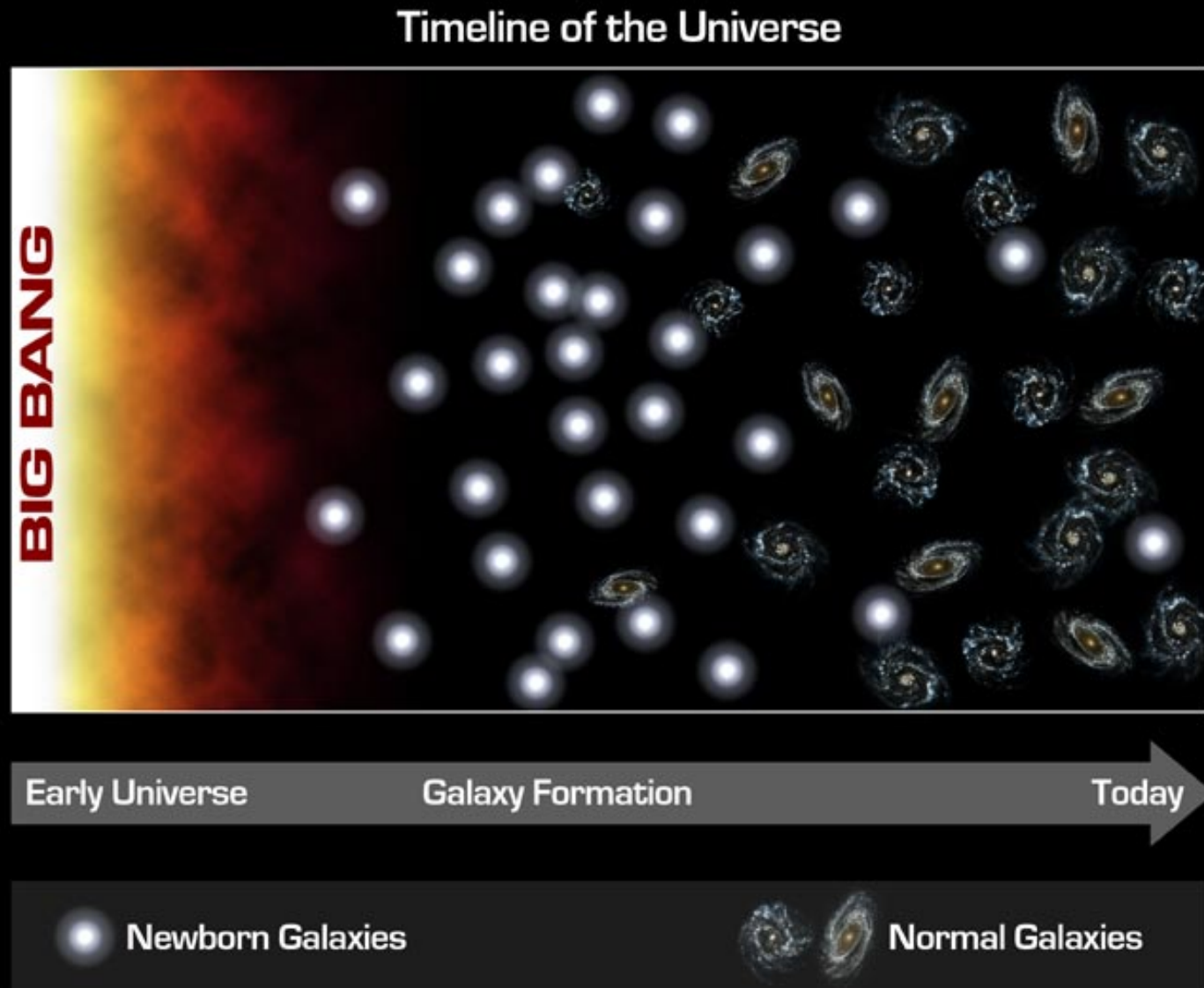


Introduction to the Universe

The universe began 13 billion years ago



The universe is expanding in all directions



Lecture Tutorial: The Big Bang

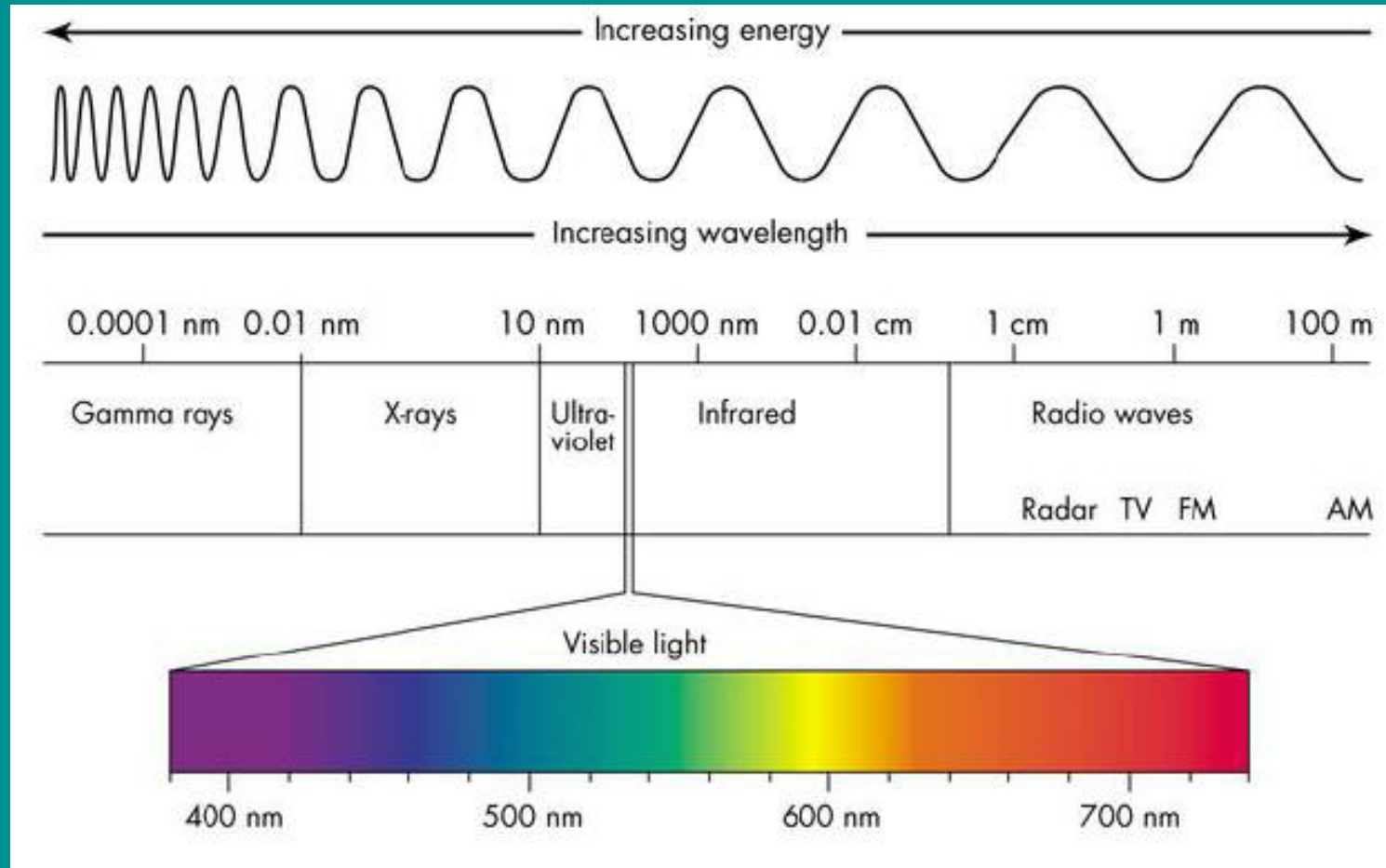
How do we *know* the universe is expanding?

