

11/27/06

Exam 4, THIS FRIDAY

Book Chapter 11 (Book Chapter 11 material is in New Revised, posted Chapter 11 on Gamma-ray Bursts and Chapter 12 on Supernovae and Cosmology).

Book Chapter 12 is NOT on this exam (will be on final).

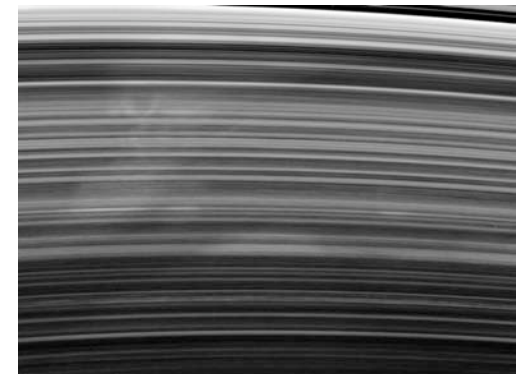
Review sheet posted today.

Skywatch returned Wednesday. Fourth and last anytime before end of classes, December 8.

Review session Thursday, Nov. 30, 5 PM, RLM 4.102

News:

Pic of the day; spokes in Saturn's rings.



Course survey is now available in the eCIS system at <https://utdirect.utexas.edu/diia/ecis/>

Should get automatic email

Experiment to do electronically

The University, the Astronomy Department and I all pay attention to these.

Please take the time to fill out the evaluation form.

Reading:

Supernovae and Cosmology, part of old Chapter 11 in book, new separate Chapter 12 posted.

Chapter 11 Our Expanding Universe

Expanding Universe - we observe all distant galaxies (so far away we cannot sense their individual gravity) moving away from us with speed proportional to distance: as if we were in the center of an explosion.

Our Universe is not a bomb in pre-existing empty 3-D space!

Lesson from Einstein - *space itself can expand carrying the* (almost motionless) *galaxies*

All distant galaxies move away from all other distant galaxies.

No galaxy, certainly not us, is in the center.

The result: speed proportional to distance

All 3D space expands - carrying essentially motionless matter
(galaxies)

No 3D center, no 3D edge, no 3D outside

As 3D astronomers, we don't have to ask what the Universe is
expanding into, but if anything it is a 4 (or more) D
hyperspace, just as a 2D balloon expands into 3D
hyperspace.

Infinite flat rubber sheet could expand without expanding into
any hyperspace (2D embedding diagram example).

Our Expanding Universe

Expanding *surface* of a balloon as an example

2D embedding diagram of 3D expanding Universe

No 2D center, no 2D edge, no 2D outside

There is a 3D center, a 3D edge, a 3D outside, in 3D hyperspace

Einstein's theory says that for a Universe that is the same, on average, everywhere, there are only three basic shapes it can have

The 3D analog of a spherical surface - *Closed Universe*

The 3D analog of a “saddle” or “Pringle” shape - *Open Universe*

The 3D analog of a flat plane - *Flat Universe*

The *2D embedding diagrams* of these 3D Universes are, respectively, *a sphere, an infinite saddle or Pringle, and an infinite flat plane.*

A closed universe is finite in space and time, the other two are infinite in space and time, but all must have started 13.7 billion years ago in the Big Bang.

