Wednesday, April 27, 2016

Fifth exam and sky watch, FRIDAY, May 6.

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; Chapter 13 (skip) - all; Chapter 14 - all

Electronic Class Evaluation now available. Please do this!

Astronomy in the news?

Because time passes more slowly deep in a gravity well, the center of the Earth is about 2.5 years younger than the surface.

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.

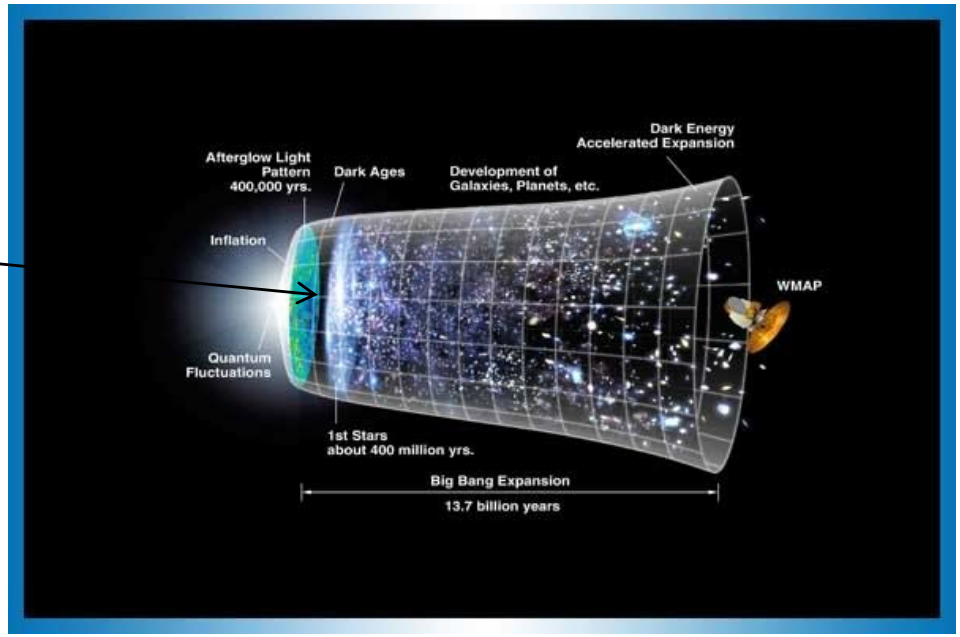
Gamma-ray bursts are intensely bright lights