The Doppler Shift: A change in the wavelength of a wave due to motion



Burkland.wmv

Light is also a wave

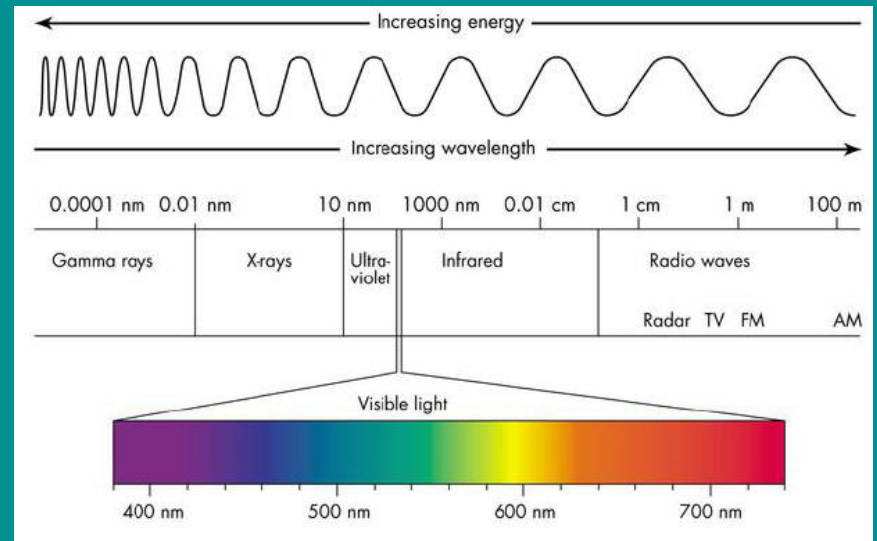


If you increase the wavelength of light, the light becomes:

(A) Redder

(B) Bluer

(C) Stays the same in color



You are in a spaceship flying away from a star. Compared to the light you would see if you were stationary, the light from that star will look:

(A) Redder

(B) Bluer

(C) The same in color

You are in a spaceship flying towards a galaxy. Compared to the light you would see if you were stationary, the light from that galaxy will look:

