Monday, October 24, 2011

Exam 3 returned Wednesday.

Reading: Chapter 9, Sections 9.5.1, 9.5.2, 9.6.1, 9.6.2. 9.7, 9.8

Astronomy in the news? Pioneering German X-ray satellite ROSAT crashed somewhere, Indian Ocean, Myanmar, or China. Launched in 1990 and retired in 1999 after being used for research on black holes and neutron stars and performing the first all-sky survey of X-ray sources with an imaging telescope.

NASA is exploring plans to put fuel depots in space to enhance human exploration of deep space.

Pic of the day: Waterfall nebular in Orion molecular cloud. Jet from a binary system containing a hot white dwarf, neutron star, or black hole???

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.

Goal:

To understand what Einstein means by an orbit.

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:

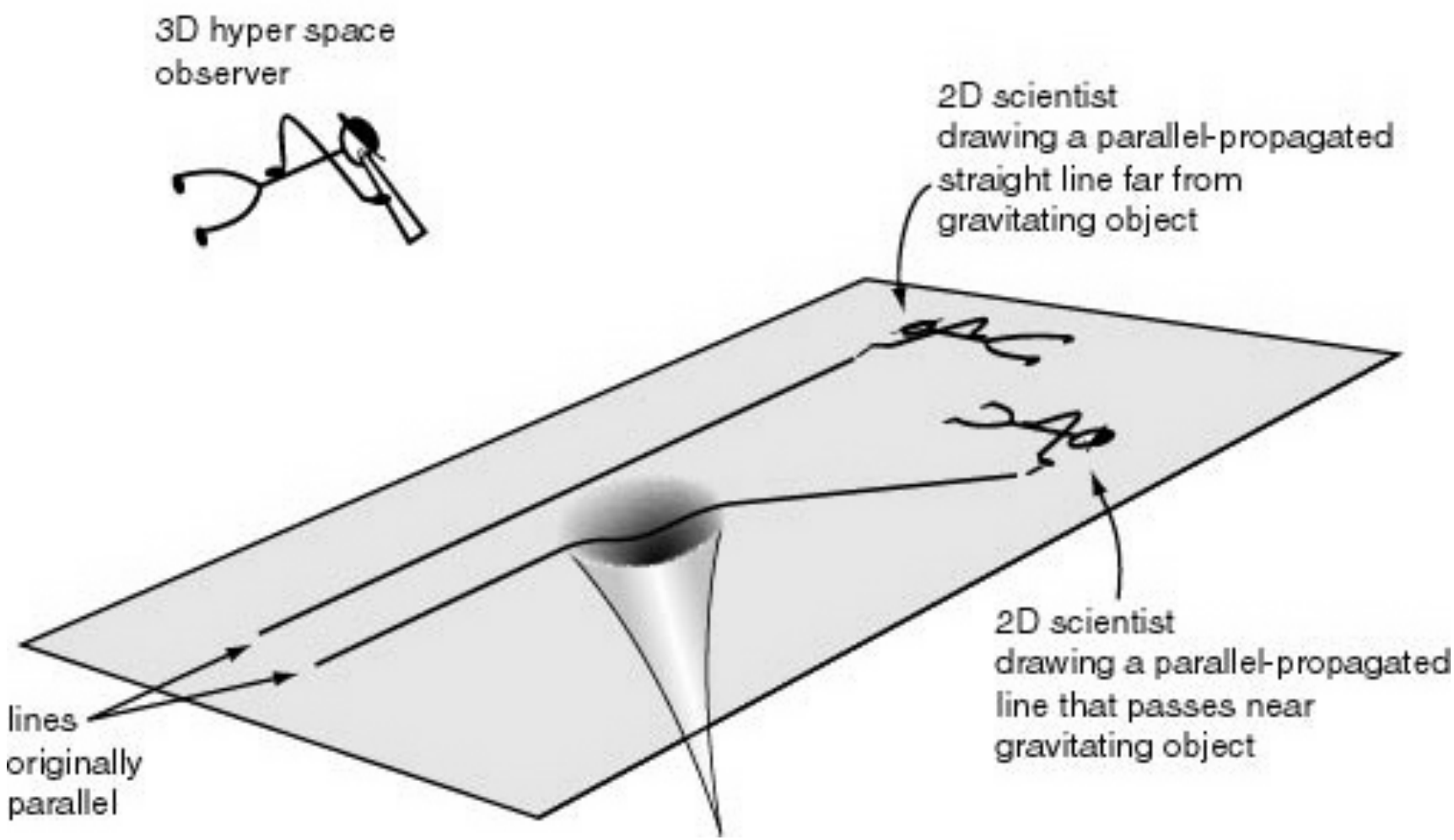
$C < 2\pi r$

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

Parallel lines diverge or cross

Orbits around “cone”