Can be seen at great distance

Probe cosmology, the early Universe

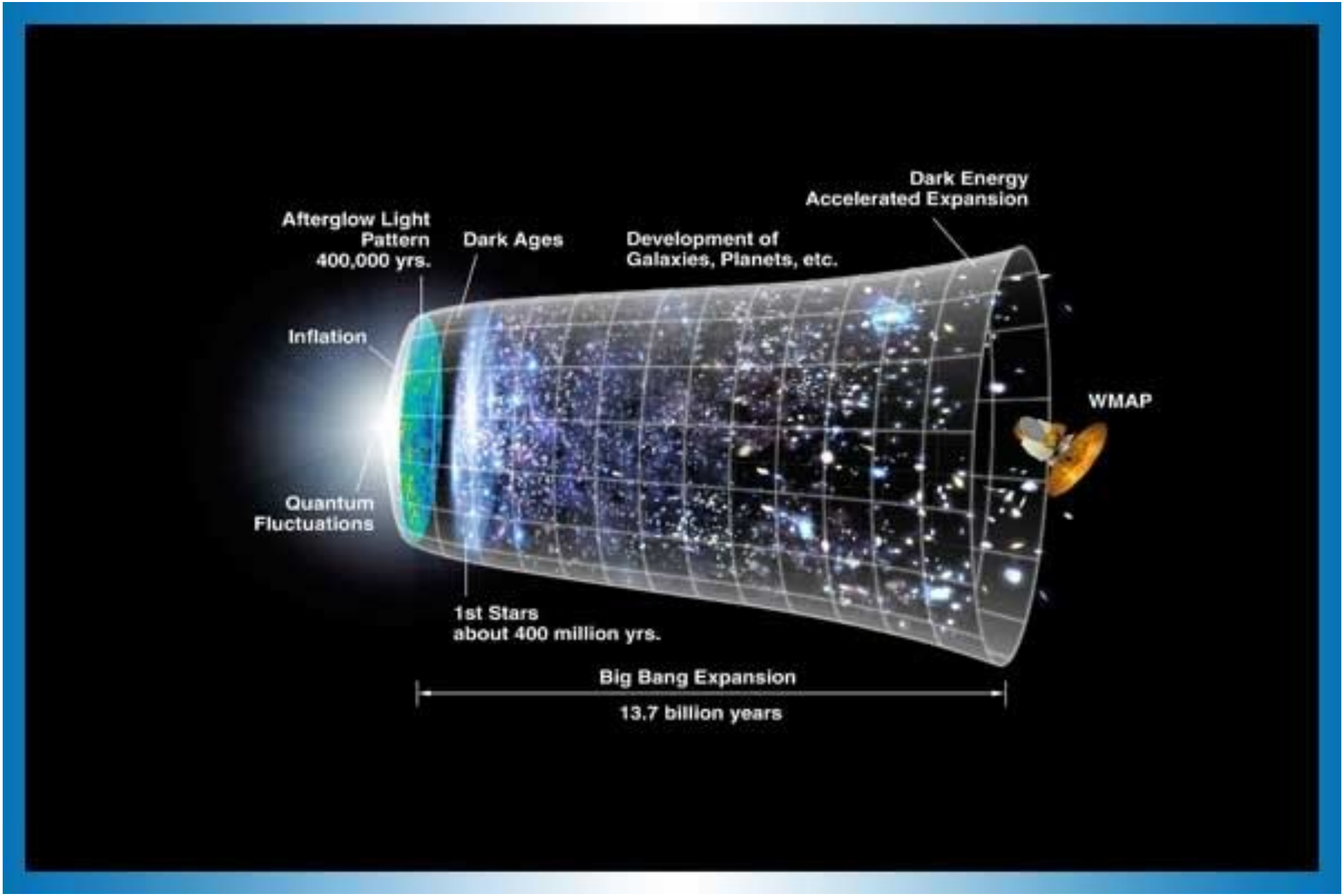
Dark Ages, after the Universe cooled off a million years after the Big Bang, before stars and Galaxies first formed half a billion years later