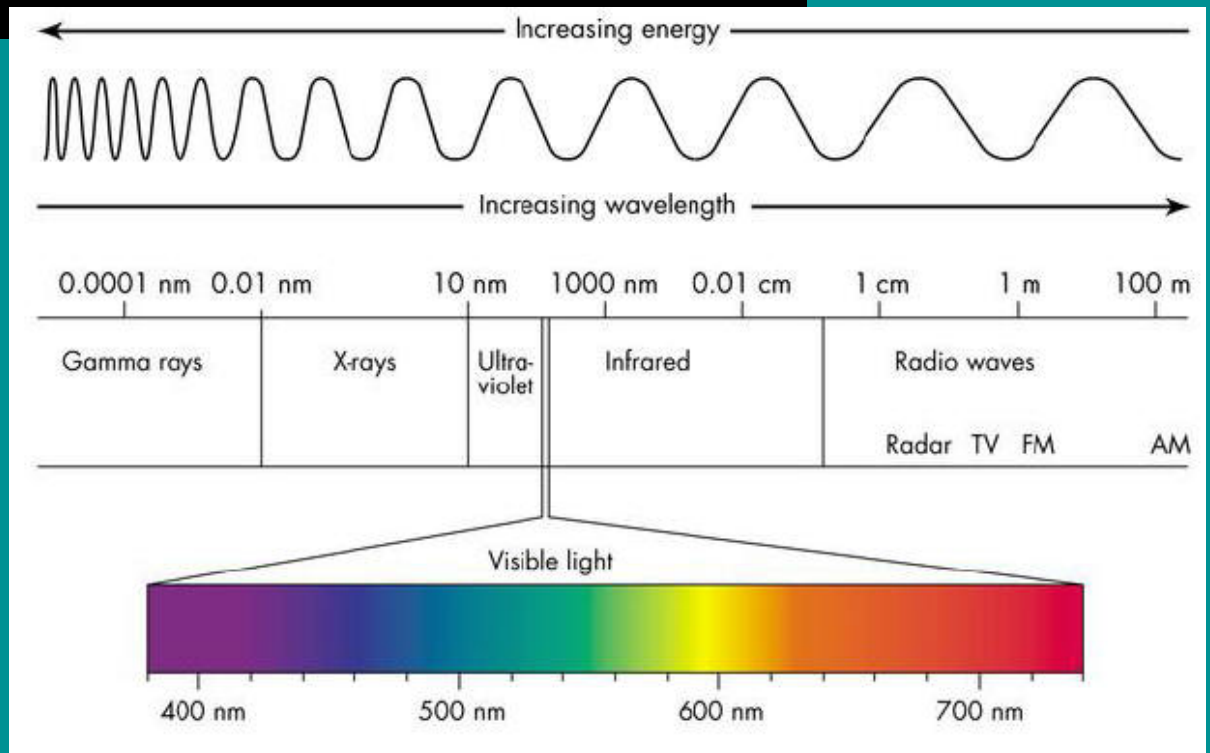
(A) Redder

(B) Bluer

(C) The same in color

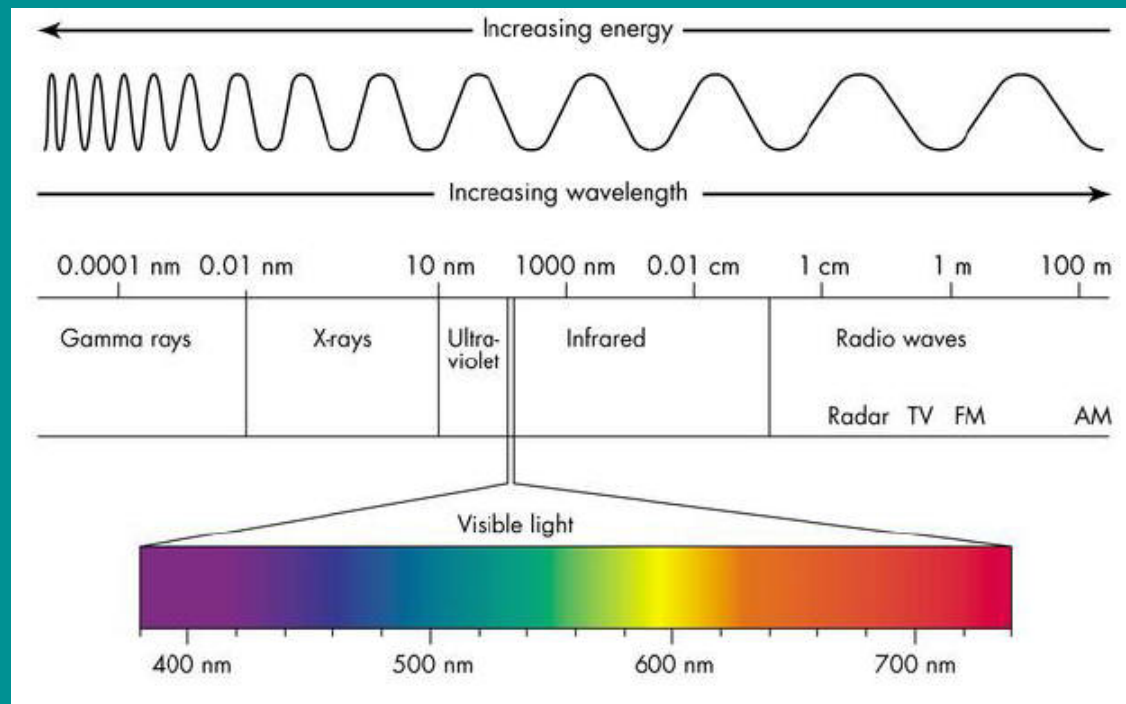
Which of the following bands of the electromagnetic spectrum has photons with the **largest wavelength**?

- A) X-Rays (or Gamma-Rays)
- B) Visible (or UV or IR)
- C) Microwave (or Radio)
- D) Choices A, B, & C all have the same wavelength



You are in a spaceship flying away from a star. When you were stationary, the starlight was in the visible light part of the electromagnetic spectrum. What part of the electromagnetic spectrum *might* the starlight appear to be in now?

- (A) Gamma ray
- (B) X ray
- (C) Ultraviolet
- (D) Infrared

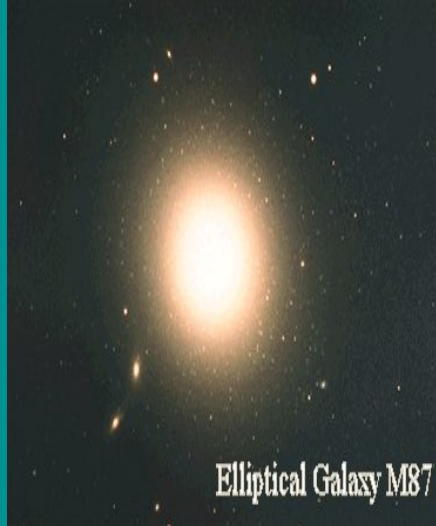


There are hundreds of billions of galaxies in the universe

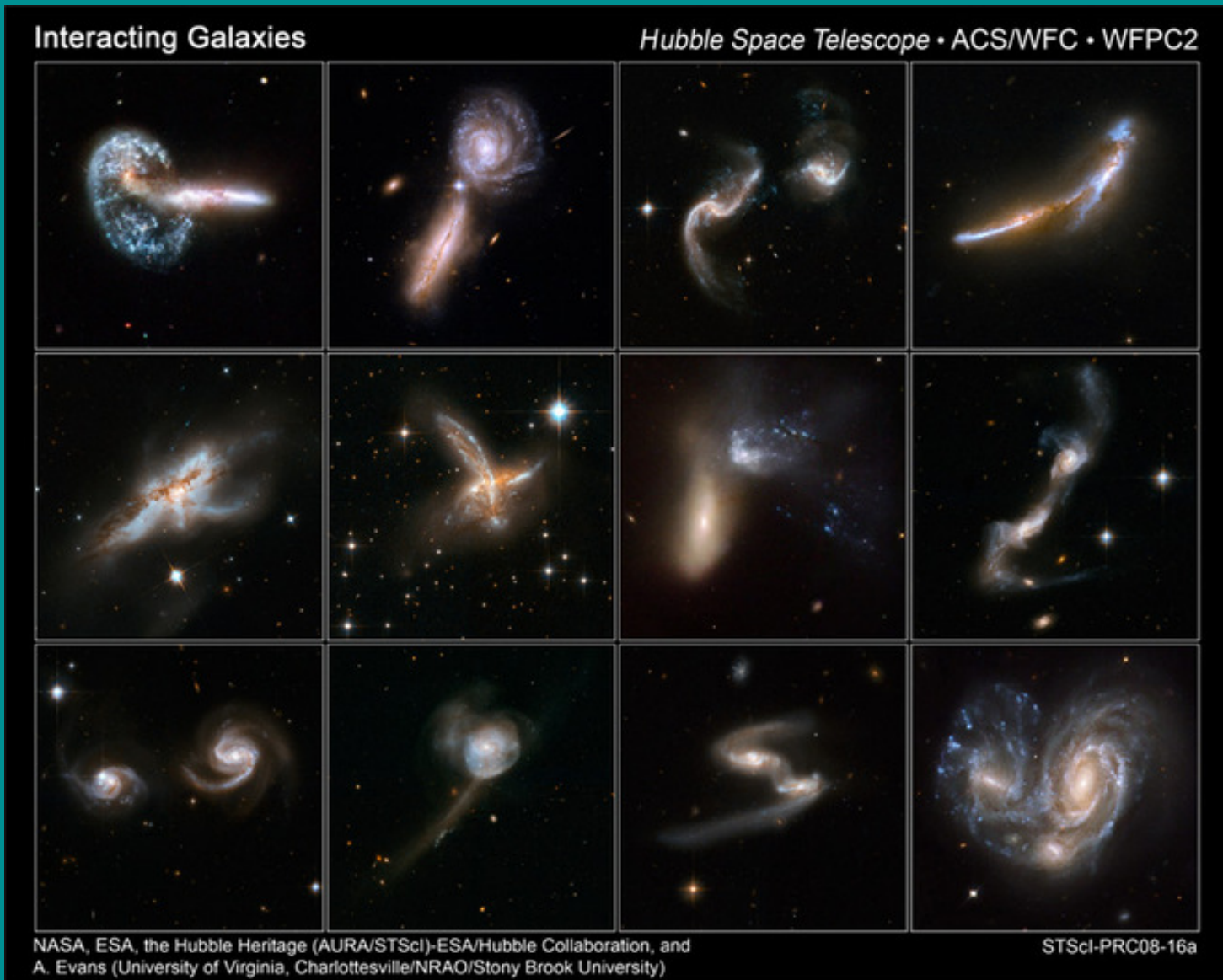


The Hubble
“deep field”

