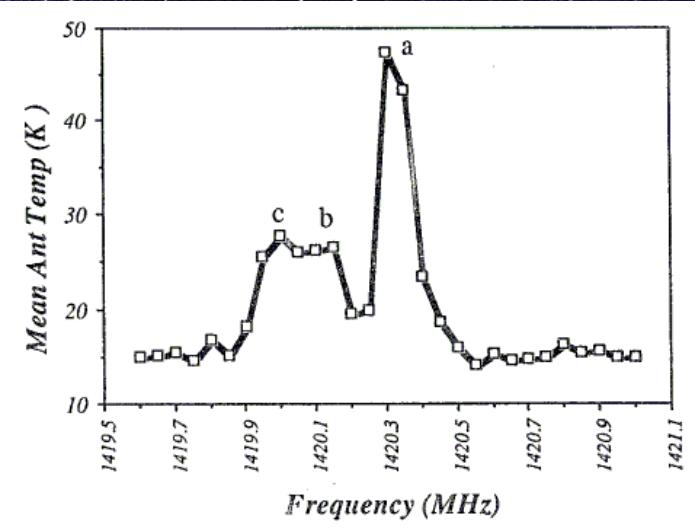
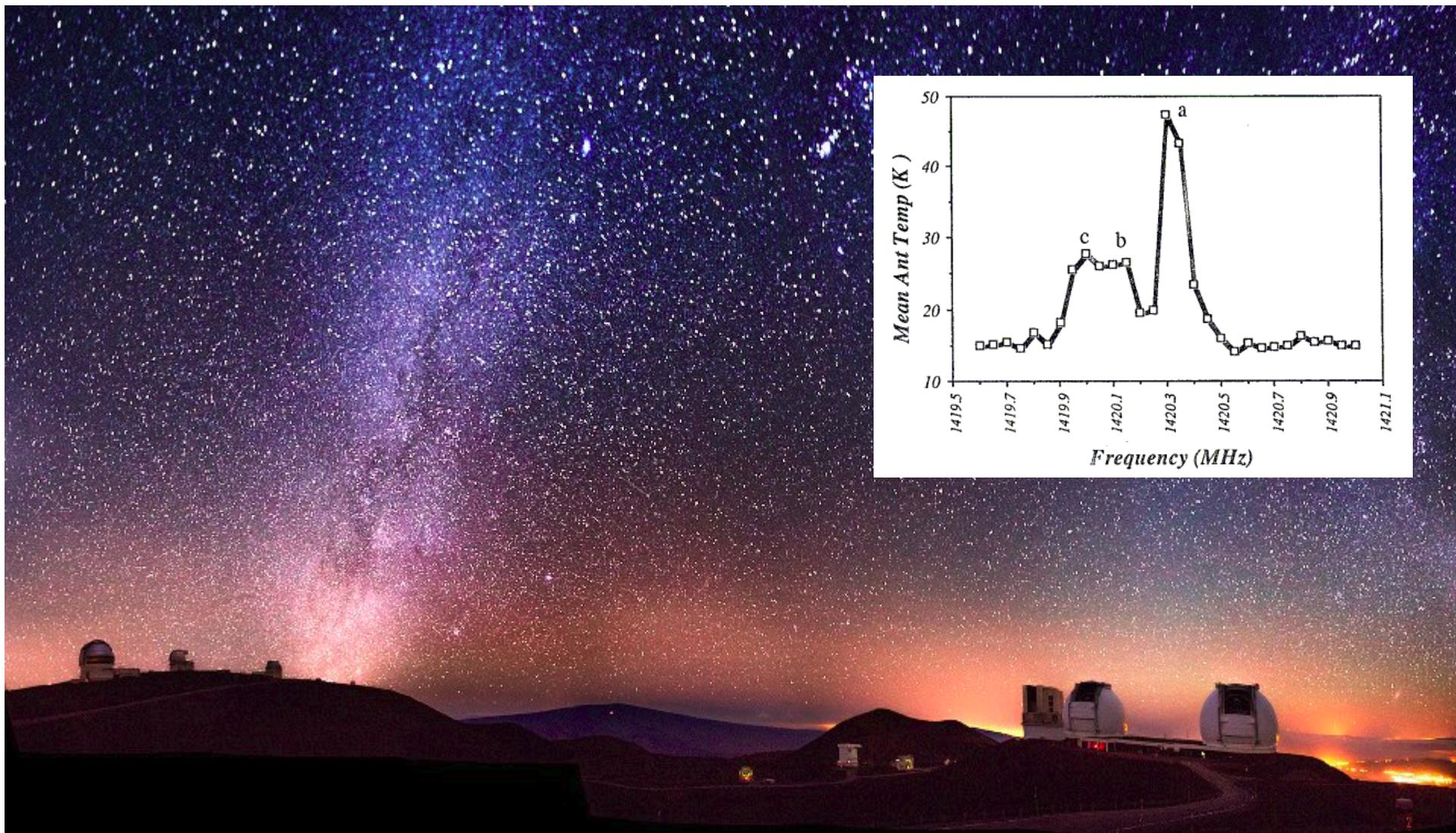