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

Orbit - circle around “cone”

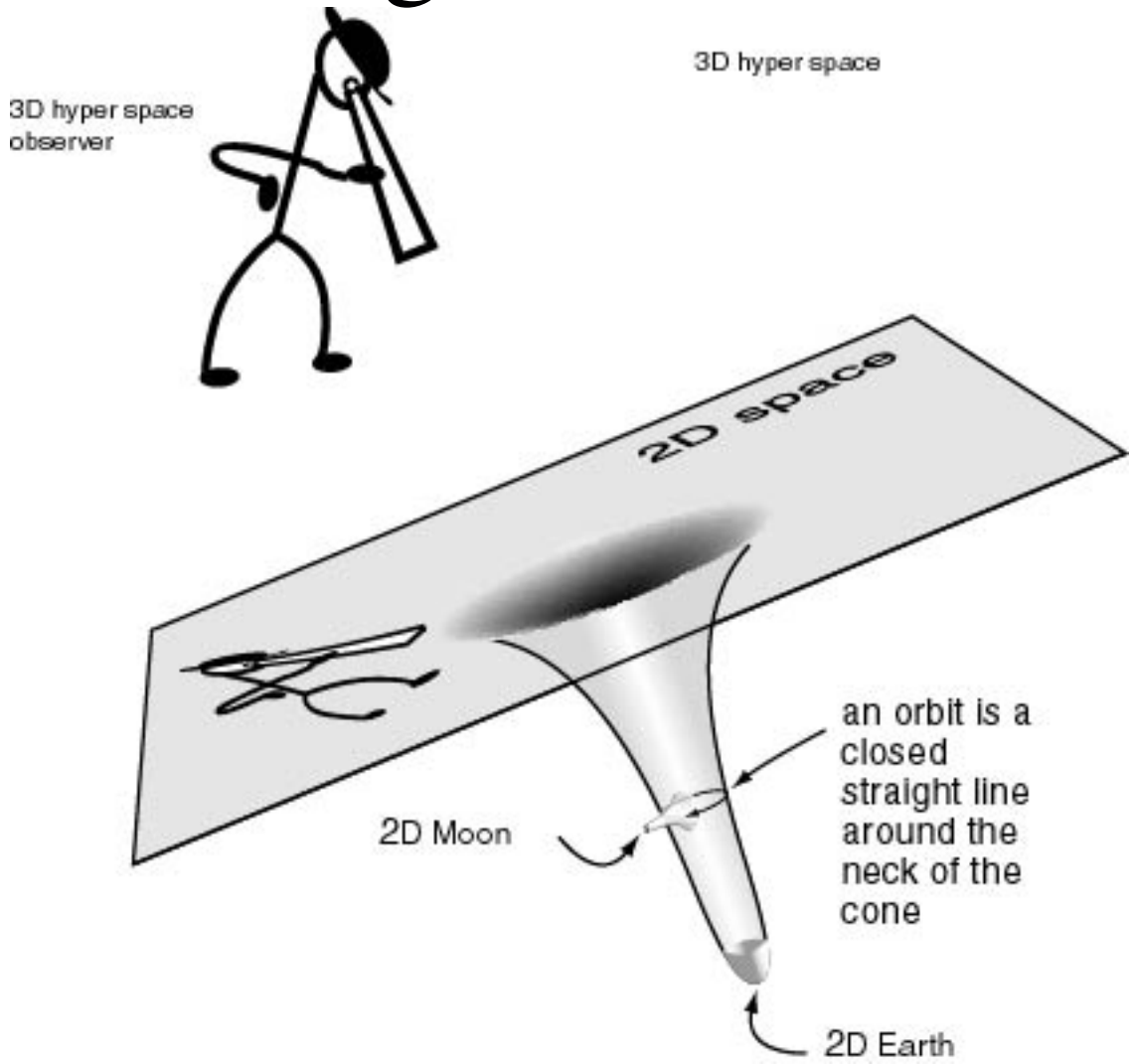
Moon is going as straight as it can in curved space around the Earth

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:

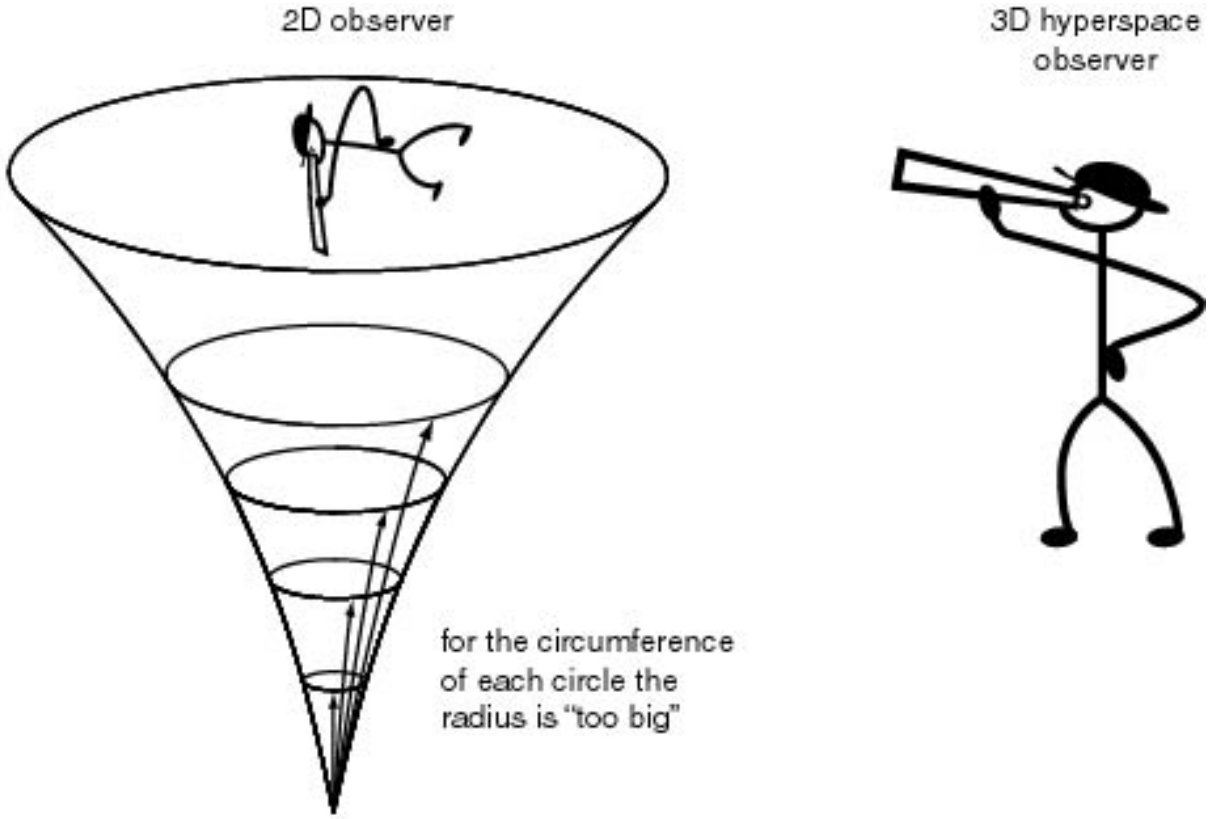
$C < 2\pi R$

Δ not equal 180^{o}

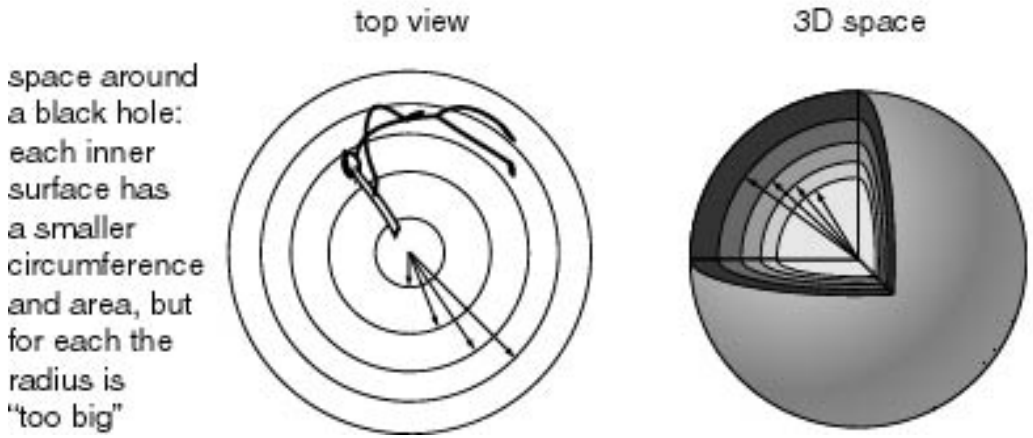
// lines cross or diverge

light is deflected (this one has been experimentally verified)