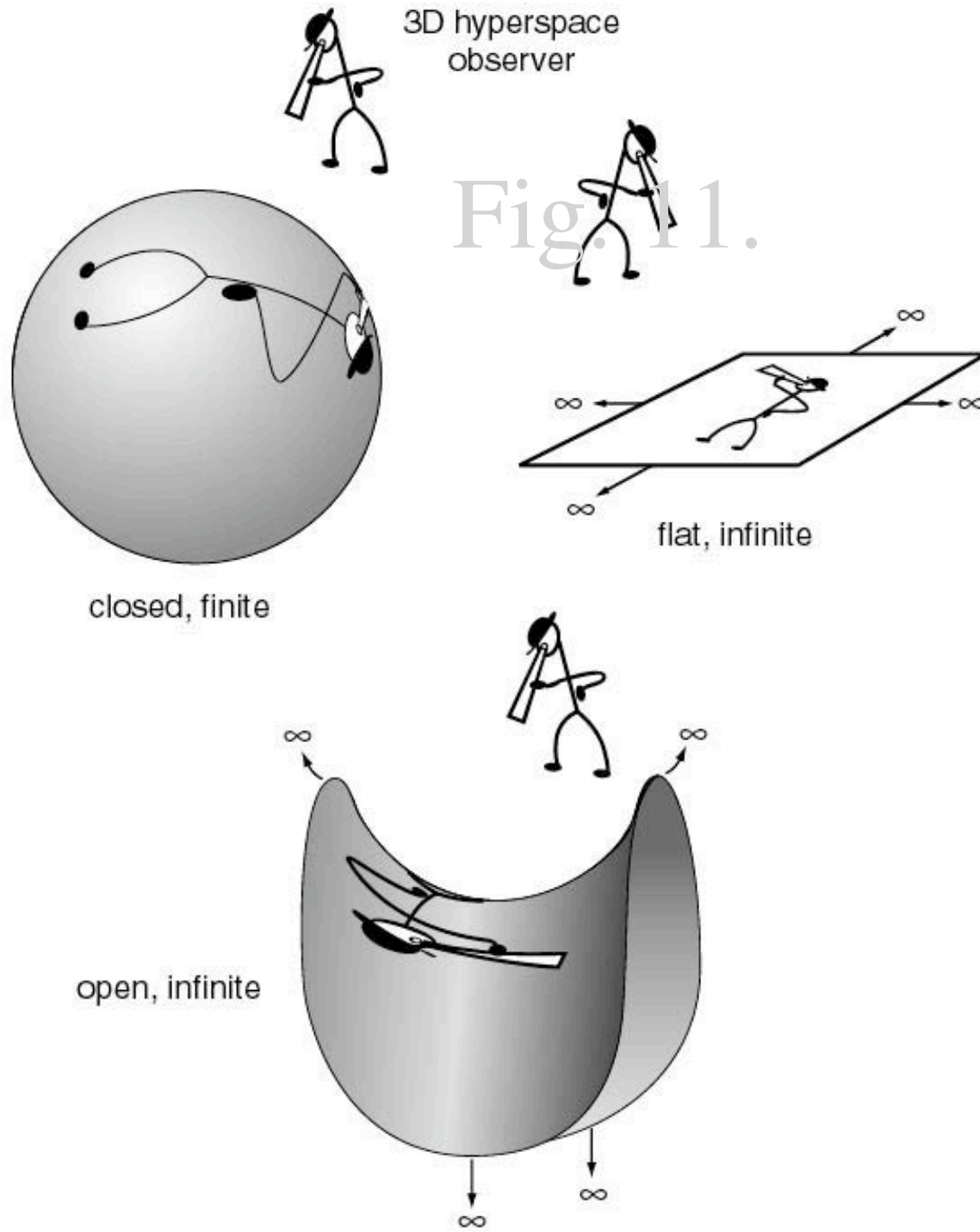


Fig. 11.1.