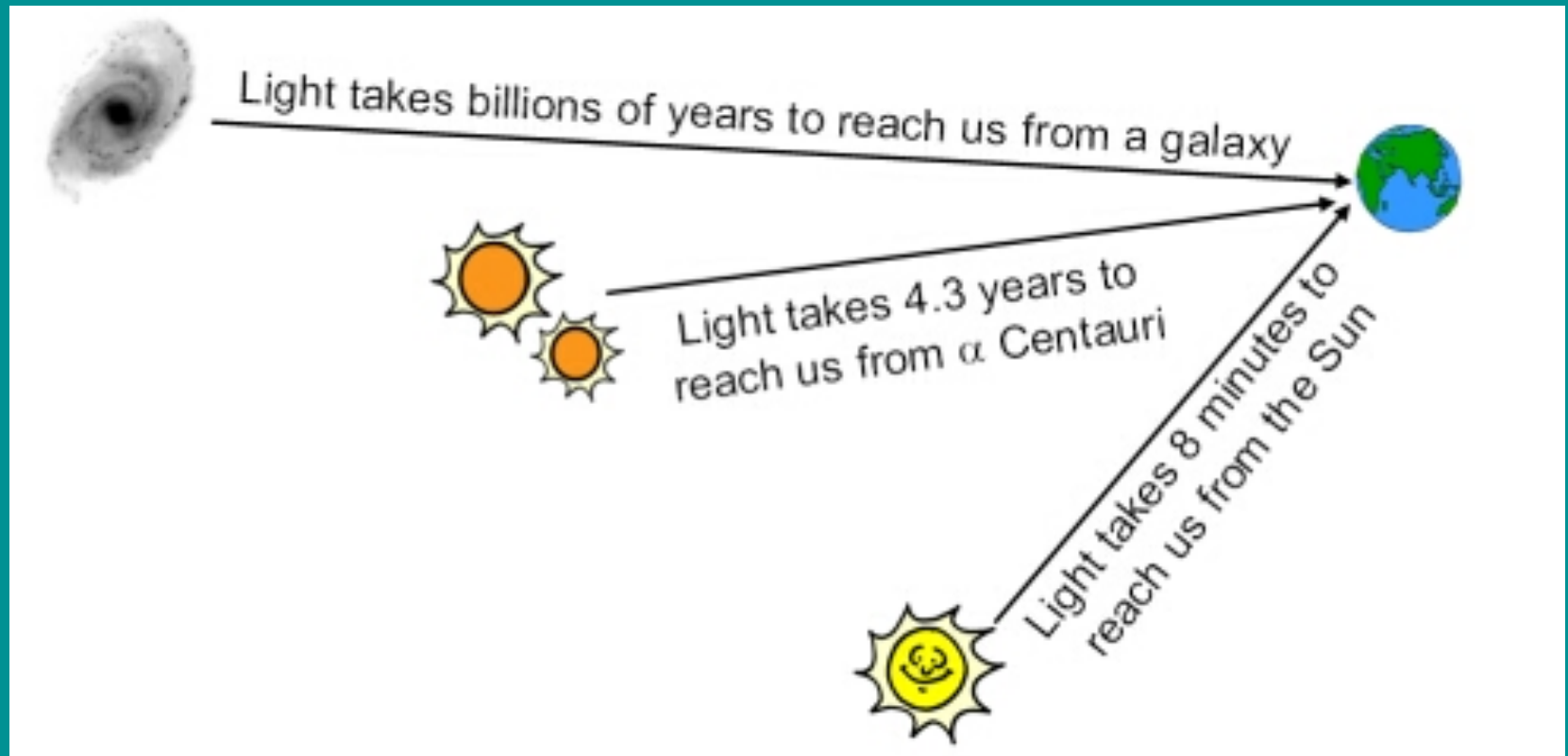
Galaxies come in many shapes and sizes.
Each galaxy is made of hundreds of billions of stars



They are shaped by collisions



The farthest known galaxy is 13 billion light years away. So, the light we see left this galaxy 13 billion years ago.



A light year is the *distance* travelled by light
in one year.

The galaxy *closest* to the Milky Way is the Andromeda Galaxy. It is so far away, that the light that reaches us left the galaxy 2.9 MILLION years ago.



Lecture Tutorial: Looking at Distant Objects

What is the distance to the nearest star?

How far away is the nearest galaxy?

How far away is the nearest quasar?

How far away is the nearest black hole?

How far away is the nearest supernova?

How far away is the nearest pulsar?

How far away is the nearest nebula?

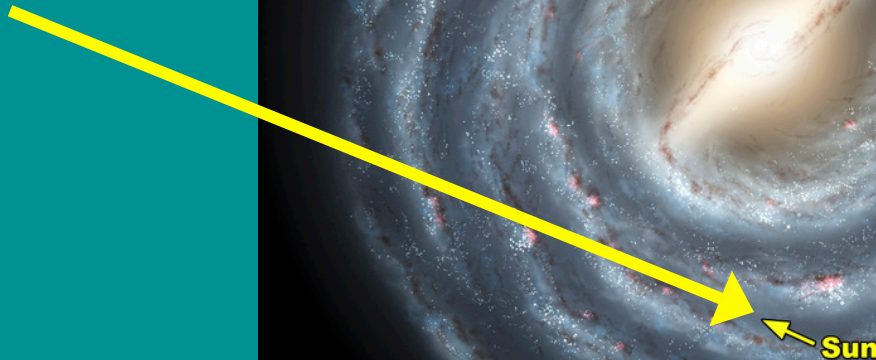
How far away is the nearest galaxy cluster?

Our galaxy is called the Milky Way.

