October 20, 2010

Exam 3 This Friday, October 22.

Review Sheet posted.

Review Thursday, 5 – 6 PM, RLM 4.102 (ground floor of RLM, south side).

Reading Chapter 7, Chapter 8 - Sections 8.1, 8.2, 8.5, 8.6, 8.10, Chapter 9: 9.1 – 9.5.1

Astronomy in the News? UFOs over El Paso?

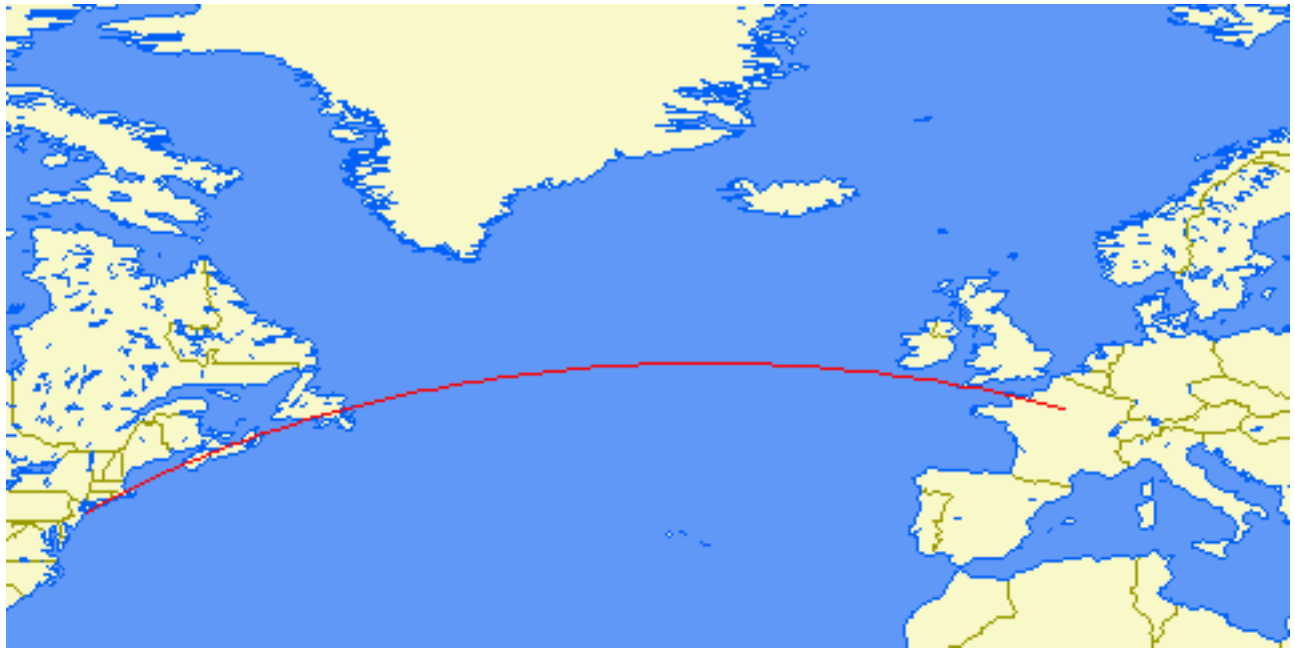
Pic of the Day – 44 nights of Venus over Turkey

Goals:

To understand how Einstein taught us to think about space, time, and gravity.

To understand what we mean by space.

To understand how space can be curved.



Route from JFK airport to Paris Orly.

Is this a straight line?