Fig. 11.1
2D
embedding
diagrams of
possible
shapes of our
3D Universe

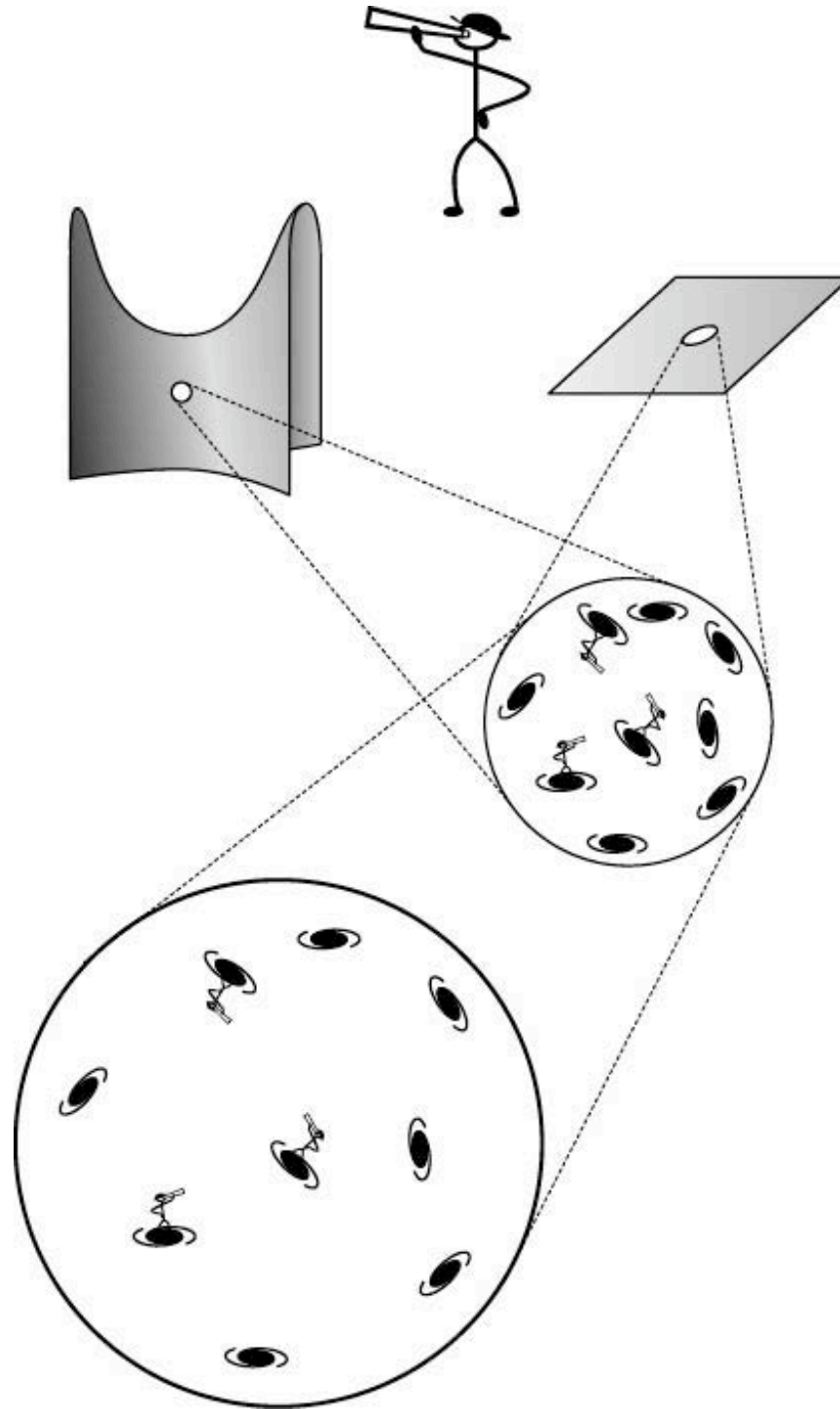


Fig 11.2

A patch of the space in a universe expands, drawing all galaxies away from all others, independent of the overall shape of the curvature of the universe.

Age and Fate of the Universe

All distances between distant galaxies are proportional to the time elapsed. Distance plus Velocity from the Doppler red shift
 \Rightarrow Age of Universe ~ 13.7 billion years

Fate of the Universe is intimately tied to the shape (we thought!)

Simplest choices: finite age, re-collapse (closed, “sphere,” high density,
high gravity)

expand forever, $v > 0$ (open, “Pringle,” low density,
low gravity)

Special Case: expand forever, $v \rightarrow 0$ as reach
infinity (flat, very special density and gravity)

In principle, we can figure out the shape and fate of our Universe by doing 3-D geometry in our 3-D Universe, in practice we often try to measure the density of the matter.