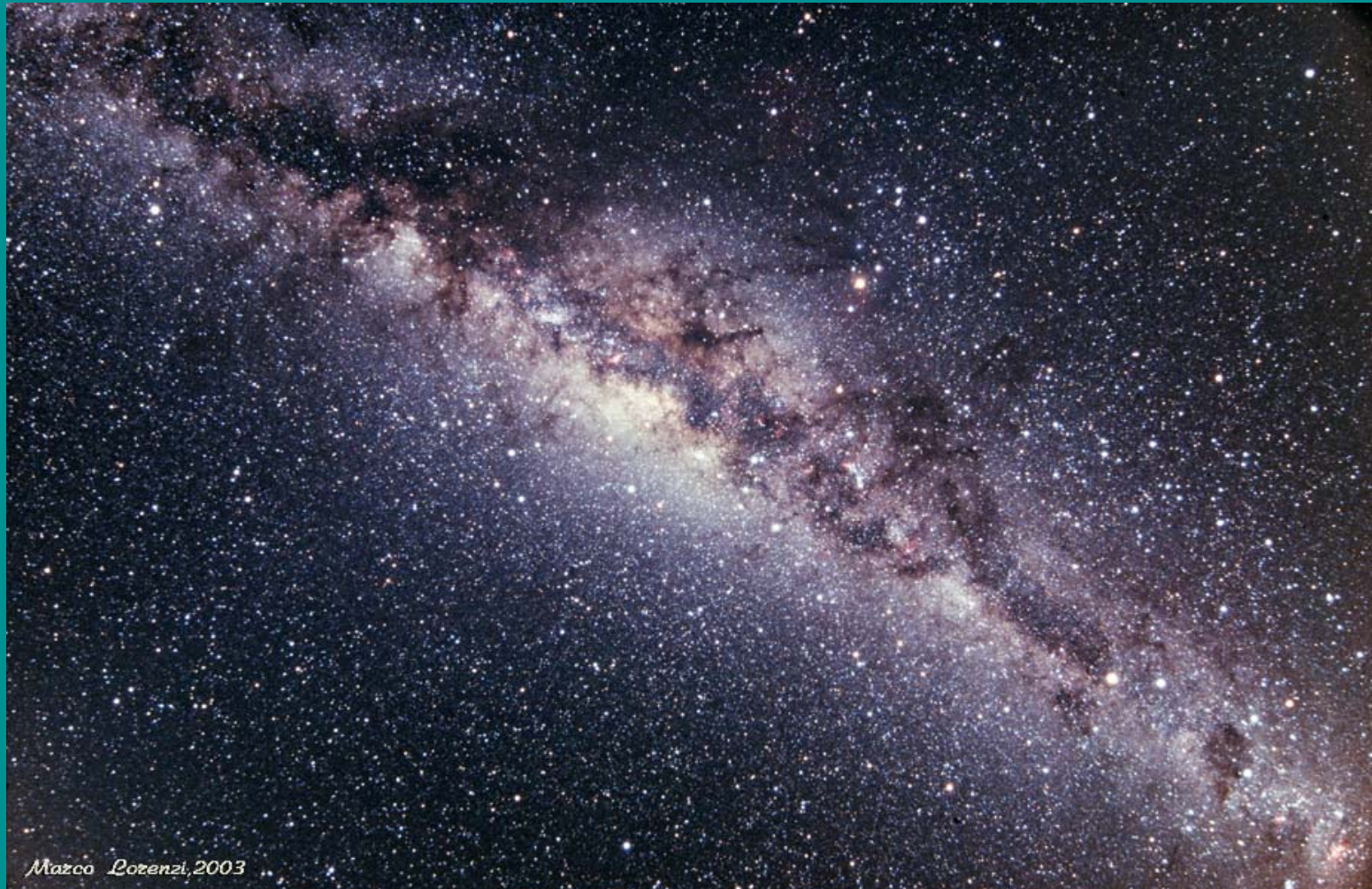
It is a spiral galaxy.

If we could see it from afar, it would look something like this:

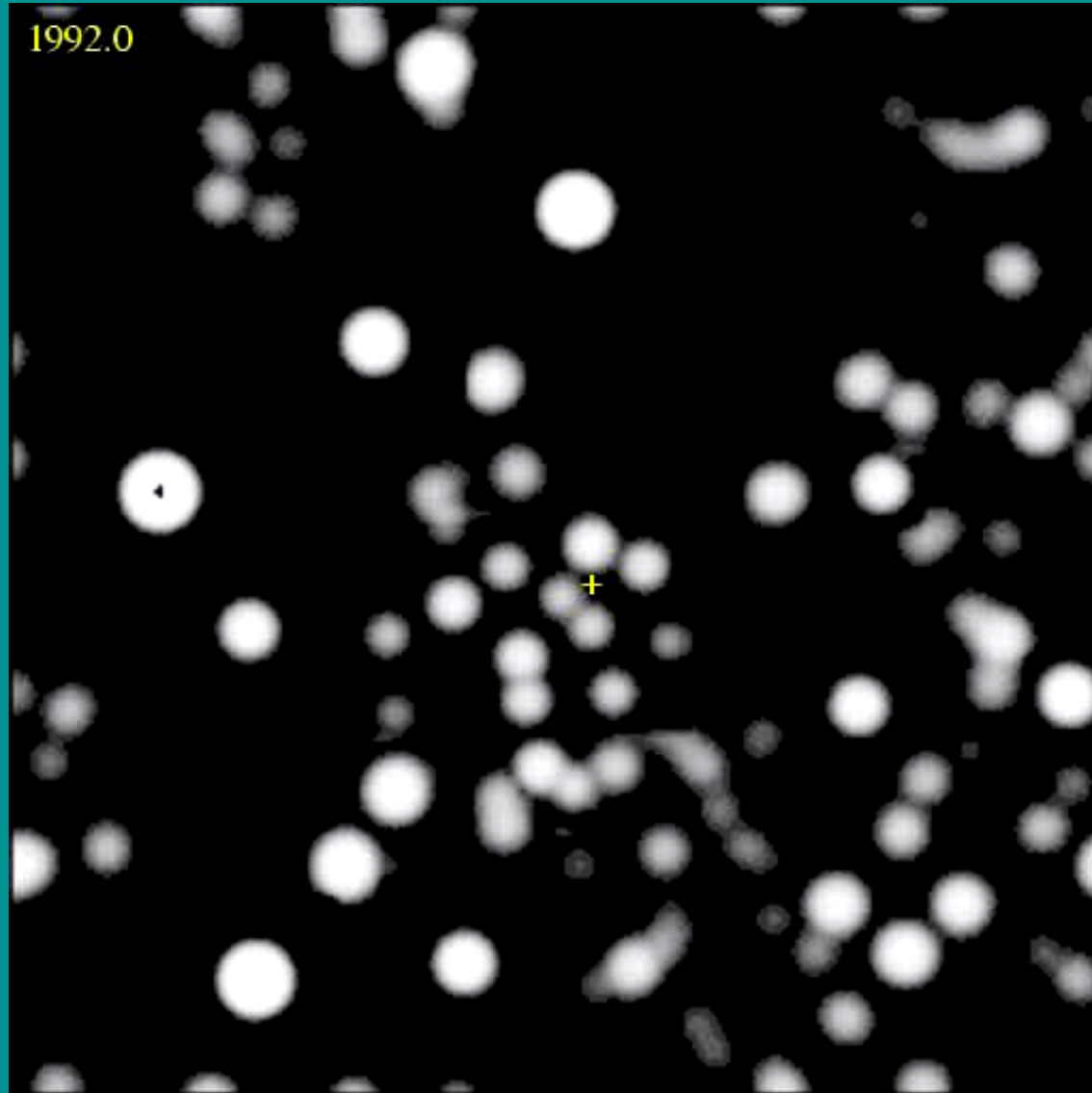
The sun



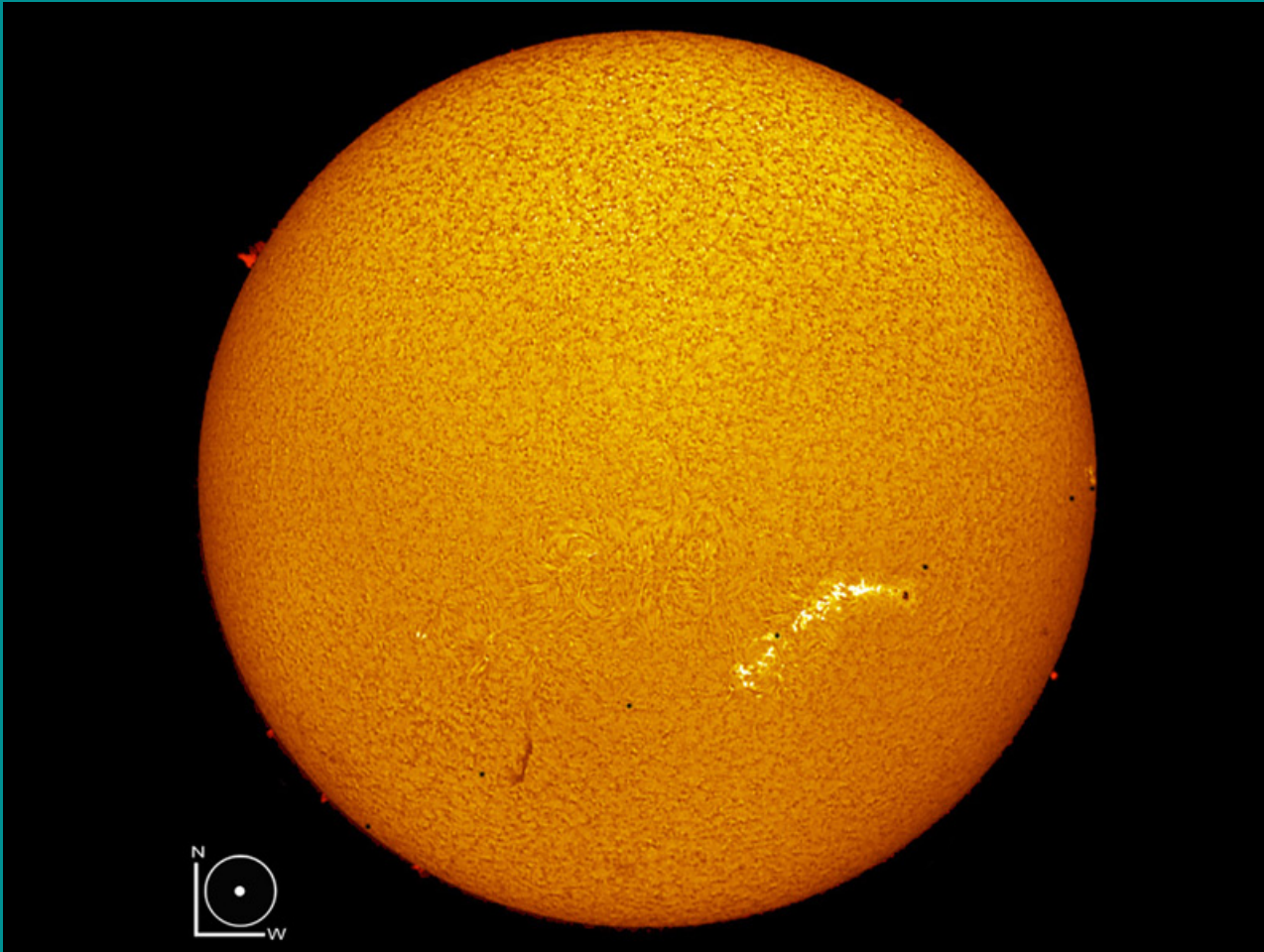
Because we live inside of the the Milky Way,
it looks like this instead:



The Milky Way consists of hundreds of billions of stars
and has a black hole at its center.



Our sun lies 10^{11} meters away from us.
(this is 8 light minutes)

