Friday, April 25, 2014

Fifth exam and sky watch, FRIDAY, May 2. Review sheet Monday. Review session Thursday, 5:00 PM.

Reading for Exam 5: Chapter 9 – Sections 9.6.1, 9.6.2, 9.7, 9.8; Chapter 10 - Sections 10.1-10.4, 10.9; Chapter 11 - all except Section 11.6 (abbreviated, focus on lectures); Chapter 12 - all; SKIP Chapter 13; **Chapter 14 – very abbreviated version.**

Electronic class reviews now available. Please respond. We find the feedback very valuable.

Astronomy in the news:
From Alicia Perry: Astronomers have found two supermassive black holes in the center of a normal galaxy. They should spiral in by gravity waves in a few million years. Why have they not already?

Update on new “nearby” supernova SN 2014J in M82

I have another draft paper to edit, comment upon. Nearly nightly spectra (very rare) from the optical through the infrared (also rare).

The data illuminate issues of the details of the propagation of deflagration and detonation waves and whether or not there might be a left-over binary companion.

Goal:

To understand the nature of cosmic gamma-ray bursts, how they may represent the birth of black holes or magnetars, and how they are connected with Type Ic supernovae.

The current picture: Gamma-ray bursts result from the collapse of a massive star from which the hydrogen and most of the helium have been stripped, probably to produce a black hole (but maybe a magnetar), that emits a tightly focused, highly relativistic jet.

Every burst, twice a day somewhere in the Universe - the birth of a black hole aiming its jet at us?

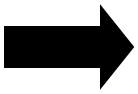
~100 aimed elsewhere for every one aimed at us.

Have not yet proven that black holes are involved. Tough problem!

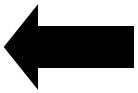
NASA Animation: Black Hole Forming in Star, producing jet and Gamma-Ray Burst

One Minute Exam

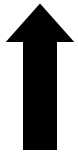
It is important to understand that gamma-ray bursts emit their energy in tightly collimated beams because otherwise



Estimates of the distance will be wrong



Estimates of the mass of the black hole formed will be wrong



Estimates of the energy emitted will be wrong

Estimates of the type of supernova in which they explode will be wrong.

Goal:

To understand what the “Dark Ages” of the Universe were, why they came to an end, and what gamma-ray bursts have to do with that.

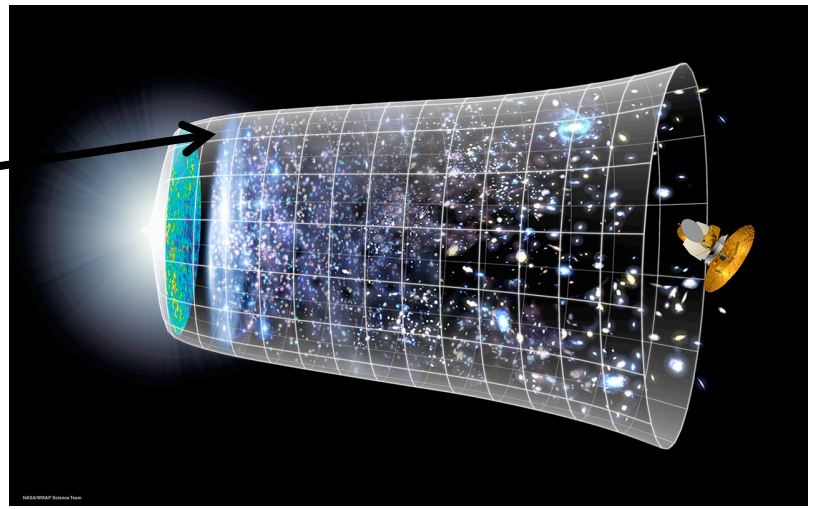
Gamma-ray bursts are intensely bright lights