An Introduction to Astronomy



A Rough Course Outline

Part I - Introductory material – Today to 6-July

- The motions in the sky
- Early history of Astronomy
- Light and telescopes

Part II – Stars – 7-July to 10-July

- Stars and the Sun
- Stellar birth, evolution, and death

Part III - Galaxies and cosmology – 11-July to 19-July

- HI and the Interstellar Medium
- The Milky Way
- The origin and evolution of the Universe
- Life Beyond Earth

Goals for Today

Goals for Today

- 1) Scientific notation and units
- 2) Where are we?
- 3) How did we get here?
- 4) **How are we moving?**

Units

In astronomy (and science in general) we use SI (Système Internationale) units.

The SI system uses length, mass, time, and temperature as its basic properties

The basic units for these properties are:

length: the meter (m) (about a yard, 3 feet)

mass: the kilogram (kg) (2.2 pounds)

time: the second (s)

temperature: the Kelvin (K) (same increments as Celsius, but 273 degrees higher)

We will encounter some other units also

Light years, parsecs, astronomical units, solar masses etc.

Scientific Notation

Astronomers use numbers that are often very large or small and writing out the numbers is cumbersome.

- The distance to the nearest star:
40,000,000,000,000km
- The radius of an atomic nucleus: 0.0000000001 m

We use ***scientific notation*** to express numbers compactly.

- The distance to the nearest star is 4×10^{13} km
(4 times 10 to the 13 km)
- The radius of an atomic nucleus is 1×10^{-10} m
(1 times 10 to the minus 10 m)

Scientific Notation

Positive exponents and common abbreviations
Just count the zeros!

$$10^1 = 10 = \text{ten}$$

$$10^2 = 10 \times 10 = 100 = \text{hundred}$$

$$10^3 = 10 \times 10 \times 10 = 1,000 = \text{thousand } (\text{kilo- k})$$

$$10^4 = 10,000 = \text{ten thousand}$$

$$10^5 = 100,000 = \text{hundred thousand}$$

$$10^6 = 1,000,000 = \text{million } (\text{Mega- M})$$

$$10^7 = 10,000,000 \text{ ten million}$$

$$10^8 = 100,000,000 = \text{hundred million}$$

$$10^9 = 1,000,000,000 = \text{billion } (\text{Giga- G})$$

Scientific Notation

Negative exponents and common abbreviations

Count the zeros (including the one to the left of the decimal place)!

$$10^{-1} = (1/10) = 0.1 = \text{one tenth}$$

$$10^{-2} = (1/100) = 0.01 = \text{one hundredth (centi)}$$

$$10^{-3} = 0.001 = \text{one thousandth (milli.)}$$

$$10^{-4} = 0.0001 = \text{one ten thousandth}$$

$$10^{-5} = 0.00001 = \text{one hundred thousandth}$$

$$10^{-6} = 0.000001 = \text{one millionth (micro.)}$$

$$10^{-7} = 0.0000001 = \text{one ten millionth}$$

$$10^{-8} = 0.00000001 = \text{one hundred millionth}$$

$$10^{-9} = 0.000000001 = \text{one billionth (nano.)}$$

For you to do....

Write the following in scientific notation (3 min):

- 1) 100 billion (# stars in Milky Way)
- 2) 0.009154 (Earth's diameter compared to the Sun's)
- 3) 18,332,507,225,851 (US national debt as of 4 August 2015)

For you to do....