Fig 9.6



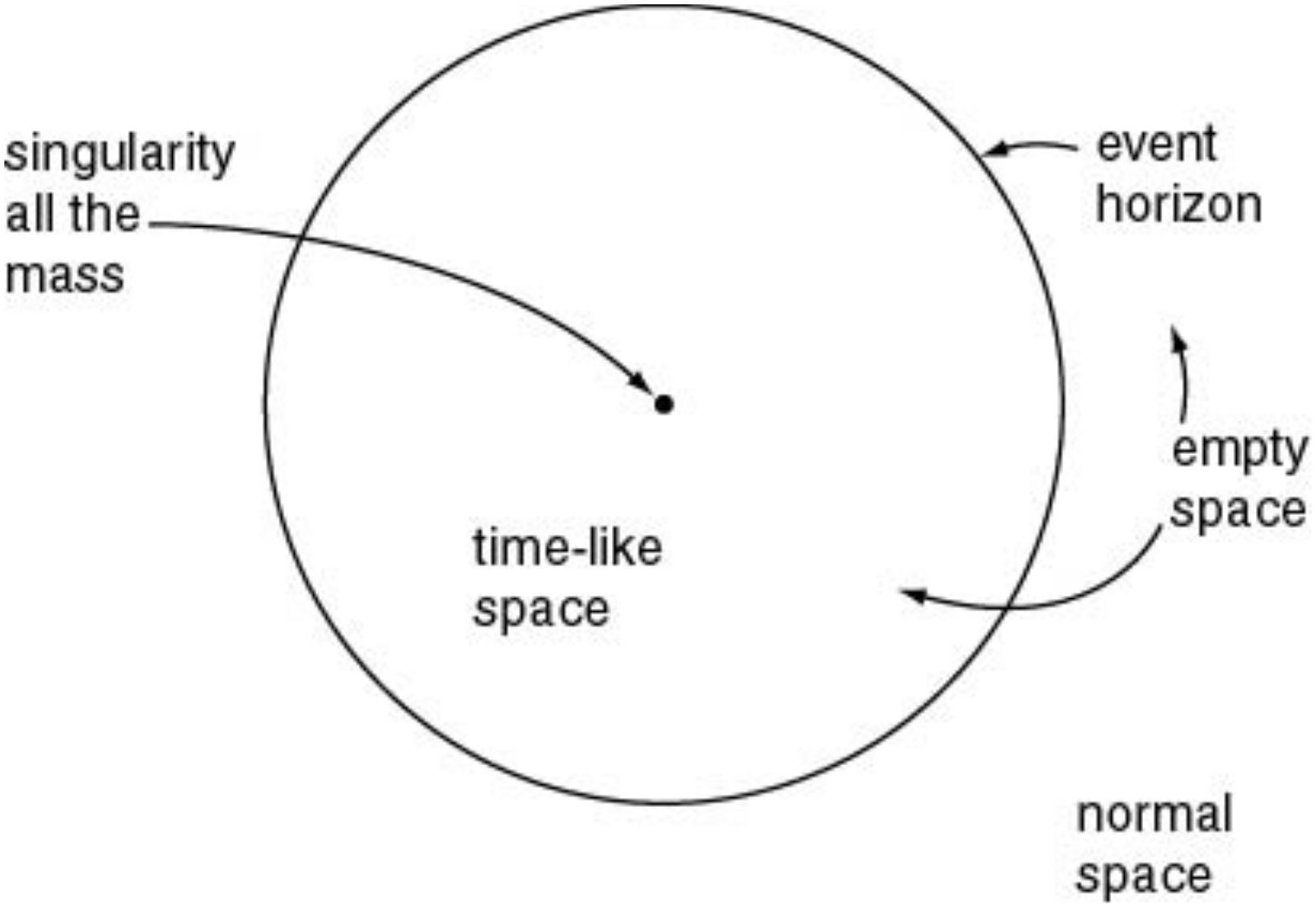
Curved 3D space



Goal:

To understand the basic features of a black hole

Figure 9.1



Basic properties of a (non-rotating) black hole