Dark Ages



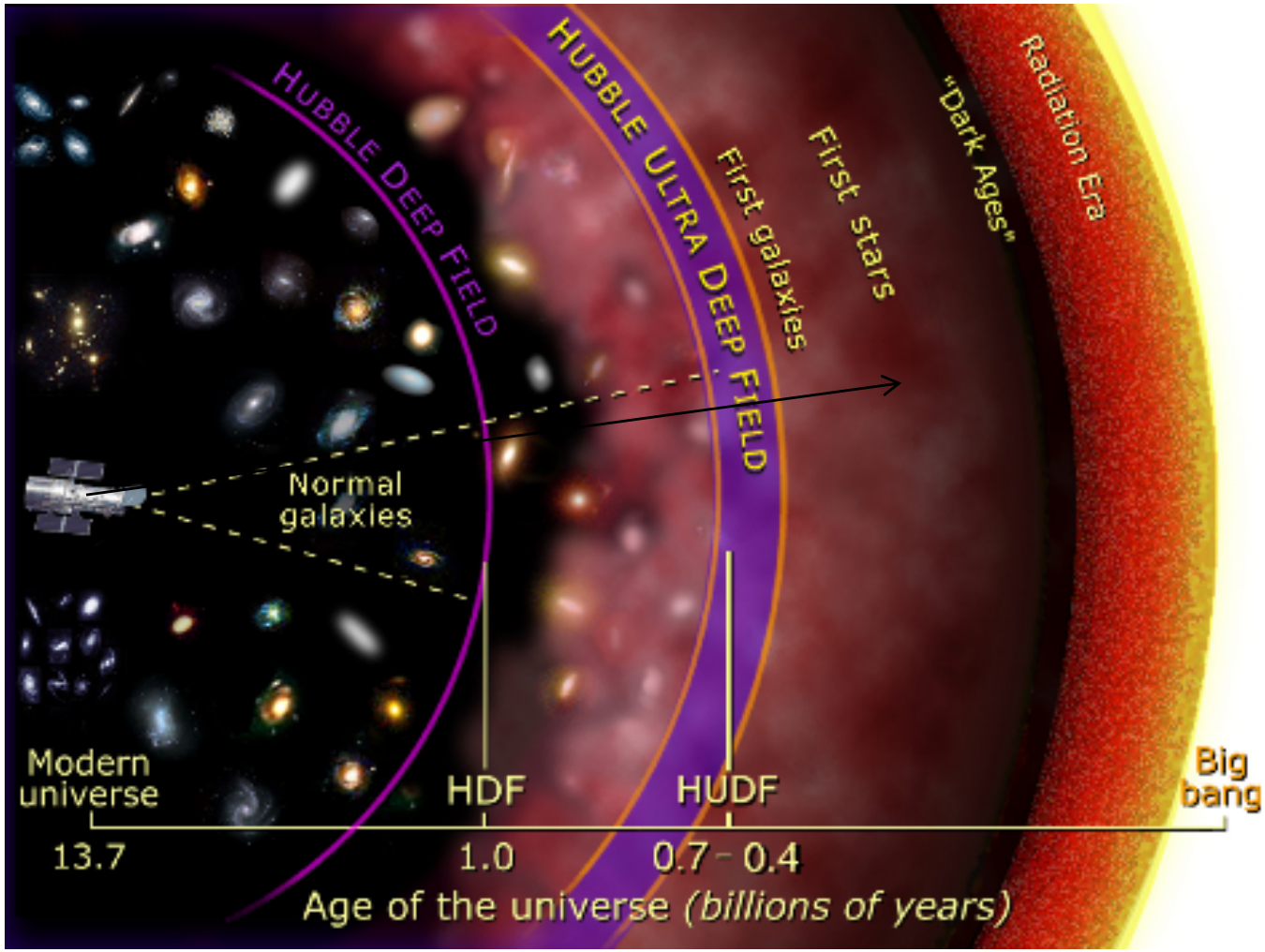
Point toward the Big Bang.