Write the following in scientific notation (3 min):

$$1) \text{ 100 billion} = 1.00 \times 10^{11}$$

$$2) \text{ 0.009154} = 9.15 \times 10^{-3}$$

$$3) \text{ 18,332,507,225,851} = 1.83 \times 10^{13}$$

Where are we?

“I’m a lonely insignificant speck on a has-been planet orbited by a cold and indifferent sun.” - Homer in “El Viaje Misterioso de Nuestro Homer”

OR

We live on a rocky planet in the inner part of our Solar System that orbits an average size star in the outer part of a large galaxy inside a small group of about 30 galaxies, in our local supercluster, in the Universe.

Where are we?

Universe

approx. size: 10^{21} km

Local Supercluster

approx. size: 3×10^{18} km

Local Group

approx. size: 10^{18} km

Milky Way Galaxy

Earth

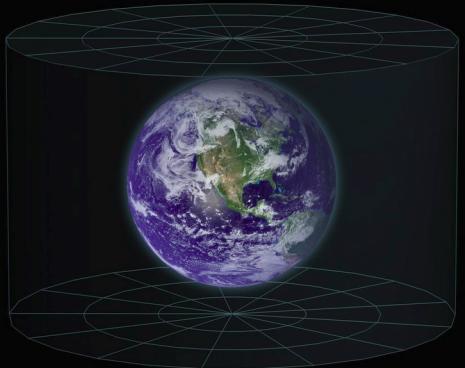
approx. size: 10^4 km

Solar System
(not to scale)