Can be seen at great distance

Probe cosmology, the early Universe

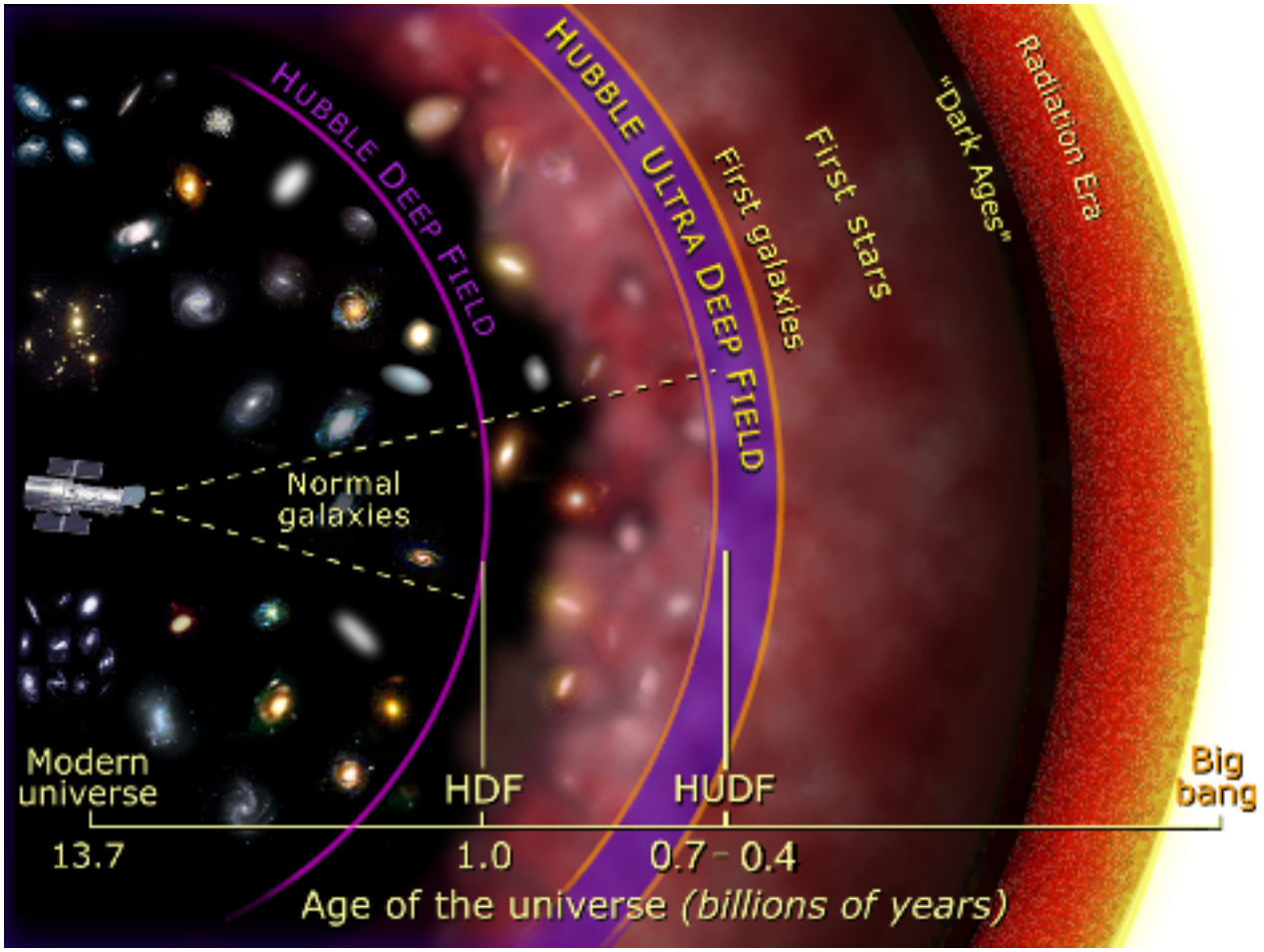
Dark Ages, after the Universe cooled off a million years after the Big Bang, before stars and Galaxies first formed half a billion years later

