

Monday, November 21, 2011

Reading: Chapter 12, Chapter 13, Chapter 14

Astronomy in the news? “Faster than light” neutrino experiment repeated. Original, neutrino pulses 10,000 billionths of a second, delay versus speed of light, 58 billionths. New experiment, pulses 3 billionths of a second, delay 62 billionths. Still questions of synchronizing clocks, measuring distance from CERN to Gran Sasso.

The Fabric of the Cosmos, last installment, Universe or Multiverse, Wednesday, November 23, PBS (KLRU) 8 PM (re-runs <http://www.klru.org/schedule/viewProgram.php?id=246736>).

Pic of the day: Earth, with aurorae, from International Space Station. Video on Facebook.

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.

Worm Holes and Time Machines

(Chapter 13)

Amazing mathematical developments in the context of Carl Sagan's *Contact* by Kip Thorne and Igor Novikov:

Einstein's equations allow the possibility of worm holes. To be stable, they must be held open by some imagined "substance" that anti-gravitates.

Highly curved space, but no singularity.

The Dark Energy gives a hint that such a "substance" could exist.

Wormholes

Serious physics lesson - leads to need for quantum gravity

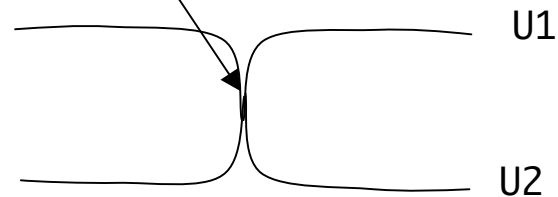
Wormhole - connection from one place in 3D space to another
(through hyperspace? Do not need to know to construct 3D solution)

Result - highly curved space, but no event horizon, no singularity

Use 2D Embedding Diagram to help picture what is going on in 3D space (balloon: but can't connect, would need to tear rubber and reconnect)

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.

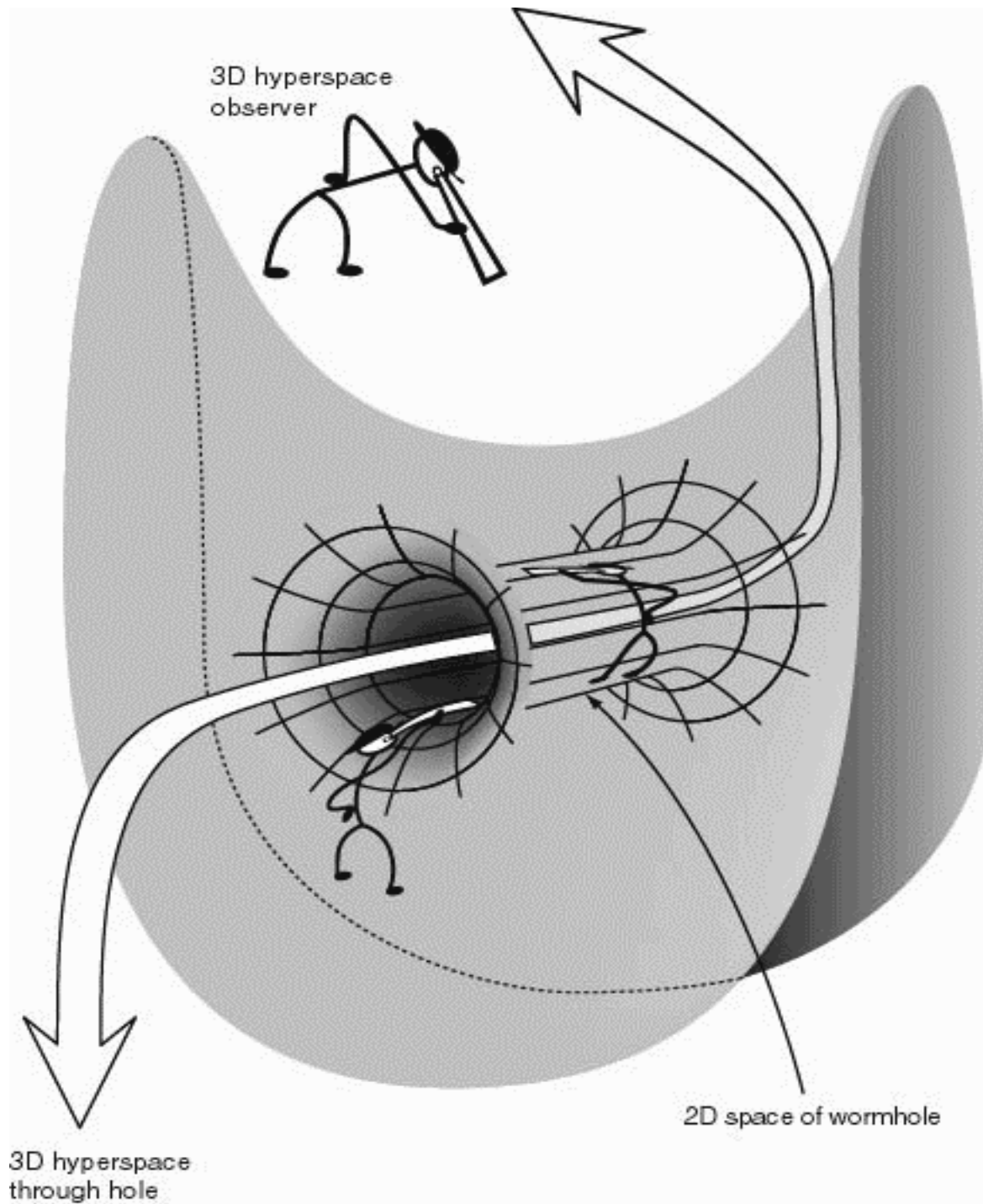
In principle, could stabilize with “Exotic Matter,” anti-gravity stuff like Dark Energy.