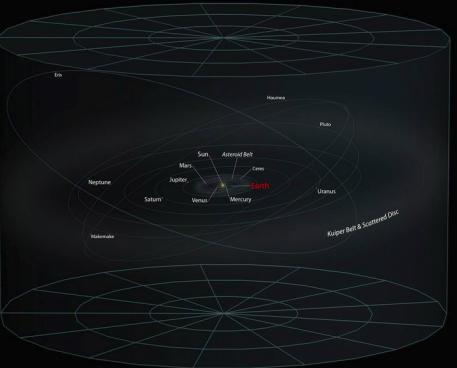
approx. size: 10^{10} km



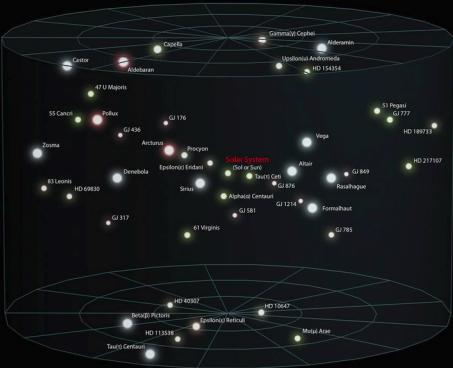
Earth



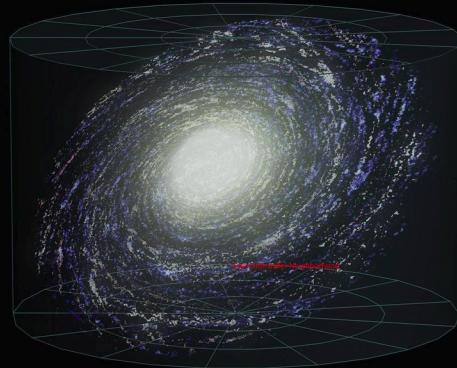
Solar System



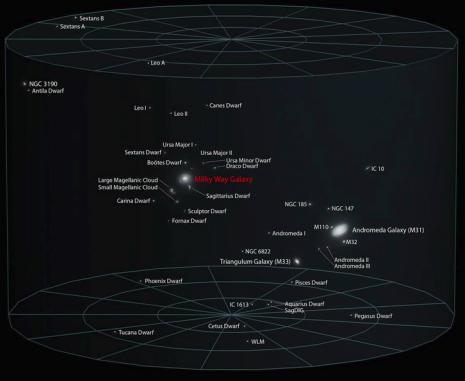
Solar Interstellar Neighborhood



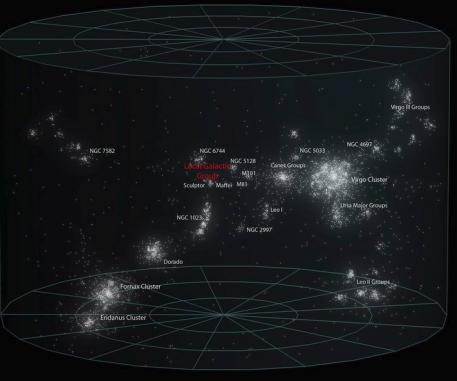
Milky Way Galaxy



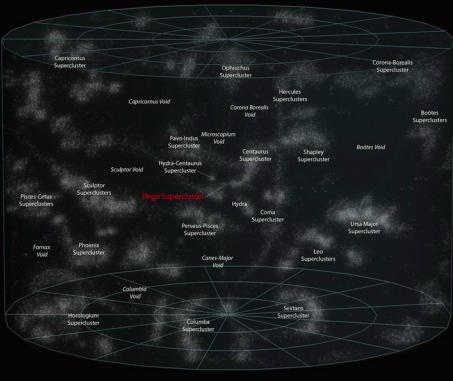
Local Galactic Group



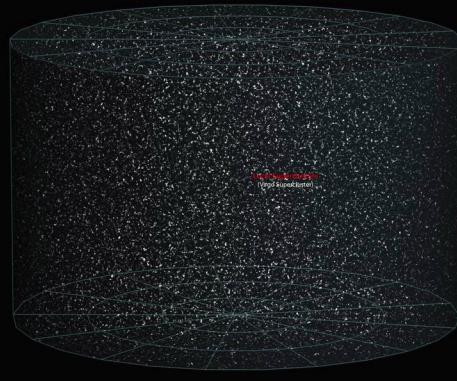
Virgo Supercluster



Local Superclusters



Observable Universe

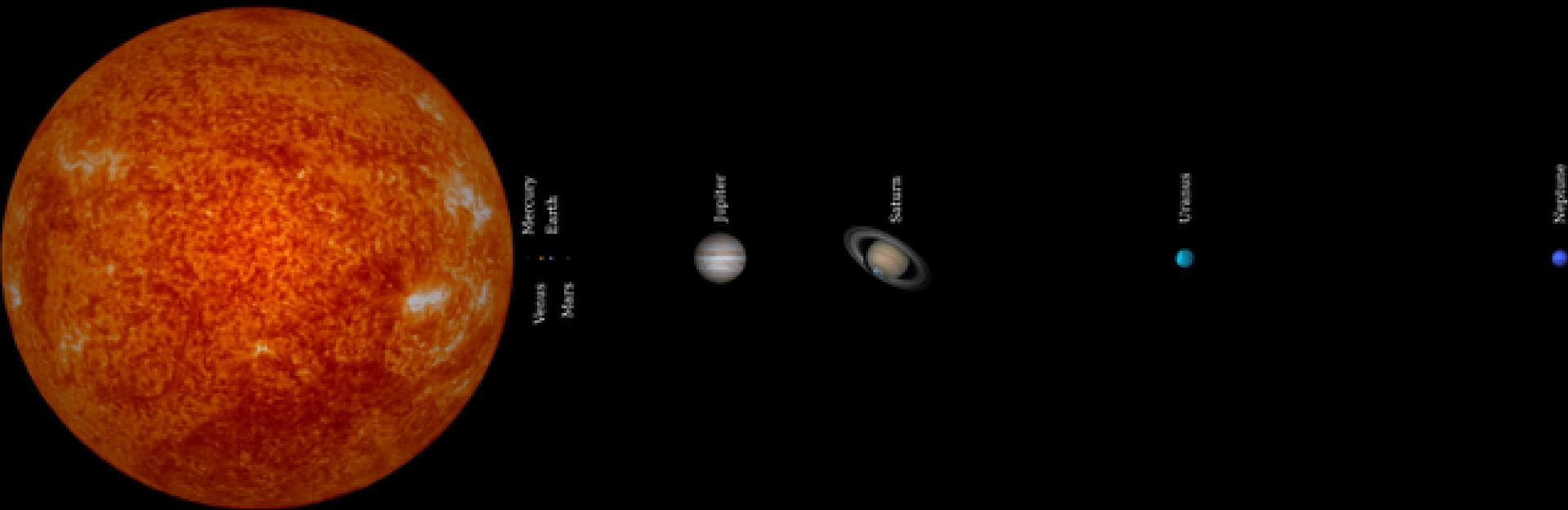


Components of our Solar System

A **solar system** is: A star and all the material that orbits it, including its planets and moons.