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:

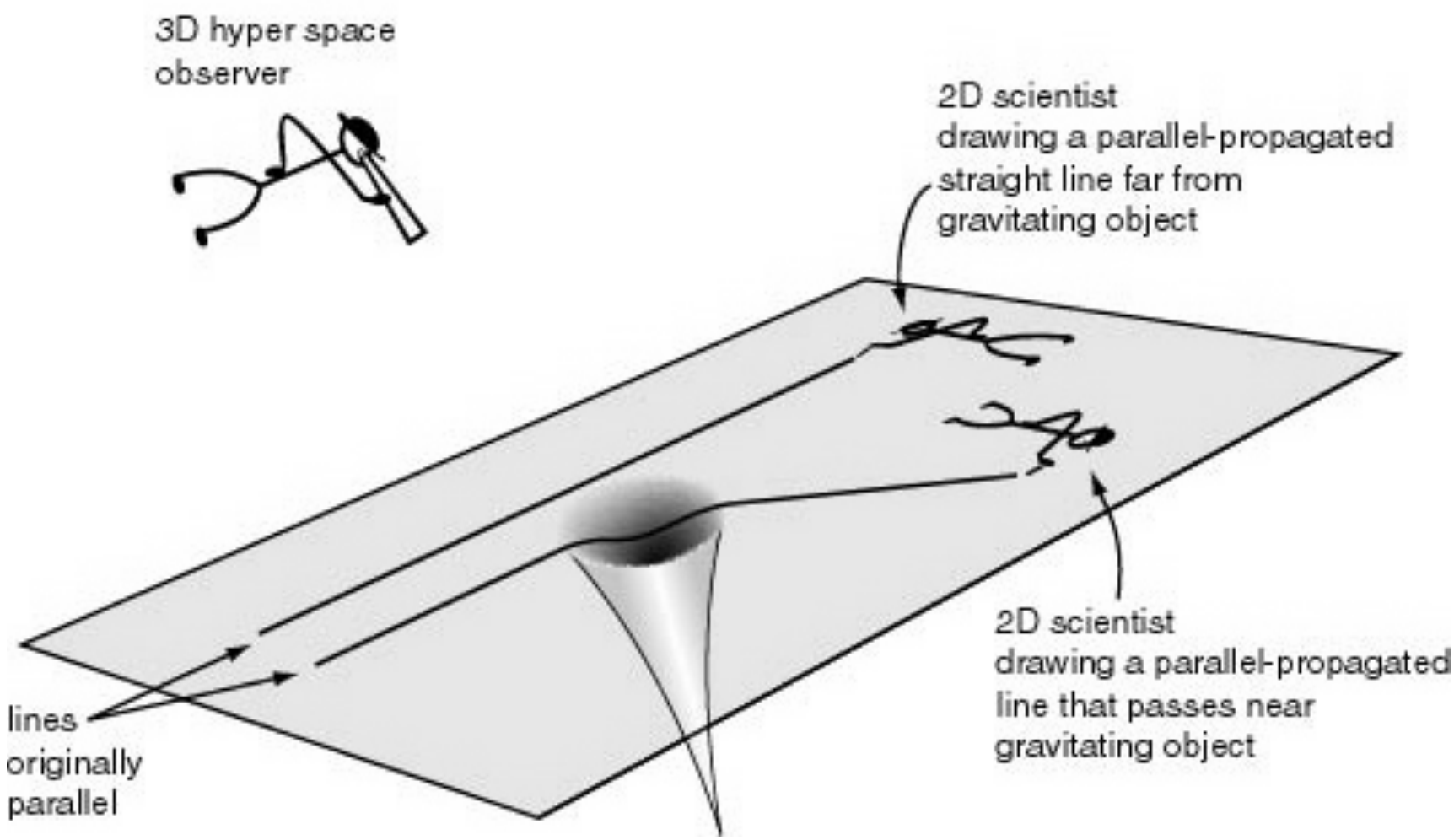
$C < 2\pi r$

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.

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.

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:

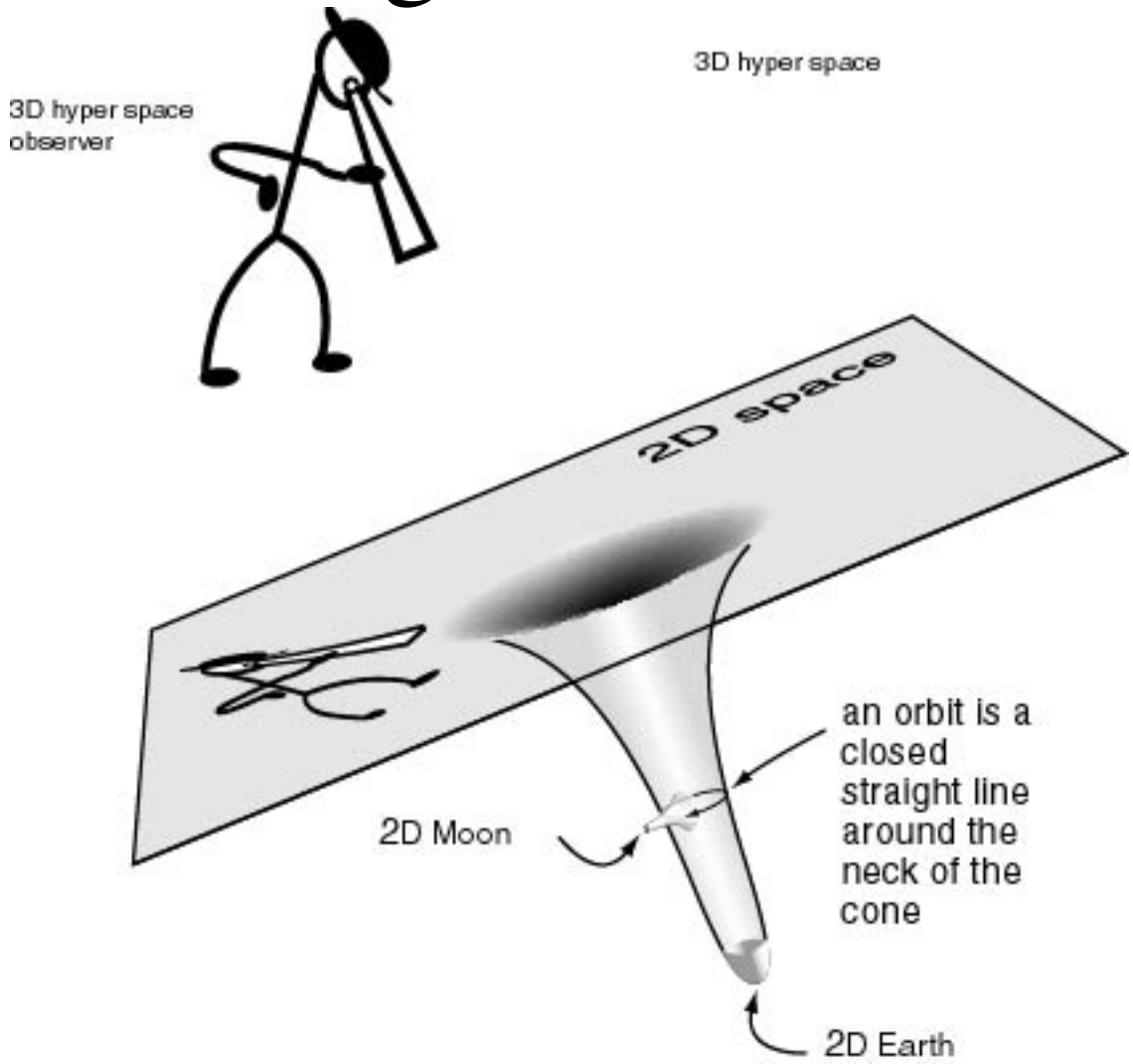
 A volume

 A surface

 A line

 A point

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:

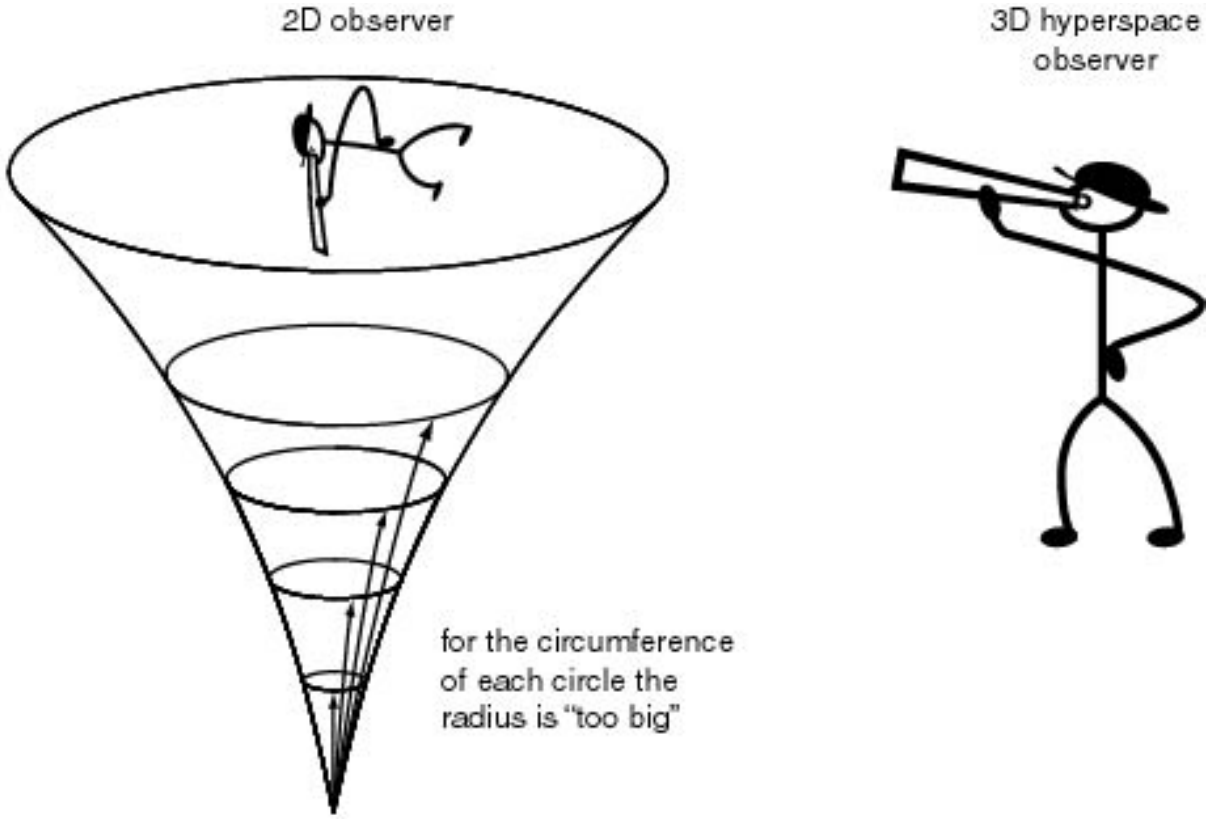
$C < 2\pi R$

Δ not equal 180^{o}

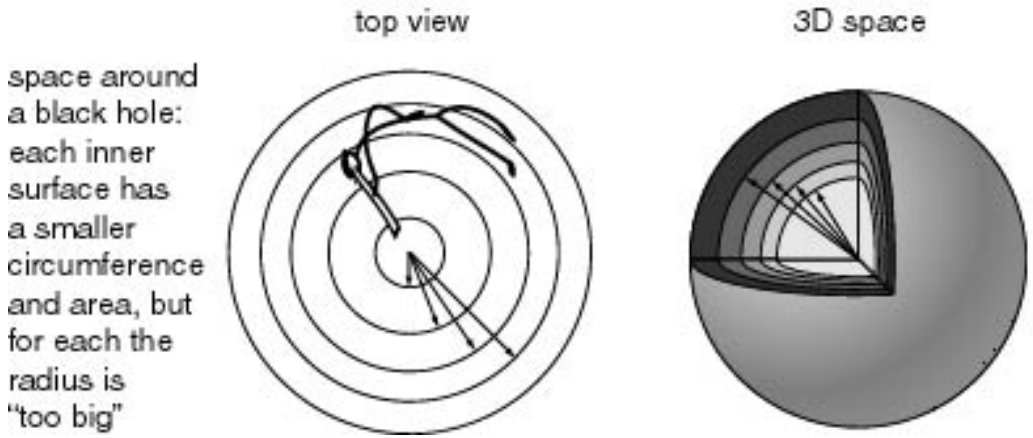
// lines cross

light is deflected (this one has been experimentally verified)