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?

Fig 13.2



2D Analogy -
Embedding
Diagram

Can go
“through”
wormhole, but
also once deep
inside can turn
“sideways,”
parallel
propagate -
return to point
of origin

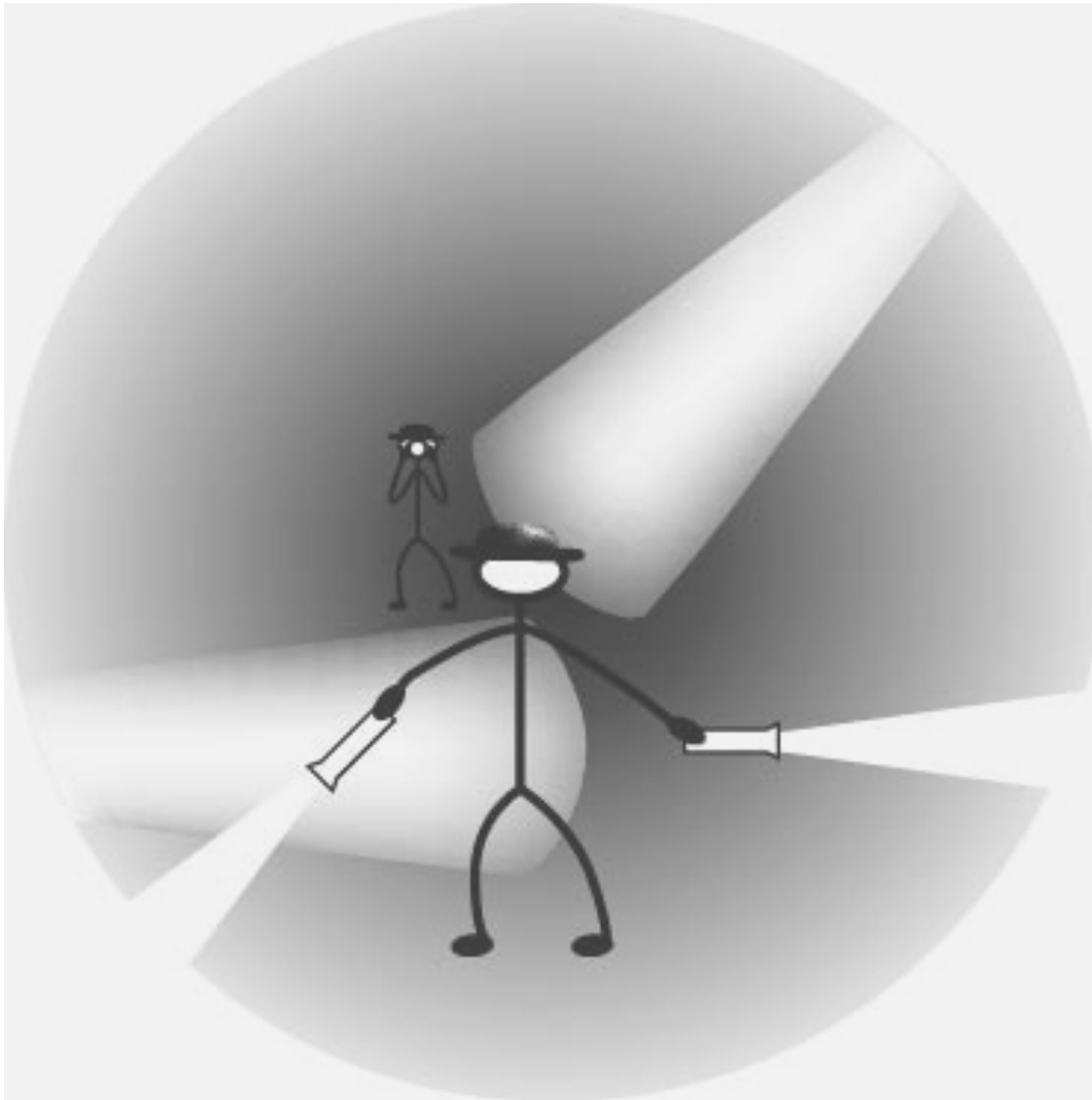