- The Sun
- Planets and their moons
 - Now only eight planets (Sorry Pluto)
- Asteroids/Comets/Planetoids
- Spacecraft and space junk

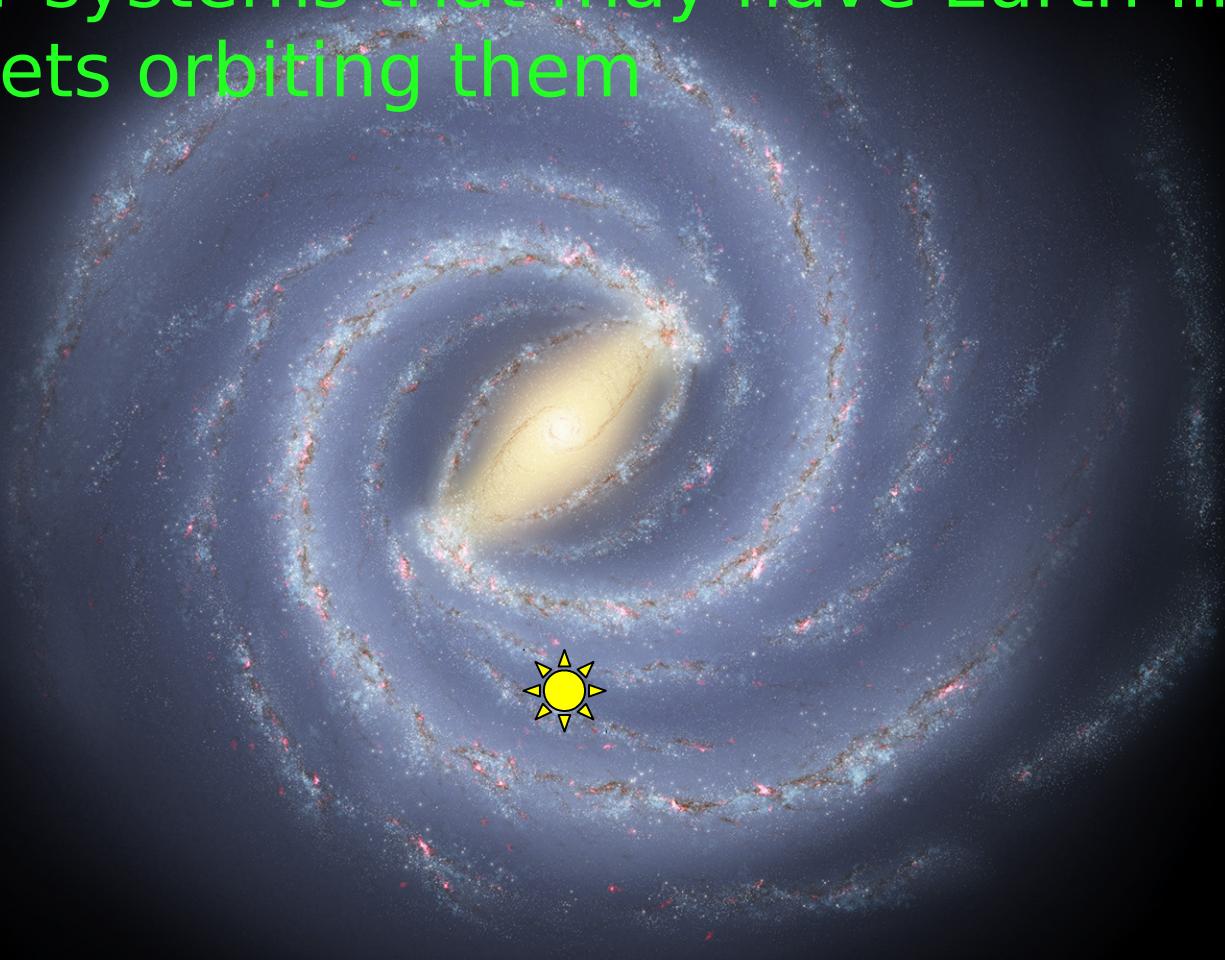
Our Solar System (distances to scale)



