-universe wormholes, and each of these is further subdivided into macro and micro wormholes. The whole history of wormhole science began in 1935 when Einstein and Nathan Rosen found solutions of the black hole where the singularity was missing; it was replaced with some kind of bridge called the Einstein-Rosen bridge. On the other side of this bridge was an object opposite to a black hole, called a White hole. (Nothing can go into a white hole; it can only spit things outward). The white hole had an event horizon called Antihorizon, which were very unstable and had short lifetimes

(This wormhole is therefore an inter-universe, micro, transient wormhole!!) Later, in 1963 as we saw in the last lecture, Roy Kerr predicted the existence of a spinning black hole with a ring singularity. The equations seemed to indicate that once a person tries to go through the Cauchy horizon and the ring singularity, it would turn into a Nuel Weak singularity which could bridge the person into another universe. However, this singularity could still trap the person!!!

In the 1980’s, Kip Thorne argued that a Traversable wormhole could exist not formed from a black hole and without any dangerous event horizons. One could construct this kind of wormhole by enlarging a quantum wormhole (if one could find one as it was forming), or by enlarging a wormhole left over from the Big Bang, which would also entail having to find one. The best way would be to construct one from scratch using a strange form of matter called Exotic Matter, which has negative mass or energy!!! The basic features of a wormhole are simple ---> 2 mouths and a throat. The mouths are someplace where you enter or exit the wormhole and the throat connects the two mouths. One of the difficult issues of using traversable wormholes is that the equations predict that the mouths are highly unstable and would close on a would-be space traveler. Therefore, physicists have sought to come up with suggestions for keeping the mouth and throat open.

The Casimir effect proven to be true in 1948 affords a great example of this. Two metal plates were placed close to each other and the space between them was made into vacuum. The energy of this vacuum
pushed the plates apart and prevented them from falling onto each other. (Negative energy can be acquired from the constant seething virtual particle/antiparticle creation inside a vacuum!!)

Therefore, their energy can possibly be harnessed to keep the mouth and throat of wormholes open. Other types of wormholes have been predicted by Hawking and Sidney Coleman. These wormholes pop into existence and out of existence and are believed to connect our universe with others. They help to reduce the size of the cosmological constant by dumping the high vacuum energy into other universes. Remember that quantum mechanics predicts that vacuum should be seething with energy and therefore, the vacuum between galaxies should be filled with energy with should cause the galaxies to be pushed apart very strongly like in the Casimir Effect. However, these wormholes dump a lot of this energy into other universes and prevent the galaxies from accelerating too rapidly and therefore allowing life to form!!!!

One of the most interesting topics regarding wormholes is their connection with Time Travel. The general term for an object which can be used to travel through time is called Closed Timelike Curves (CTC’s). The basic idea behind these is that a person can travel through a Complete loop through these curves and come back to the same time and space that they started with. The first such proposed

The region of spacetime around the cylinder would be twisted and could contain a time loop. Kurt Gödel, the famous mathematician, in 1949 described an abstract universe containing time loops. His universe itself rotated instead of expanding like in the big band scenario.

If a space traveler traversed a large circular path around this universe, they would get back before they set off!! (Godel also formulated and proved the Incompleteness Theorem of Mathematics which states that there are questions that are unprovable based on the axioms and rules of Mathematics.) Newman, Unti, and Tamburino proposed a similar universe in 1963 which had closed timelike curves. Frank Tipler in 1974 took Stockum’s idea a step further. He suggested that we might be able to make a non-infinite cylinder around 100 km long and 10 km wide. It would have to be strong enough to avoid being crushed by the enormous gravitational strain and being flung apart by surface speeds of over half the speed of light. He argued that traversing this cylinder a few times would make a person wind up in the past. Some physicists believe that a spinning naked singularity black hole can act like a Tipler cylinder also. Cosmic strings can also spin and function like a Tipler cylinder. In

Lastly, wormholes have also been proposed as possible CTC’s. If one could find a traversable wormhole and keep it open somehow, they could enter it at one end and come out the other at a different time. Tom Roman has come up with ways of using a combination of 2 wormholes. Matt Viser, another wormhole specialist, has extended Roman’s idea to using a ring of wormholes -- > you come out of one wormhole and enter another
Stephen Hawking disagrees with the whole concept of time travel and has come up with a theory known as the Chronology Protection Conjecture.

When one considers the possibility of doing time travel, (these involve either going into the past of our universe, the future of our universe or the past and future of another universe,) certain paradoxes arise which boggle the mind. One of the overall things you have to keep in mind is that Time Machines can only allow us to travel back to times when the machines themselves were invented. (So, if I build a machine in 2000, I can’t go back to a year before 2000, but in a future date like 3478 AD, I can go back up to 2000 AD). The first paradox is called the

The gist of the paradox is that a person goes to the past and marries their mother, so the question is “where did the person originally come from?” (If they marry their mother and have children from her, how did they come about?) The second main paradox is called

This paradox involves situations that do the most damage to the fabric of spacetime. The basic gist of this is that a person goes to the past and attempts to kill someone like their father, mother, or any other important figure in history, like Einstein or Washington. The question is put, “Will they succeed in killing that person?” If they do, then what’s going to happen to recorded history or the accomplishments of that person? If they kill their father or mother, what’s going to happen to the person?

There are 4 possible scenarios offered as an answer to this paradox. First,

Second, you must fail somehow in your attempt to change the past. The second scenario forces a person to fail in all their attempts at changing the past. For example, let’s say you go back and try to prevent Kennedy from being shot. To your dismay, you will find all your efforts come to naught, and he will still be shot. The third possibility is that you actually become the tool to accomplish the past history that we know of. For example, you go back to attempt to save Kennedy, but you end up helping the person who killed him or you go back to kill Einstein but end up helping him discover Relativity. The fourth one is

No matter how you think of time travel and what solutions you consider, it’s always a brain twister. Another interesting question with time travel is, “Can you come back to the present after your attempted act?” My favorite answer is that you can come back to the present, but not necessarily the present of our universe. You might end up coming to the present of another copy of our universe. This is reminiscent of the newer version of the Planet of the Apes movie. At the end of the film when they return to Earth, they find that the statue of Abraham Lincoln is a huge ape and the cops come to catch them and they are apes too!!!