From the Big Bang to Now



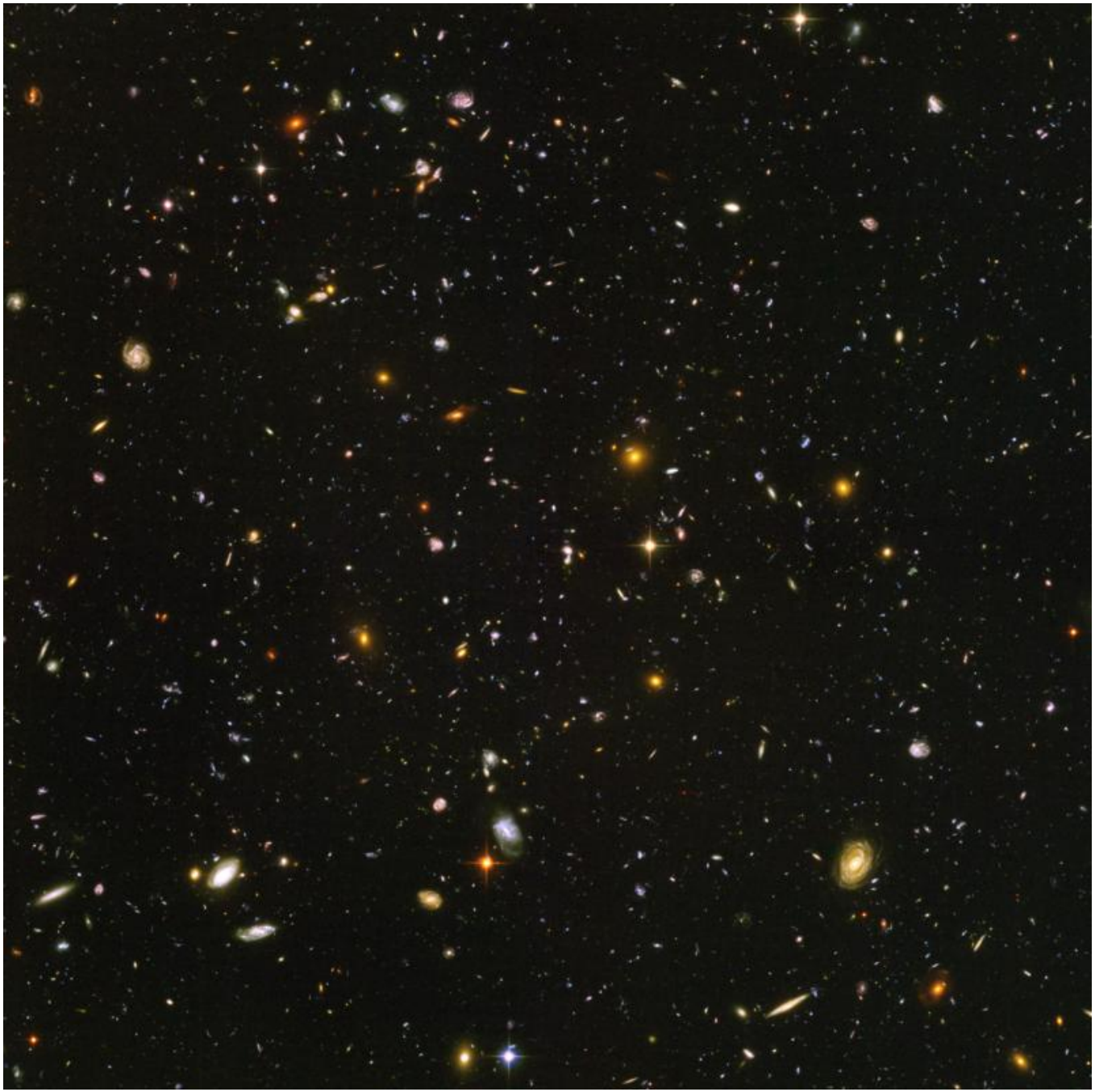
The past is all around us, in every direction, out in space, back in time.

James Webb Space Telescope, 2018, first stars



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.

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.