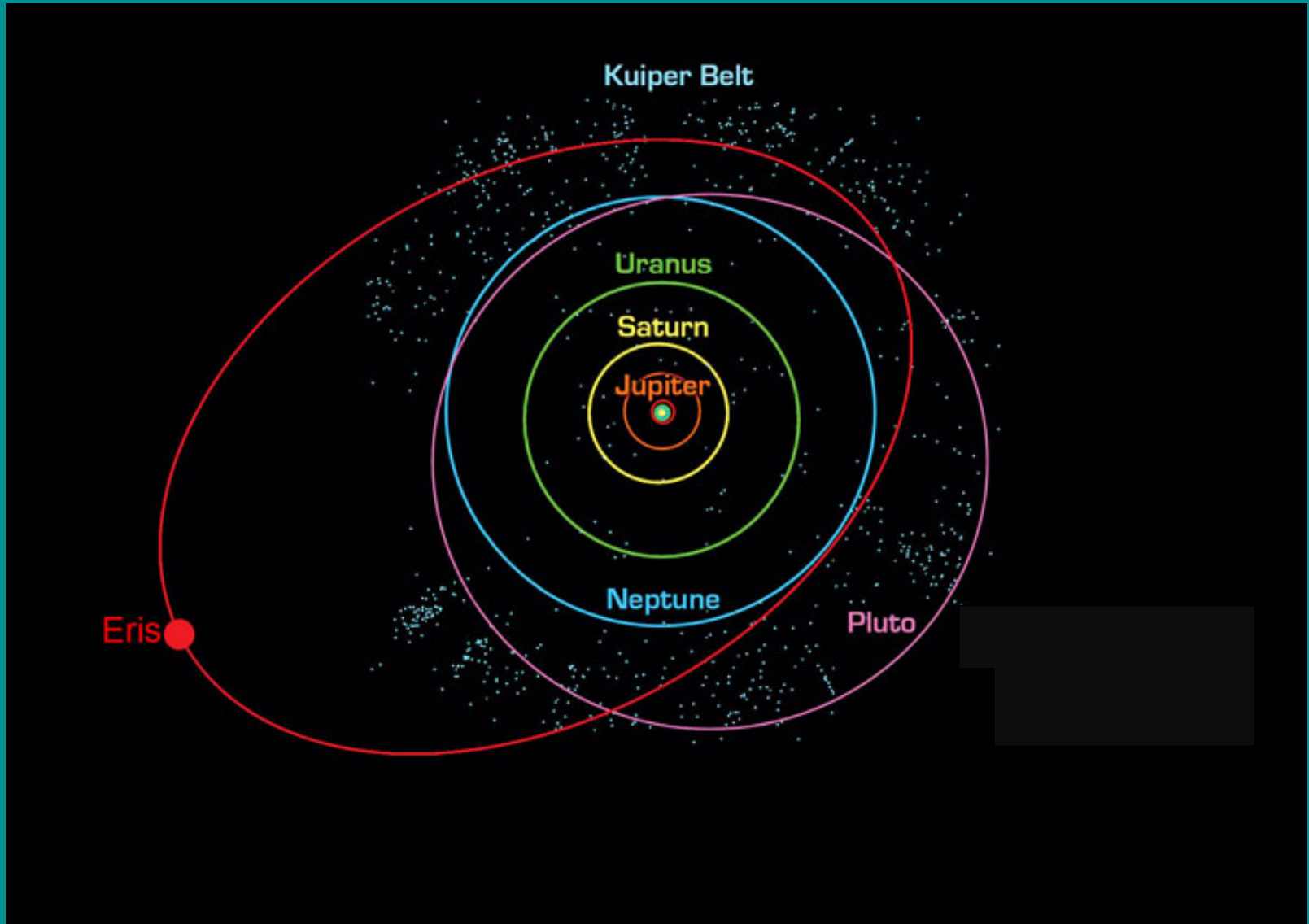


Our sun lies 10^{11} meters away from us.
(this is 8 light minutes)

8 light minutes is the _____ that light travels
in a time of _____

We live in the solar system.

Here is a diagram of the planetary orbits.



What might the solar system actually look like from afar?

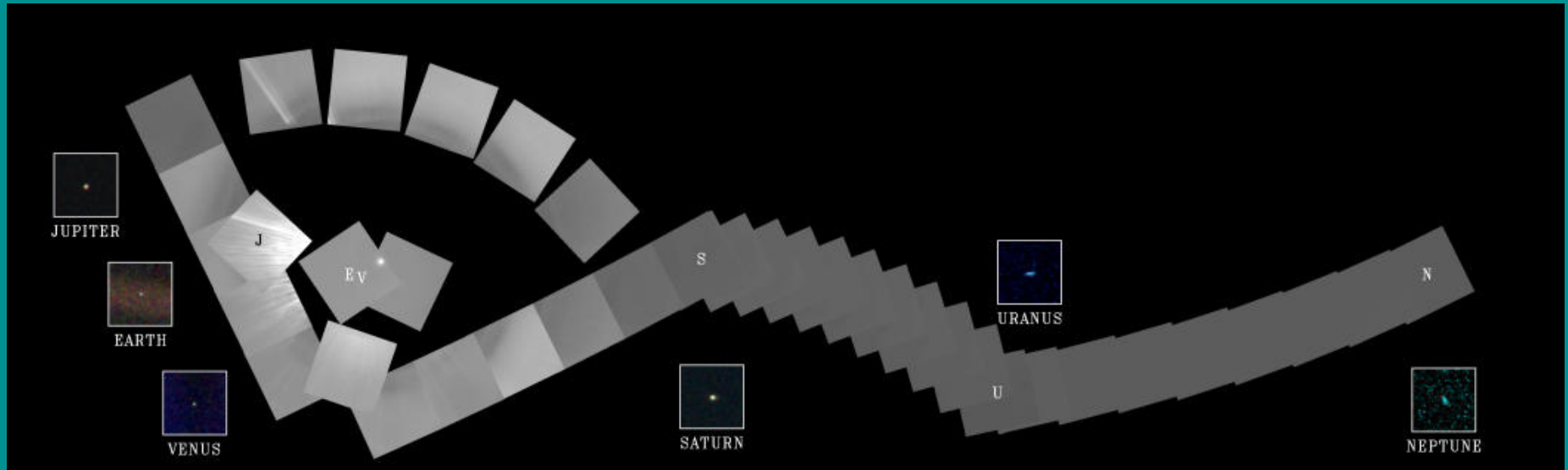
What might the solar system actually look like from afar?



This is a photo of
Alpha Centauri

What does the Earth look like from afar?

A solar system portrait from the Voyager spacecraft.



What does the Earth look like from afar?

A portrait of the Earth from the Cassini spacecraft.



Lecture Tutorial: Milky Way Scales

What is the size of the Milky Way?

Activity: What is your cosmic address?

Street number/PO Box, City, State, Country

P.O. Box 3129, Sells, AZ, USA

Introductory Concepts: Scale

Adapt Question:

In the organizational diagram below, the term **Earth** would most appropriately fit in the area labeled...?



(A) Solar System (B) Milky Way (C) Universe

Show Answer

Introductory Concepts: Scale

Adapt Question:

In the organizational diagram below, the term **Saturn** would most appropriately fit in the area labeled...?