Fig 9.6



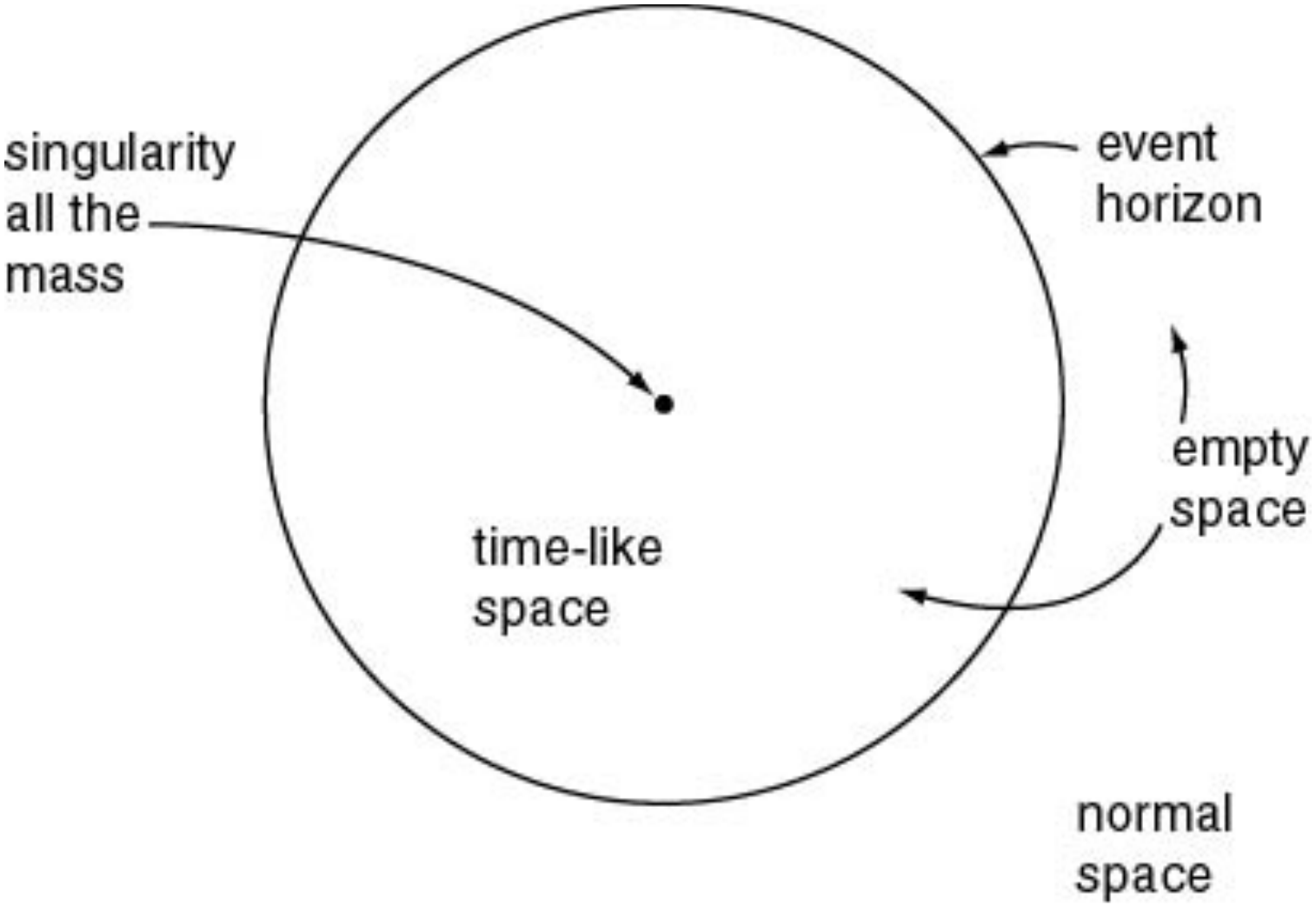
Curved 3D space



Goal:

To understand the basic features of a black hole

Figure 9.1

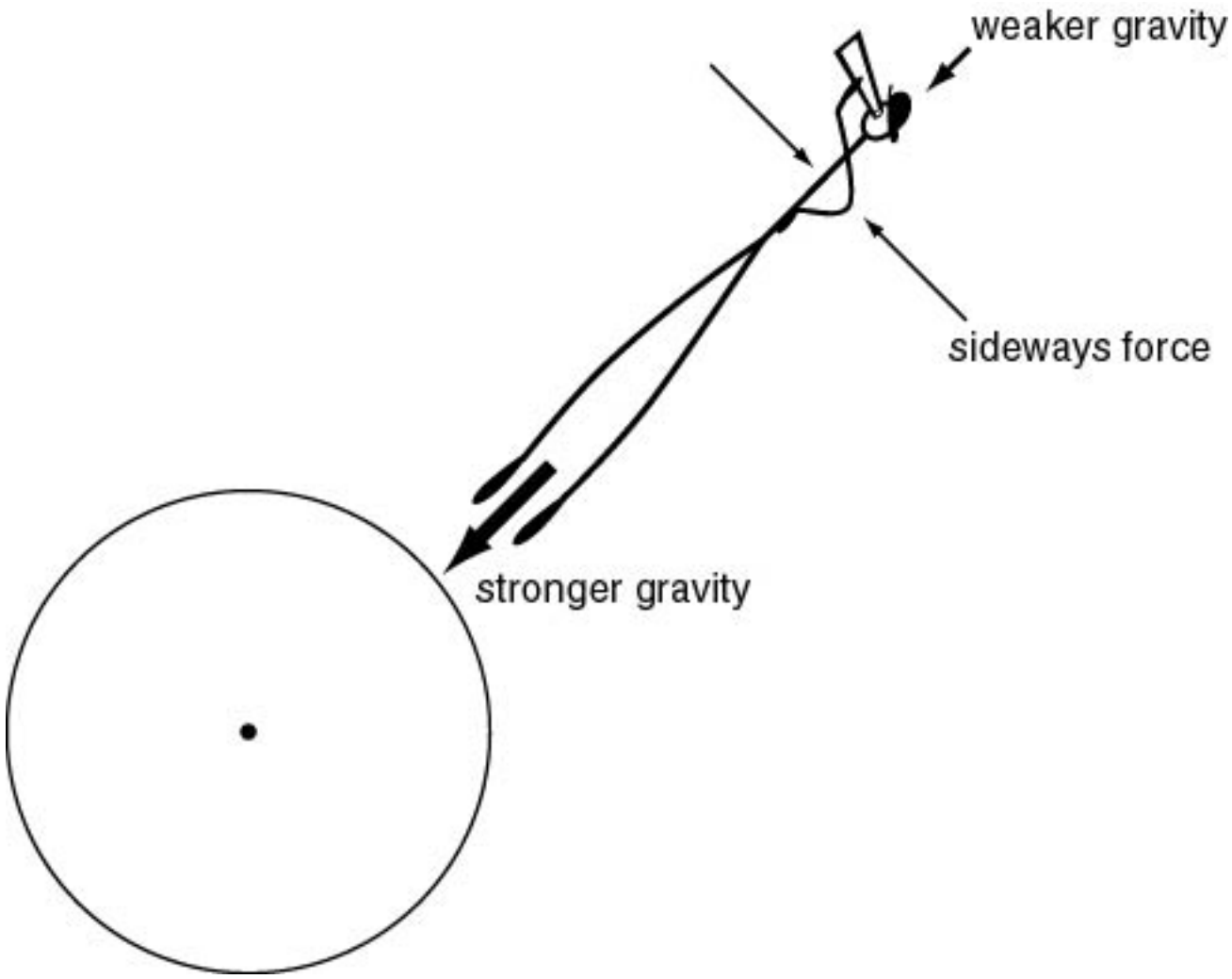


Basic properties of a (non-rotating) black hole

Goal:

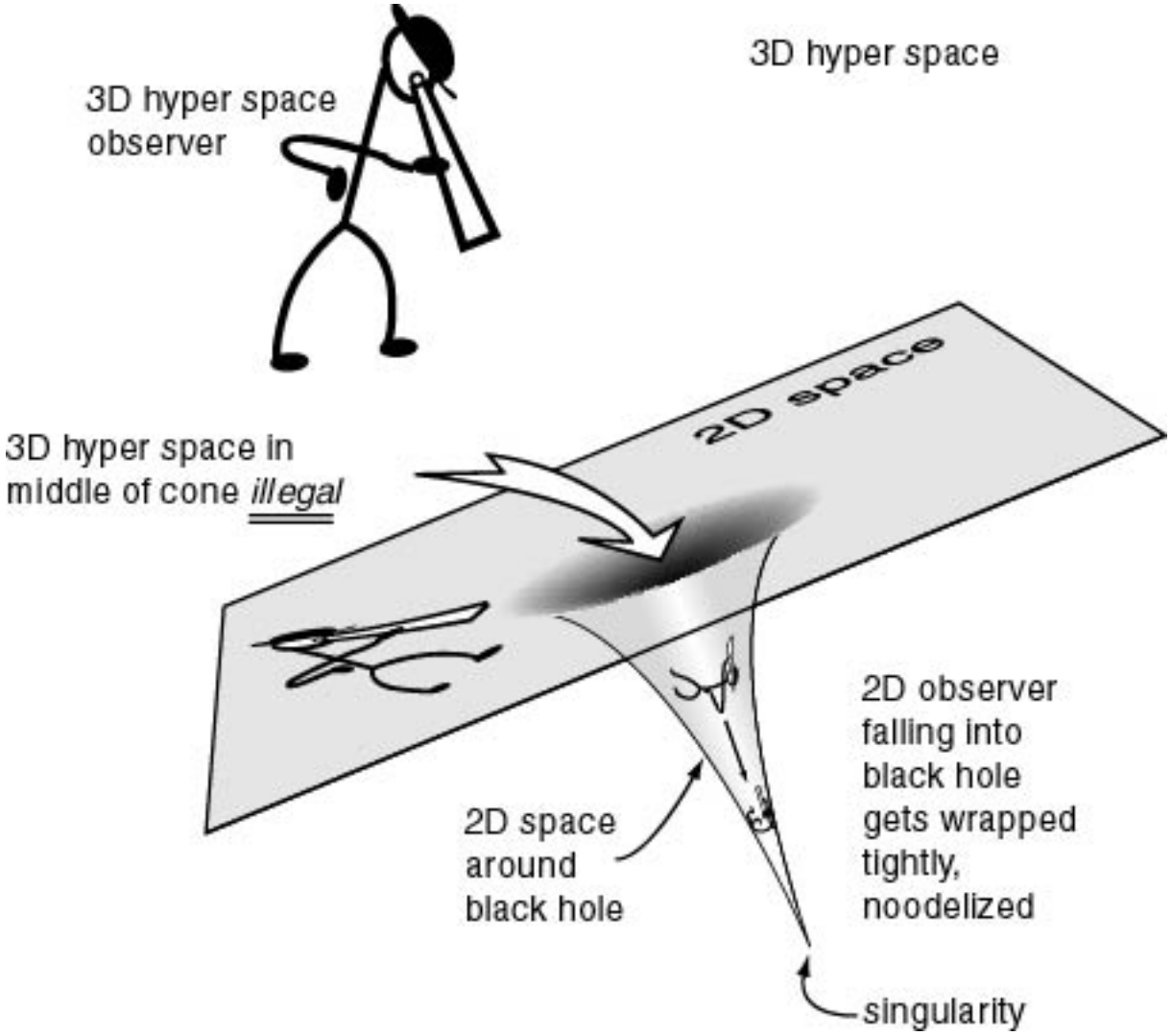
To understand what it is like to die falling into a black hole.

Figure 9.2



Tidal Forces

Figure 9.3



2D embedding diagram of 3D curved space around a black hole

End of Material for Test 3