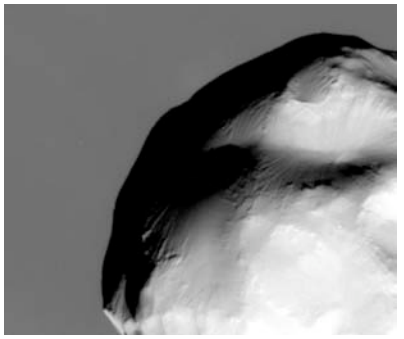
March 10, 2010

Reading, Chapter 9: all except 9.6.3, 9.6.4

Astronomy in the News?

Pic of the Day - Saturn's moon, Helene



Goal:

To understand the historical roots and basic theoretical concepts behind black holes and the huge conceptual differences between Newton's and Einstein's view of gravity.

Black Holes

Mitchell, Laplace, late 18th Century: with Newton's Gravity
could have escape velocity greater than the speed of light =>
light could not get out, completely dark, *corps obscurs*.

Now know Newton was wrong. (Historical note on Kowa Seki)

Excellent approximation for weak gravity - "true" in that case

Conceptual problems $F = \frac{G M_1 M_2}{r^2}$

infinite force for zero separation (in physics infinity
$\Rightarrow$ problem)

instantaneous reaction => infinite speed of gravity

Experiment - wrong deflection of light.

Need Einstein and more!

Great conceptual differences between Newton and Einstein on the Nature of Gravity

Newton - Force between two objects

Einstein - Mass curves space, objects move *with no force* in curved space

Need to explore curved space - use geometry in multiple dimensions

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.

SPACE - *The Final Frontier*

Dimensions - defined by the number of mutually perpendicular directions

0 D - point

1 D - line

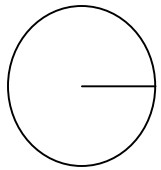
2 D - area

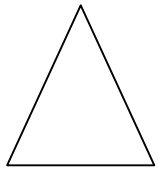
3 D - volume (secret hand sign)

4 D - ?

Hyperspace - space with more dimensions than the one under consideration

Euclidian - Flat Space Geometry





$C=2\pi r$ $\sum = 180°$ never cross

Answers only good in ***flat space***: operational definition of flat space
NOT necessarily two-dimensional!

Non-Euclidian geometry - curved space

Both flat space and curved space use concept of “straight line”

Curved Space - explore with straight lines

Definition of straight line

Shortest distance between 2 points - rubber band

Draw a free hand straight line

Parallel propagation - rulers

Parallel propagation will give the shortest distance between two points without necessarily knowing where the two points are in advance.

Parallel propagation works easily, even when the space is *curved*.

Balloon

Surface is curved 2 D space

3 D space around the balloon, inside the balloon is ***hyperspace*** with respect to the 2D surface

Imagine a 2 D creature that can only perceive 2 D space.

2 D creatures can learn all about the curvature of the space they inhabit by doing geometry in 2 D - they never need to know about or care about “hyperspace.”

That’s us in 3 D! There might be 4D (or higher!) hyperspace around us, but we don’t perceive it.

We can, in principle, learn everything we need to know about our 3D Universe by doing 3D observations and experiments in the confines of our own dimensionality, just as 2D creatures could learn of their universe, the surface of the balloon.