Wednesday, April 25, 2012

Reading: Chapters 11 (omit 11.6), 12, 13, 14

Astronomy in the news?

News:

Wheeler on review committee for Department of Physics and Astronomy at Rutgers. Major center for research in string theory.

### Goal:

To understand how Einstein's theory predicts worm holes and time machines and how we need a theory of quantum gravity to understand if those are really possible. Backstory: Sagan/Thorne CONTACT

Sagan wanted "connection" through Einstein-Rosen Bridge



Thorne - Jodie Foster will die a screaming death by noodleization in singularity - no good. He worked out a new theory.



Could open a "mouth" to make a worm hole, but would be unstable, would slam shut.

In principle, could stabilize with "Exotic Matter," anti-gravity stuff like Dark Energy.

Not ruled out by physics - good enough for Sagan, book and film

## **Discussion Point:**

What would it look like to go into a worm hole?





2D Analogy -Embedding Diagram Can go "through" wormhole, but also once deep inside can turn "sideways," parallel propagate return to point of origin



Figure 13.1 In principle, a light beam would travel "around" the interior of a worm hole. You could also see through the wormhole.

One Minute Exam

If I flew straight into a worm hole and once inside turned at 90 degrees and kept flying as straight as I could, I would

Emerge from the other mouth of the worm hole

Run into myself

Be in hyperspace

return to the point where I made the turn





The mouth of a worm hole would be a 3D "object," the space inside highly curved.

3D hyperspace through hole

Embedding diagram of a worm hole in an "open" universe

Do not confuse the "tunnel" through the middle of an embedding diagram representation of a worm hole (that is hyperspace!) with the tunnel-like aspect of the real three dimensional space.

Stargate - two dimensional "opening" not "realistic"



## Goal:

To understand how Einstein's theory predicts worm hole time machines.

Thorne went on to study worm holes (Thorne - Black Holes and Time Warps: Einstein's Outrageous Legacy)

#### Worm holes are automatically time machines!

Igor Novikov elaborated (Novikov - The River of Time)

Twin paradox - twin who accelerates out and back in space will be younger than the twin who stays behind (special relativity).

Do this (conceptually) with one mouth of a worm hole or lower one mouth into strong gravity where time runs slower.

Time "connects" differently through the wormhole and in the surrounding space - one mouth is "younger"

# **Discussion Point:**

What happens when you go into a worm hole time machine?

Can, in principle, travel back in time (but not before the time the machine is constructed)

Go in one mouth, come out in the past, go around in normal space, meet yourself before you go in. [Thorne video]

Time travel paradoxes - Grandfather Paradox, Self-suicide

Pool Ball Paradox (purely mechanical, get people, intention, and will out of the analysis) - fire pool ball through time machine to deflect itself before it went in so could not have deflected

Novikov - there is no paradox - Physics always works out so that a paradox is avoided

Pool ball just nicks, Grandfather ducks.

With time machines, the future is already "there" in space-time

Premise of many famous time travel movies is undone, cannot change the future by tinkering in the past.

Implication - no free will

We just live through time with impression we are making choices

Novikov - I exert my free will to fly around the room or to walk through solid walls

Physics says I cannot - what's the big deal?

Likewise - I cannot will a time travel parodox, physics says "no."

*Novikov Consistency Conjecture:* physics will arrange itself so that there is no time-travel paradox - you cannot travel back in time and kill yourself before you enter the worm hole/time machine.

Back to the Future films

Terminator films

Consistent or not with the Novikov Consistency Conjecture?

Is Donnie Darko about split universes or time travel? If time travel, is it consistent with the Novikov Consistency Conjecture? Ultimate resolution - will not know if worm holes can be constructed, even in principle, without a theory of *quantum gravity*.

Hawking - vacuum fluctuation energy (from uncertainty principle applied to vacuum) can go into wormhole, come out in past, pile up at mouth where began, quickly build up huge energy density, curve space, slam worm hole shut.

Maybe, but cannot actually compute that process without a theory of quantum gravity to handle the change in the "connectivity" of space time - must space time be smooth, or can it be laced with "tunnels" in space and time?

One Minute Exam

The Novikov Consistency Conjecture says:

Worm holes cannot lead to the future

Worm holes cannot lead to the past

Worm holes cannot exist



Worm holes cannot lead to time travel paradoxes