Figure 13.1


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

One Minute Exam

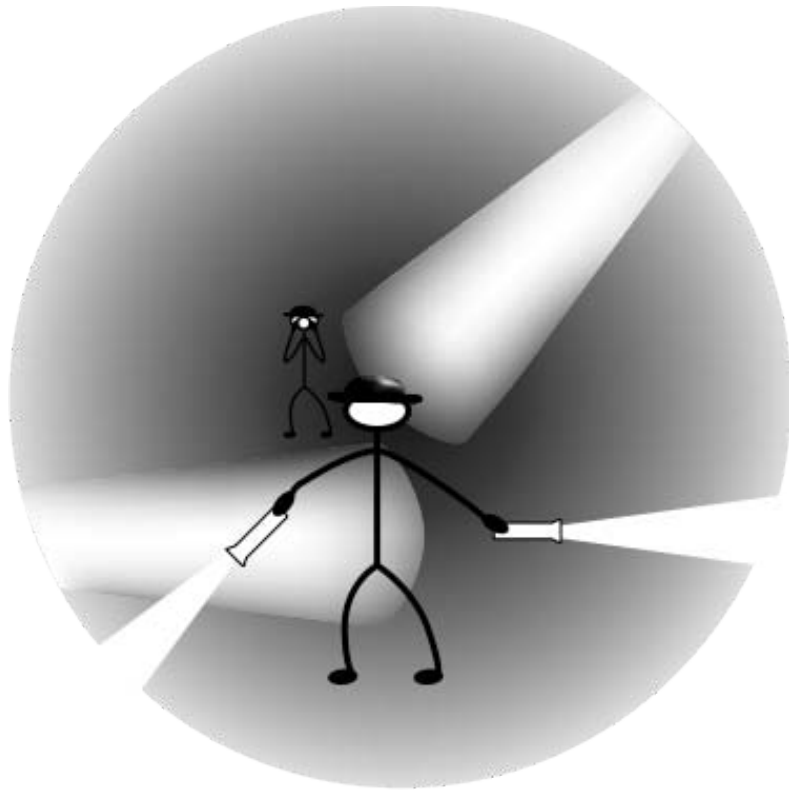
If I flew straight into a worm hole and once inside turned at 90 degrees and kept flying as straight as I could, I would

