Wednesday, October 30, 2013

Exam back. Key posted.

Reading: Chapter 9: all except 9.6.3, 9.6.4

Astronomy in the news?

Steve Finklestein's distant galaxy was observed 700 million years after the Big Bang, so about 13 billion years ago.

Goal:

To understand the nature of curved space, and hence of gravity, in the vicinity of a massive object, a planet, star, or black hole.

To understand the role of an “embedding diagram” in helping to explain that curved space.

Embedding diagram:

Real Space	->	Embedding Diagram Space
Volume (3D)	->	Surface (2D)
Surface (2D)	->	Line (1D)
Line (1D)	->	Point (0D)

Invert balloon - 2 D embedding diagram of curved 3 D space around gravitating object

Properties of this curved space that are preserved in the embedding diagram:

$C < 2\pi r$

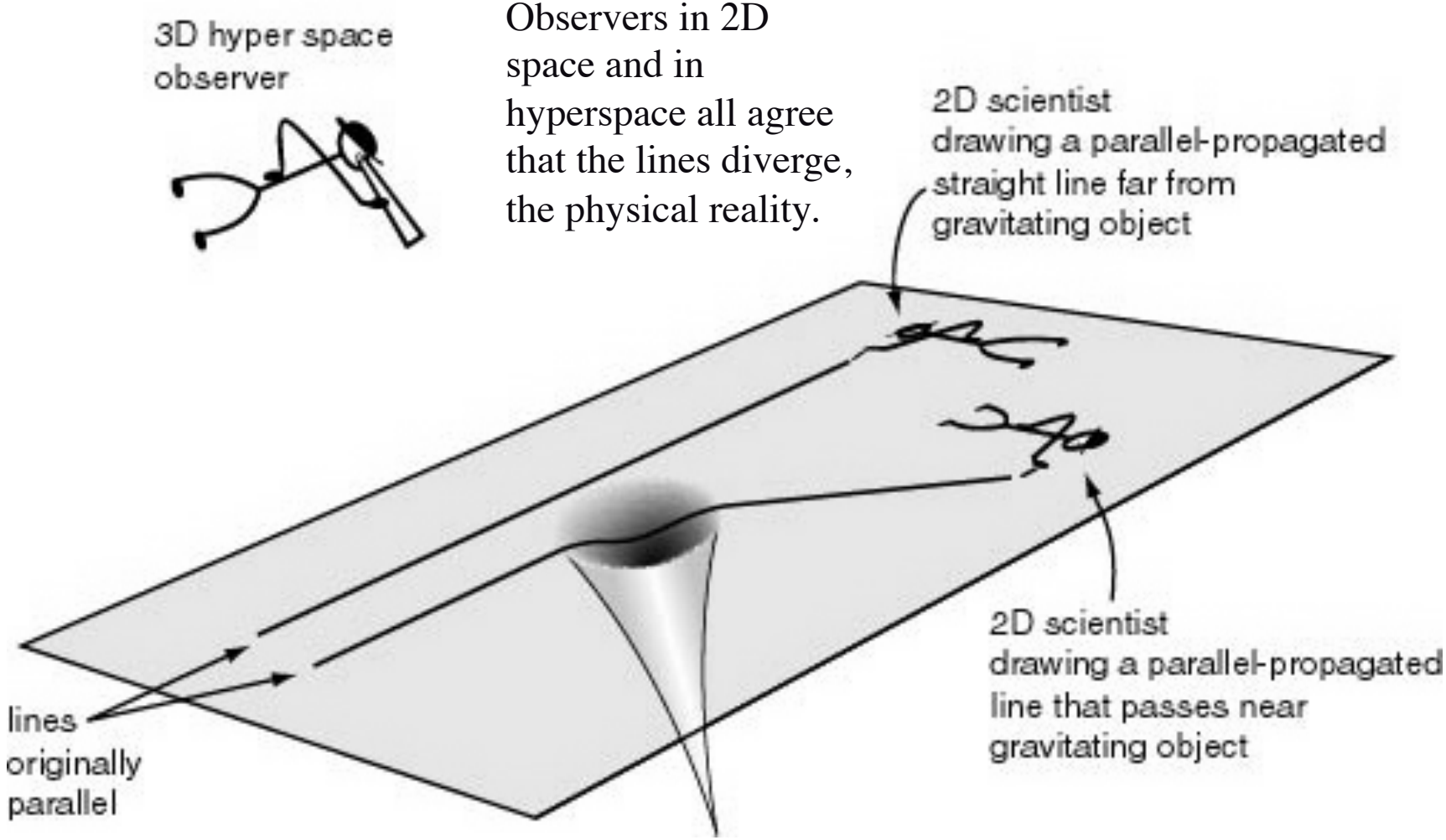
Sum of angles of triangle not equal 180^o (can be > or <)

Parallel lines diverge or cross

Orbits around "cone"

Far from a gravitating object, the curvature and hence gravity, gets very weak, 3D space becomes FLAT, and the corresponding embedding diagram is a flat 2D plane (can't show this with the balloon).

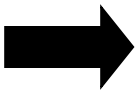
Figure 9.4



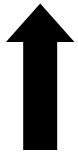
Straight lines in the 2D embedding diagram of curved, gravitating space.