Our Galaxy

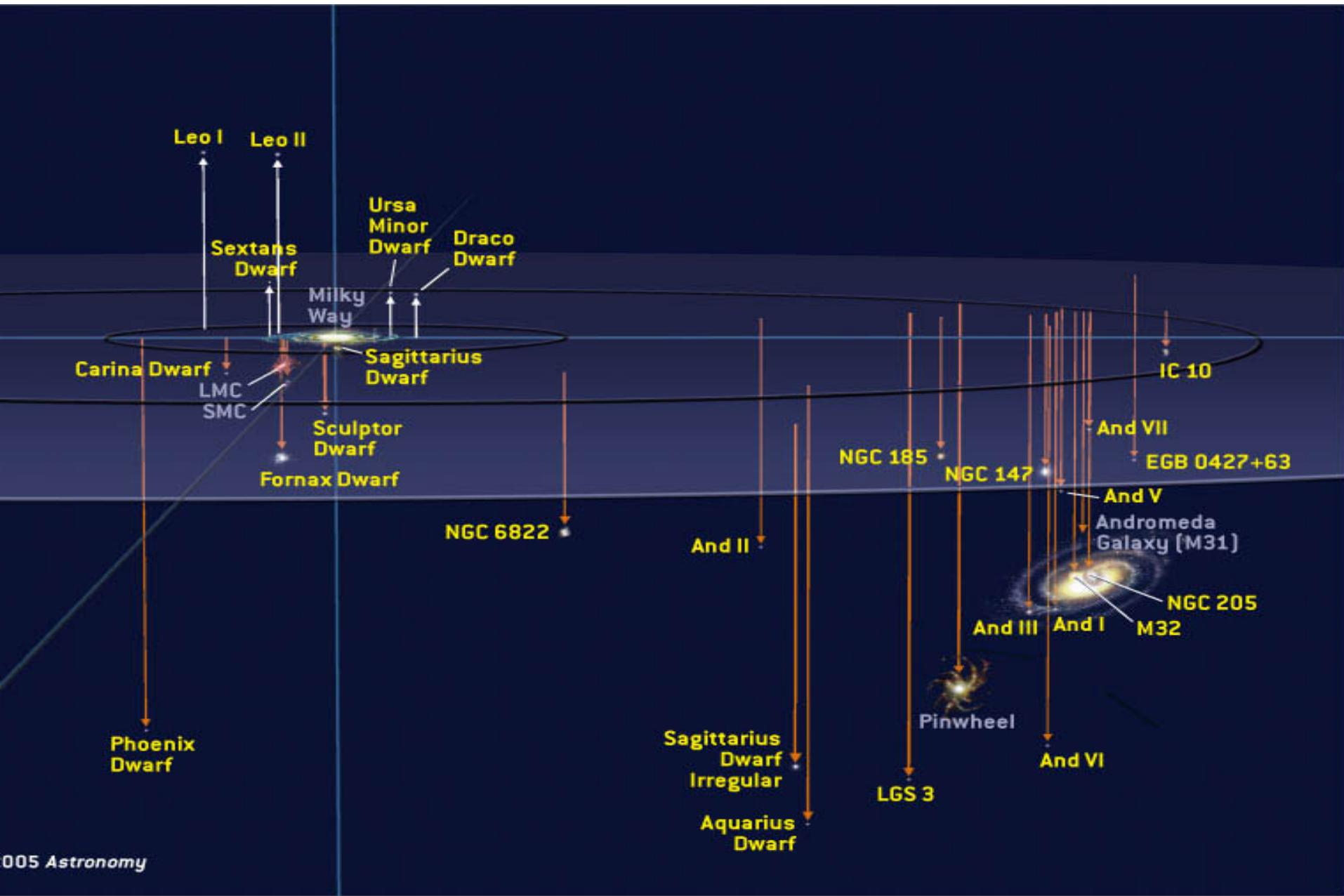
100 billion stars! That's 10^{11} !