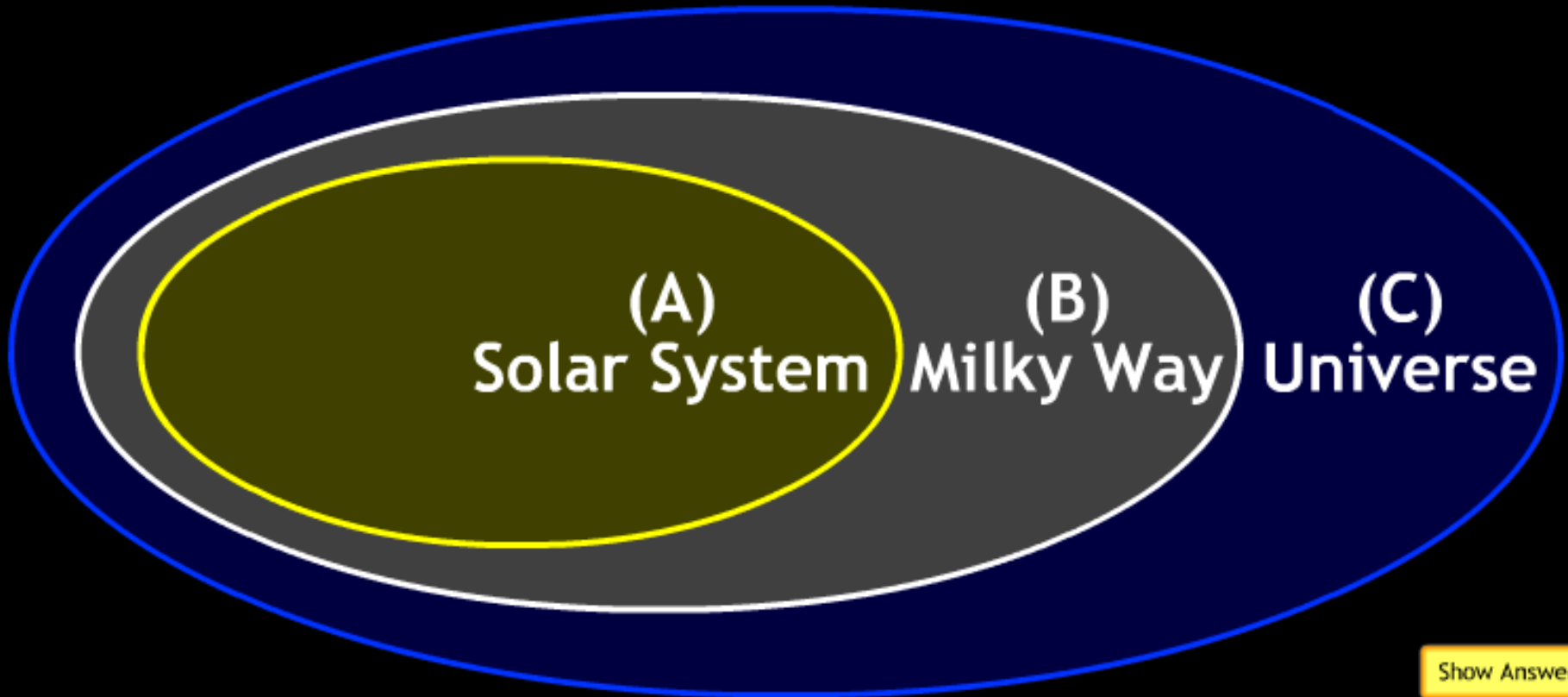
(A) Solar System (B) Milky Way (C) Universe

Show Answer

Introductory Concepts: Scale

Adapt Question:

In the organizational diagram below, the **star Alpha Centauri** would most appropriately fit in the area labeled...?

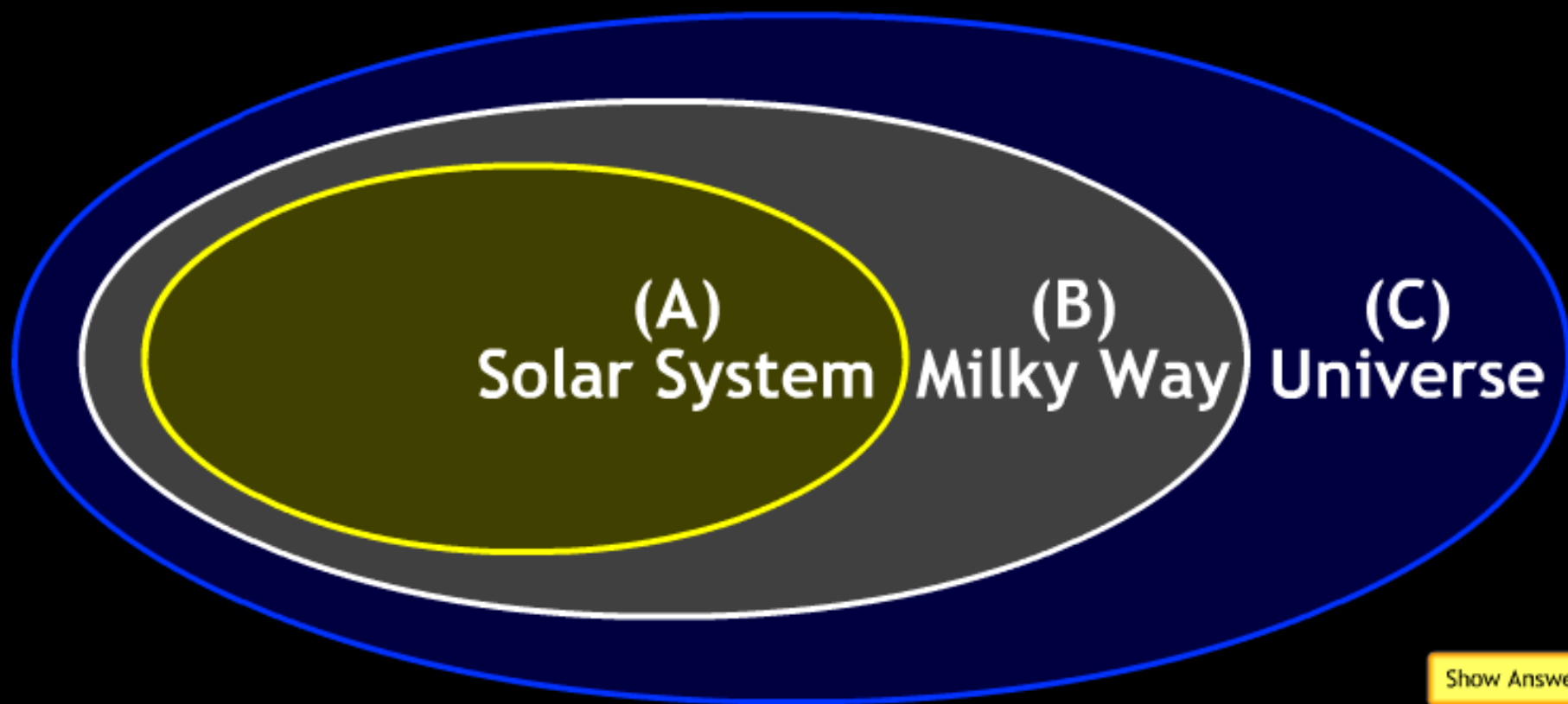


Show Answer

Introductory Concepts: Scale

Adapt Question:

In the organizational diagram below, the term **Andromeda Galaxy** would most appropriately fit in the area labeled...?



Show Answer