

3/29/06

Chapter 9 - Black Holes

Test 4, Chapters 7, 8, (parts of) 9 week from Friday

News: Solar eclipse

Pic of the day; Norway aurora -
charged particles channeled along
lines of magnetic force



Balloon - what is a straight line, what is not?

What is “inside?” What is “outside?”

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

Real 3 D curved space (for us!!) might curve in a 4 D
“hyperspace,”

but we do not directly perceive that hyperspace.

Can determine curvature, shape of 3 D real space by doing 3
D geometry

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

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 $=180^\circ$; 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.

One Minute Exam

In a curved space

- A) Straight lines always connect to themselves
- B) Straight lines are the shortest distance between two points
- C) There are no straight lines
- D) The sum of the interior angles of a triangle is 180 degrees

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° (can be $>$ or $<$)

Parallel lines diverge or cross

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.