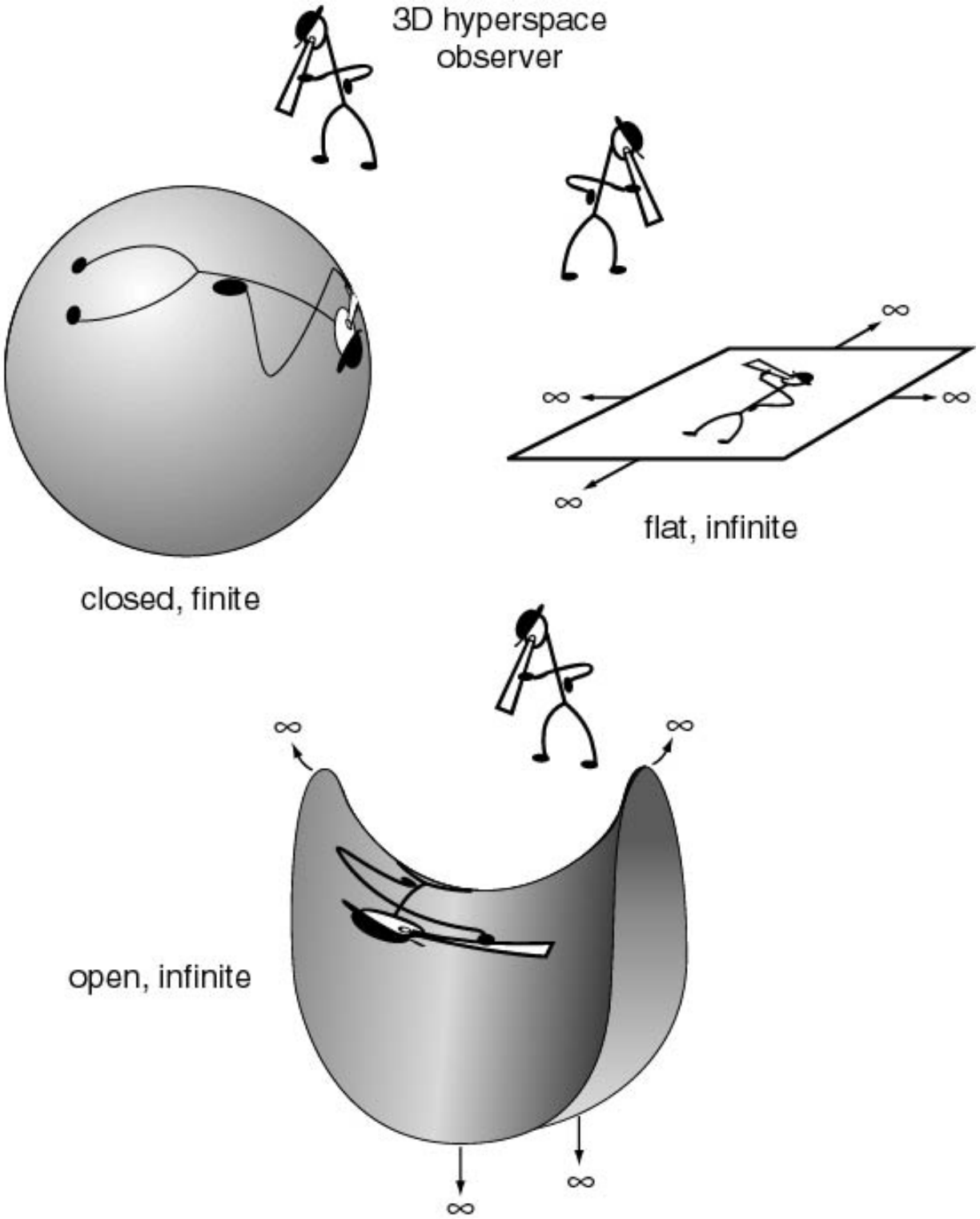


Fig. 11.1

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

Fig 11.2

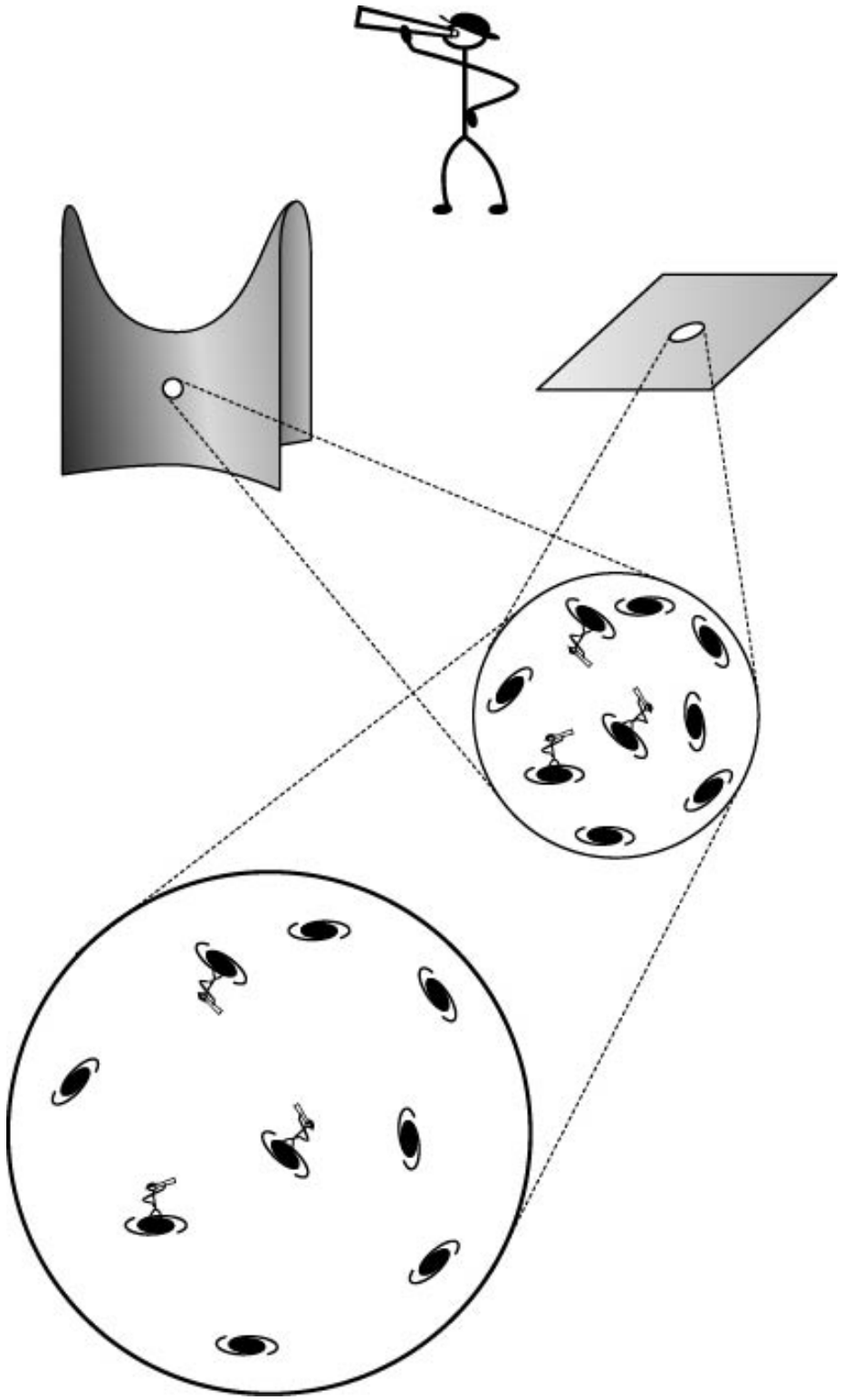
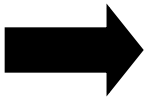


Fig 11.2

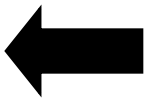
A patch of the space in a universe expands, drawing all galaxies away from all others, independent of the overall shape of the curvature of the universe.

One Minute Exam

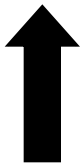
Einstein says that more distant galaxies move away from us more rapidly because:



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

☞ 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 🎭 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.

Goal:

To understand the nature of dark matter and how it affects the Universe.

Dark Matter

Most ***gravitating*** matter in the Universe is mysterious ***Dark Matter***

Not composed of p, n, e - the stuff of stars, galaxies, planets, and people

Dark Matter was ***never*** composed of that stuff (or would upset observed mix of hydrogen and helium from the Big Bang), so also not black holes once made from ordinary star stuff.

Some yet undiscovered particles that only interact by gravity and by the weak nuclear force, no electrical force, no strong nuclear force:
5 more total density and mass than "normal" stuff stars, gas, etc.