One Minute Exam

In the corresponding two-dimensional embedding diagram, the interior volume of a real, three-dimensional planet would be represented as:

 A point

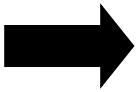
 A line

 An area

 A volume

One Minute Exam

In a two-dimensional embedding diagram of the Earth, the surface of the Earth would be represented by:

 A volume

 A surface

 A line

 A point

Goal:

To understand what Einstein means by an orbit.

Orbit - circle around “cone”

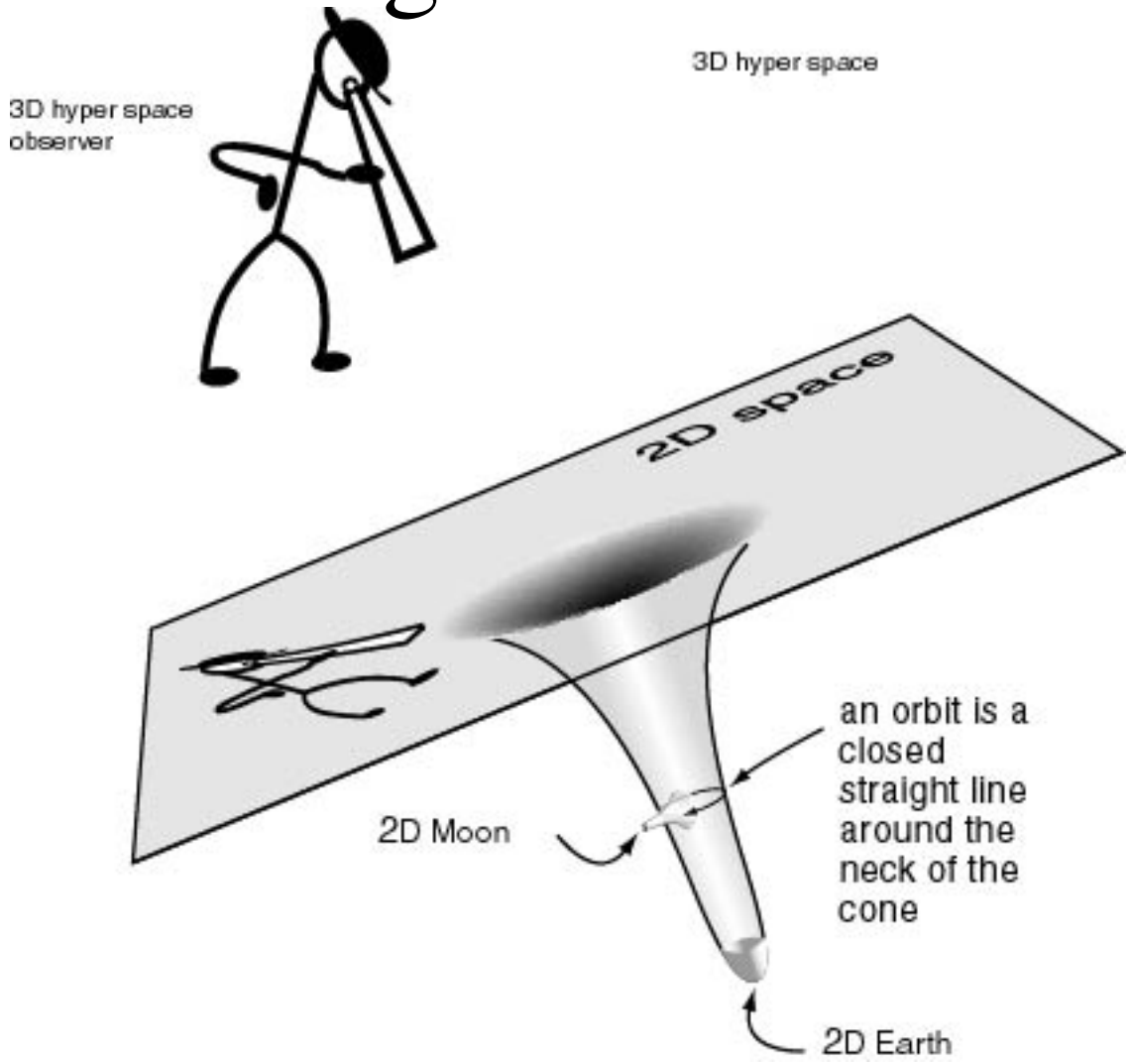
Moon is going as straight as it can in curved space around the Earth

This is how gravity works for Einstein - no Newtonian Force -

Gravitating objects curve the space around them - nearby objects move in that curved space

The parallel-propagated straight lines of their force-free motion are warped by the curved space.

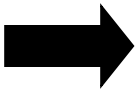
Figure 9.5



Orbits in curved 2D embedding diagram of gravitating space

One Minute Exam

An astronomer fires two laser beams so they will pass near a distant black hole. The beams are initially parallel. An astronaut on the far side of the black hole tracks the two beams and finds that they are diverging, but that they never crossed. This means that:



one of the beams entered the black hole

the beams passed on opposite sides of the black hole

the beams passed on the same side of the black hole

one of the beams had more energy than the other

Goal:

To understand the “real” curved space of a gravitating object in three dimensions

3 D gravitating space is not a "cone;" that is just an artifact of the 2 D embedding diagram.

Real 3 D space around gravitating objects has the properties:

$C < 2\pi R$

Δ not equal 180^{o}

// lines cross or diverge

light is deflected (this one has been experimentally verified)