Dark Ages



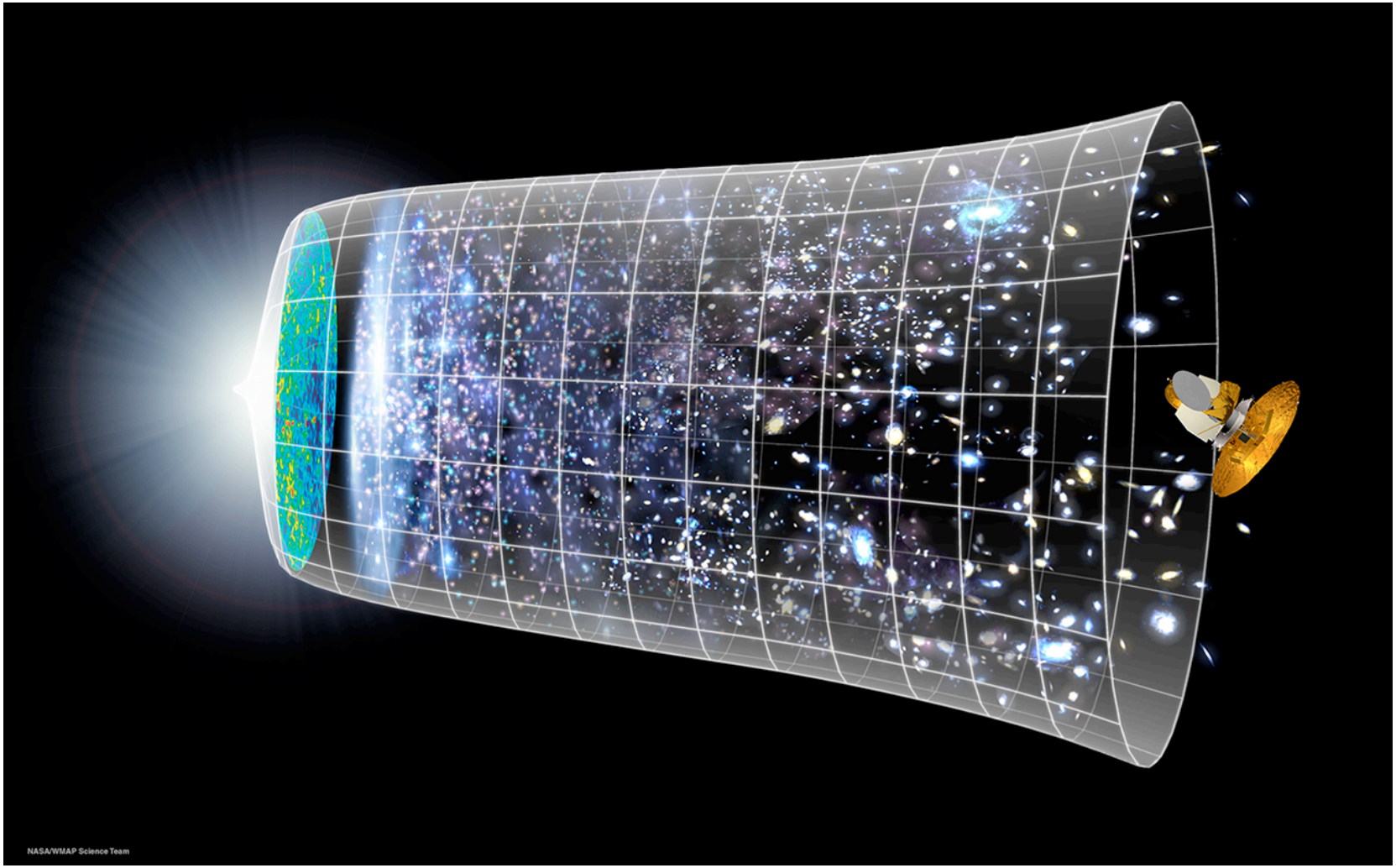
Point toward the Big Bang.

The past is all around us, in every direction, out in space, back in time.

