October 18, 2010

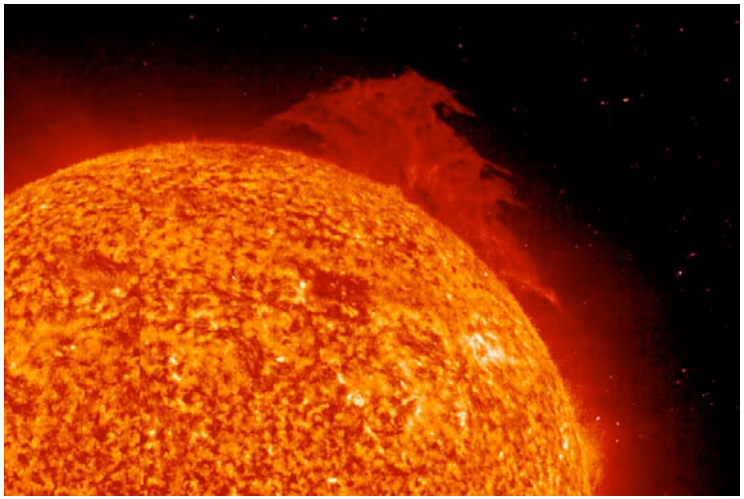
Exam 3 This Friday, October 22.

Review Sheet posted today. Review Thursday, 5 – 6 PM room TBD

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? Betelgeuse still has not blown up.

Pic of the Day – Solar prominance



Add to Sky Watch

New Soft  Gamma-ray repeater outburst, March 2010, SGR 1833--0832, in direction of Sagittarius, center of Milky Way, is a magnetar with a “pulsar” spin period of 7.56 seconds.

Recurrent Nova outburst, V407 Cygni, first ever seen in a binary system with a Red Giant and White Dwarf. Possible precursor to a Type Ia supernova.

# 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.

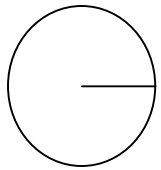
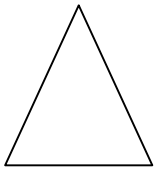
# Gravity

Still a deep mystery. Objects of different mass fall with the same acceleration.

Explore how Einstein taught us to think about gravity: no f*orce of gravity*, but the effect of ***curved space***.

Straight line on a curved surface, possible or an oxymoron?

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*.

Geometry on the 2D surface of the balloon

Exercises of drawing straight lines

***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.

What you need to know about the ***surface*** of the balloon -

What is a straight line, what is not?

What is “inside” the surface? What is “outside” the surface

Where is the “center” of the **surface**?

What does it mean to go from surface point to surface point “through” the balloon interior?

How do you determine the shape of the surface by doing geometry?

Real 3 D curved space (for us!!) might curve in a 4 D “hyperspace,” but we do not directly perceive that hyperspace.

We can determine the curvature, shape of our real 3 D space by doing 3 D geometry.

Do not need to ask about 4 D (but will!)

One Minute Exam

In a curved space:

 Straight lines always connect to themselves

 Straight lines are the shortest distance between two points

 There are no straight lines

 The sum of the interior angles of a triangle is 180 degrees

One Minute Exam

Compared to the two-dimensional surface of a balloon, the inside of the balloon is:

 A two-dimensional hyperspace

 A three-dimensional hyperspace

 A four-dimensional hyperspace

 Accessible to a two-dimensional creature

One Minute Exam

An intelligent ant crawls around on a surface, drawing triangles as the intersection of 3 straight lines. She finds that the sum of the interior angles is always more than 180 degrees and that triangles of the same size always give the same results. She deduces that the following will be true:

➡ If she draws two straight lines that are initially parallel they will begin to diverge.

⬅ The surface she is walking on is three-dimensional

⬆ If she walks off in a straight line she will never return to her point of origin

⬇ If she walks off in a straight line she will return to her point of origin

Check out

Dr. Quantum in Flatland

Right in spirit, wrong in some essential details. See if you can figure out what those are.

http://youtube.com/watch?v=KhbGYn7aAUk

# 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*** - 2 D "shadow" of 3 D curved space, preserves basic aspects of geometry, whether curved or not, and, if curved, how.

Meaning of ***flat space*** in 3 (or higher) dimensions

If 3 D space is flat: $C=2\pi r$; sum of angles of triangle $=180°$; parallel beams of light never cross ***in 3D***.

***The embedding diagram of 3D flat space is a flat 2D plane***

In curved 3D space, the flat space answers will be wrong: 2D embedding diagram will help to illustrate that.

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”