 Emerge from the other mouth of the worm hole

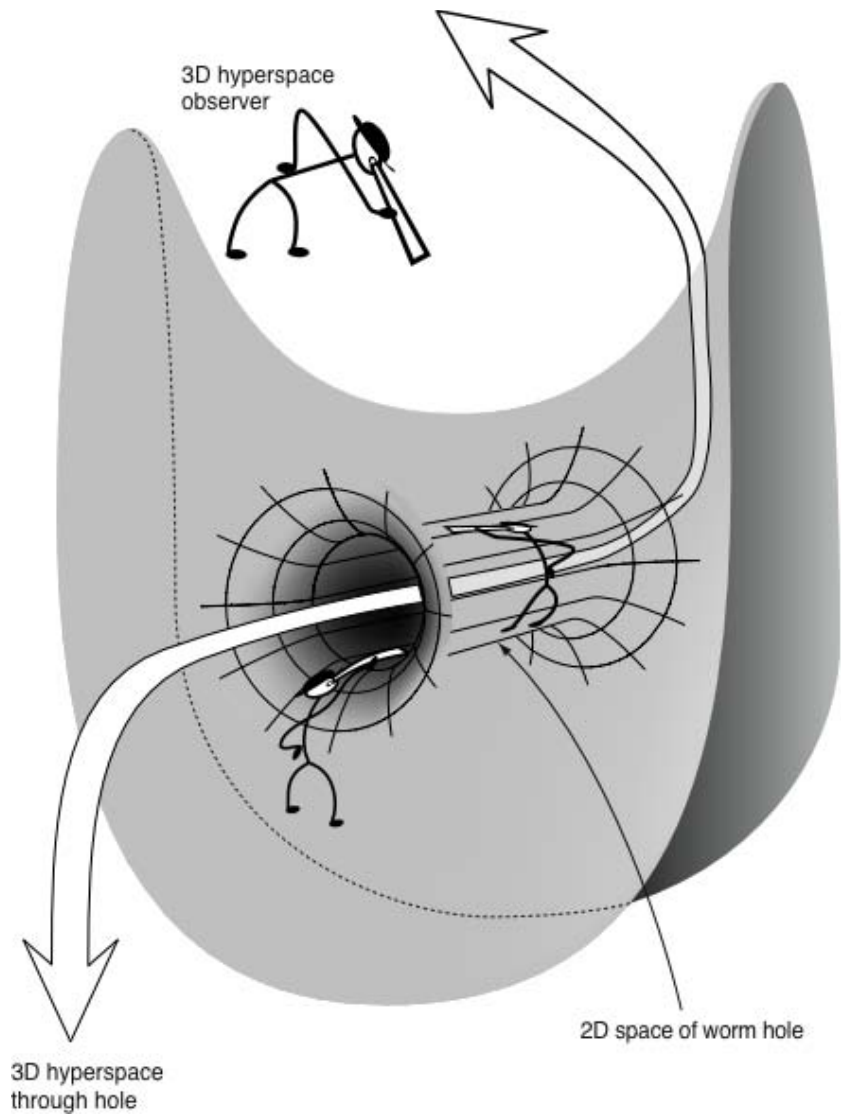
 Run into myself

 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.



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”

Thorne video

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.

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.