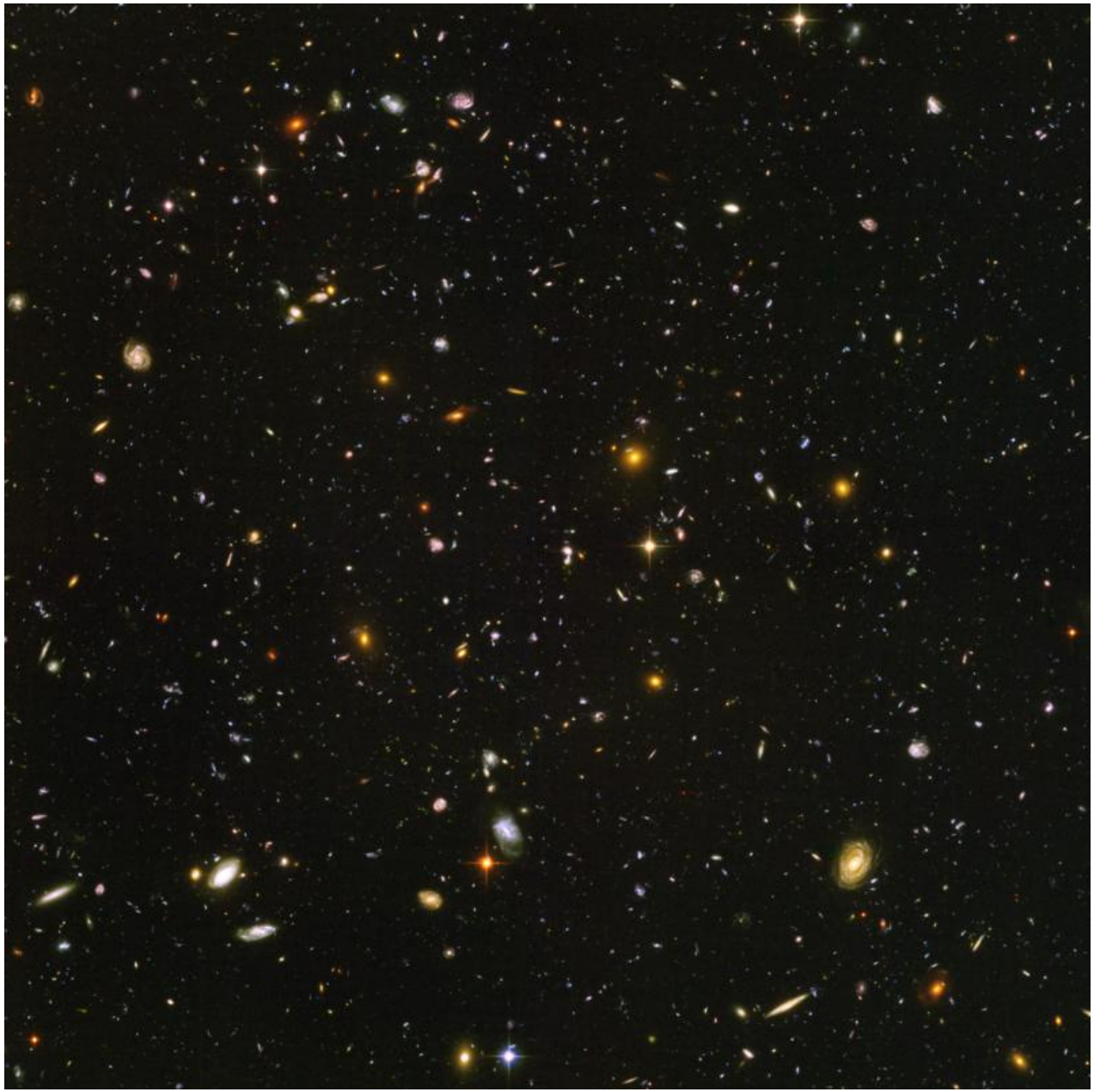


Gamma-ray bursts could be among the first objects seen at the end of the Dark Ages as the first stars are born and die, over 13 billion years ago. GRB 090423 is the first example.

From the Big Bang to Now



Hubble Deep Field – every speck a galaxy



Goal:

To understand the origin, shape, and fate of the whole Universe and how Type Ia supernovae have helped to revolutionize that understanding.

Chapter 12 Supernovae and the 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

Review:

What is hyperspace?

What is an embedding diagram?

Our Expanding Universe

Expanding ***surface*** of a balloon as an example

Expansion takes every point on the surface further from adjacent points.

2D embedding diagram of a 3D expanding Universe

No 2D center, no 2D edge, no 2D outside to the 2D surface

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

Our Expanding Universe

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 of how expansion does not necessarily mean intrusion into 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 13.8 billion years ago in the Big Bang.

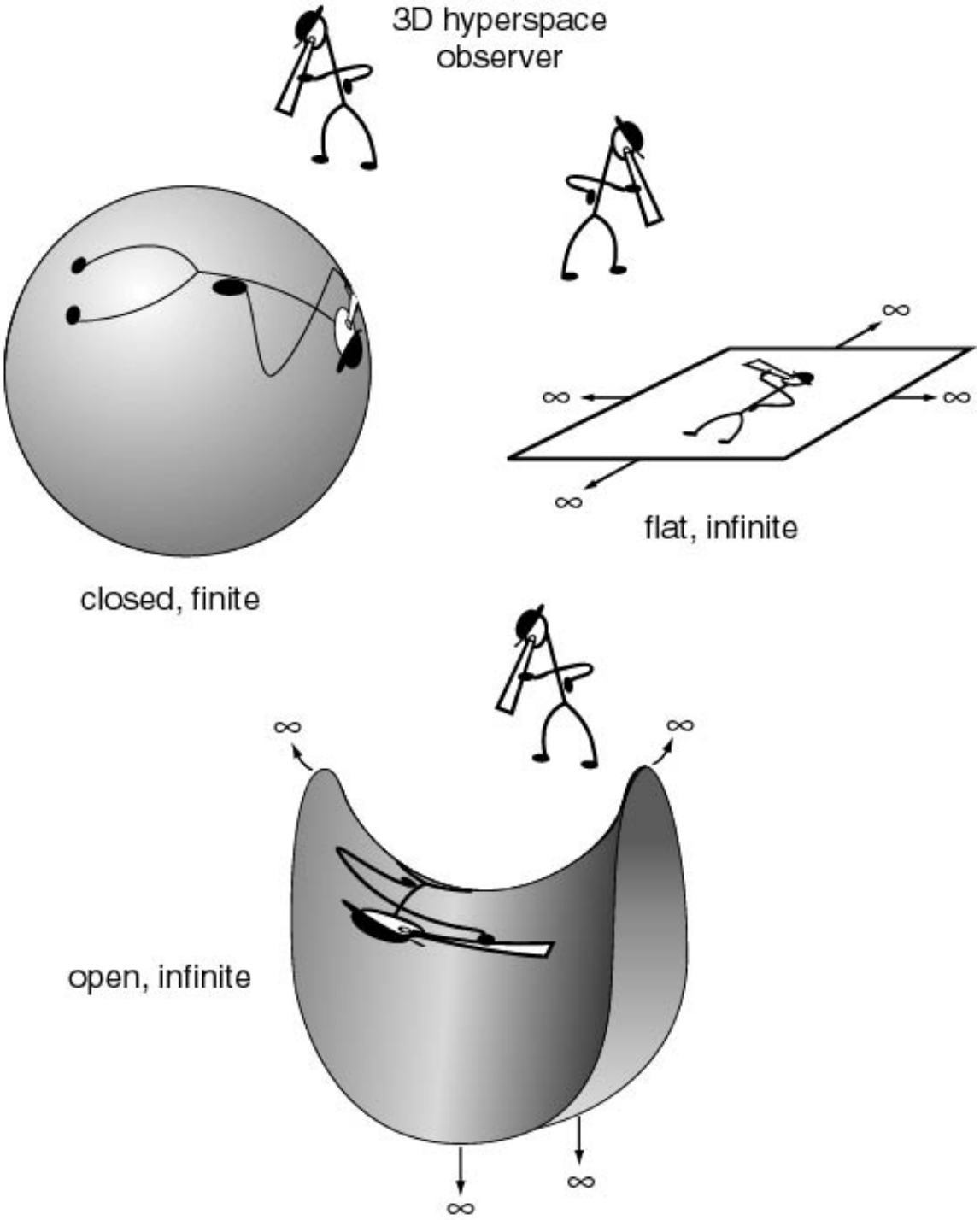


Fig. 11.1

2D embedding diagrams of possible shapes of our 3D Universe

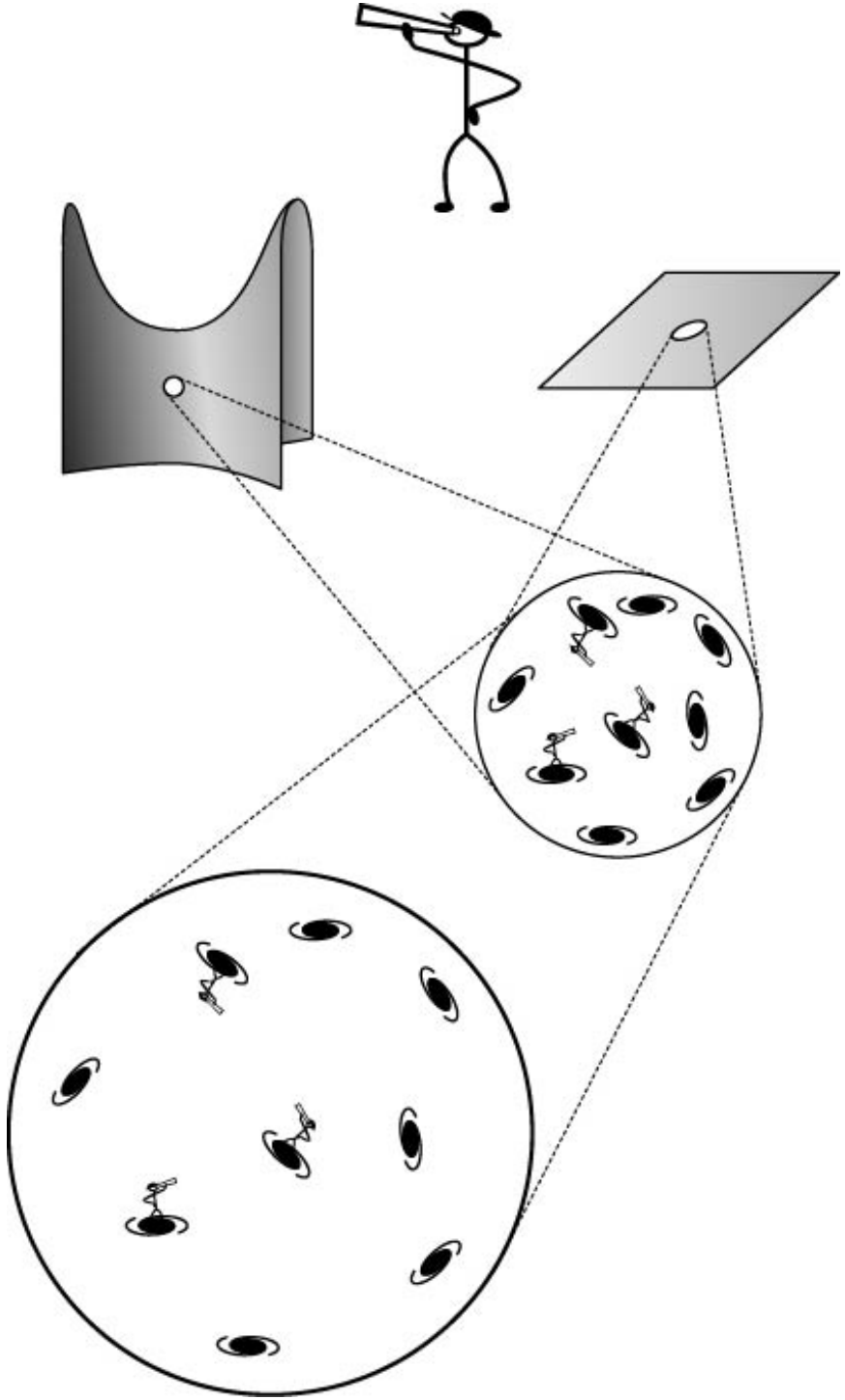
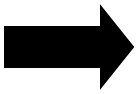


Fig 11.2

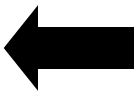
A patch of the space in a universe expands, drawing all galaxies away from all others, independent of the overall shape of the curvature of the universe.

One Minute Exam

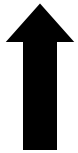
Einstein says that more distant galaxies move away from us more rapidly because:



The Earth is in the center of the Universe.



The Universe blew up in the Big Bang like a bomb blowing up in three-dimensional space.



Our 3D Universe expands into a 4D hyperspace.

Space expands, carrying all distant galaxies further apart from one another.

Age and Fate of the Universe

All distances between distant galaxies are proportional to the time elapsed; distance = velocity x time.

Distance divided by the Velocity from the Doppler red shift

$\Rightarrow$ Age of Universe ~13.8 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.