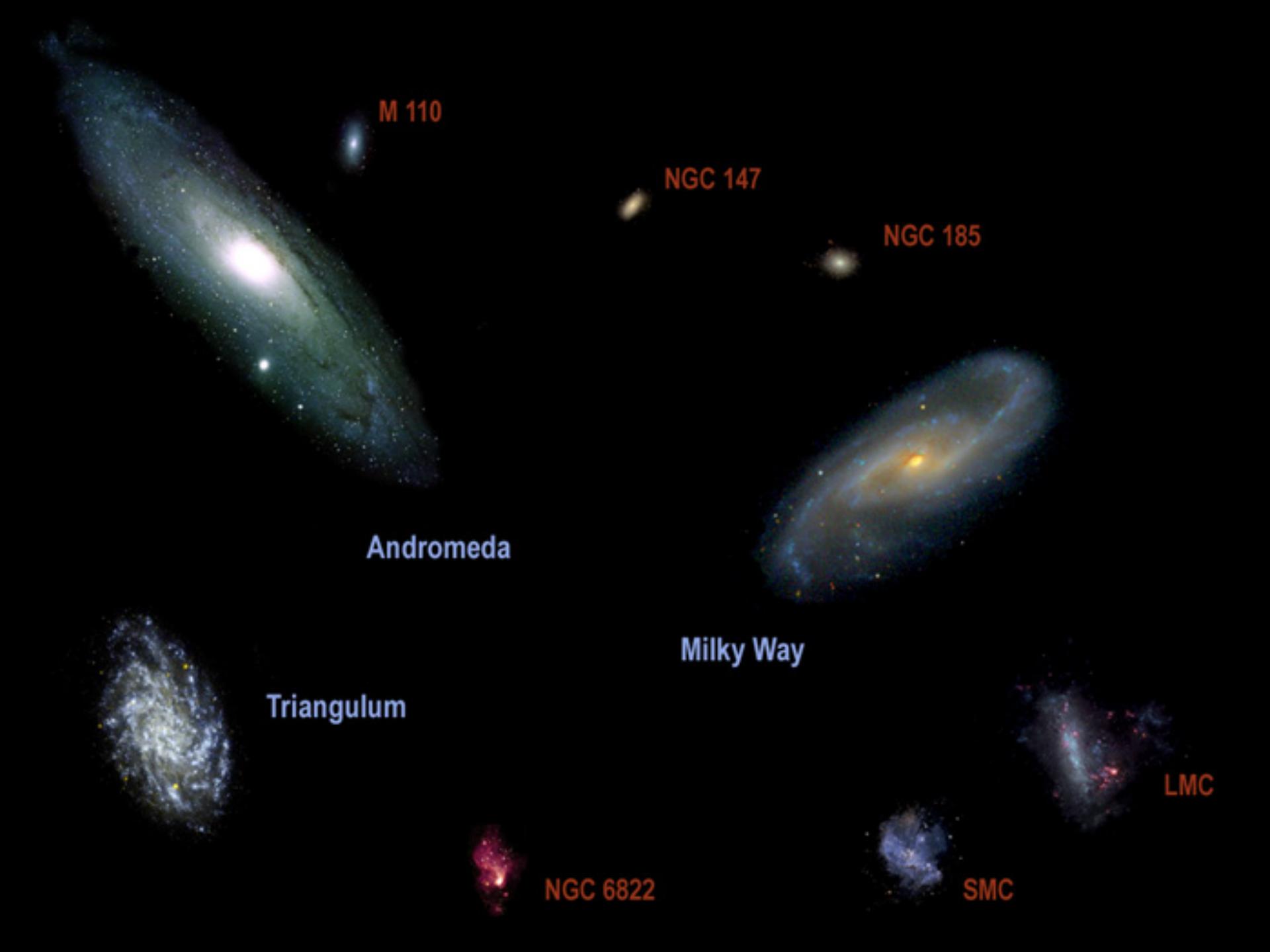
100 billion stars means 100 billion other solar systems that may have Earth-like planets orbiting them





Local Group





M 110

NGC 147

NGC 185

Andromeda

Milky Way

Triangulum

LMC

NGC 6822

SMC

The Universe

At Least 100 billion (10^{11}) galaxies.

- If each galaxy has 100 billion stars, there are $10^{11} \times 10^{11} = 10^{22}$ stars in the universe, more than all the grains of sand on all the beaches on Earth.

NOTE: EXPONENTS ADD WHEN MULTIPLIED

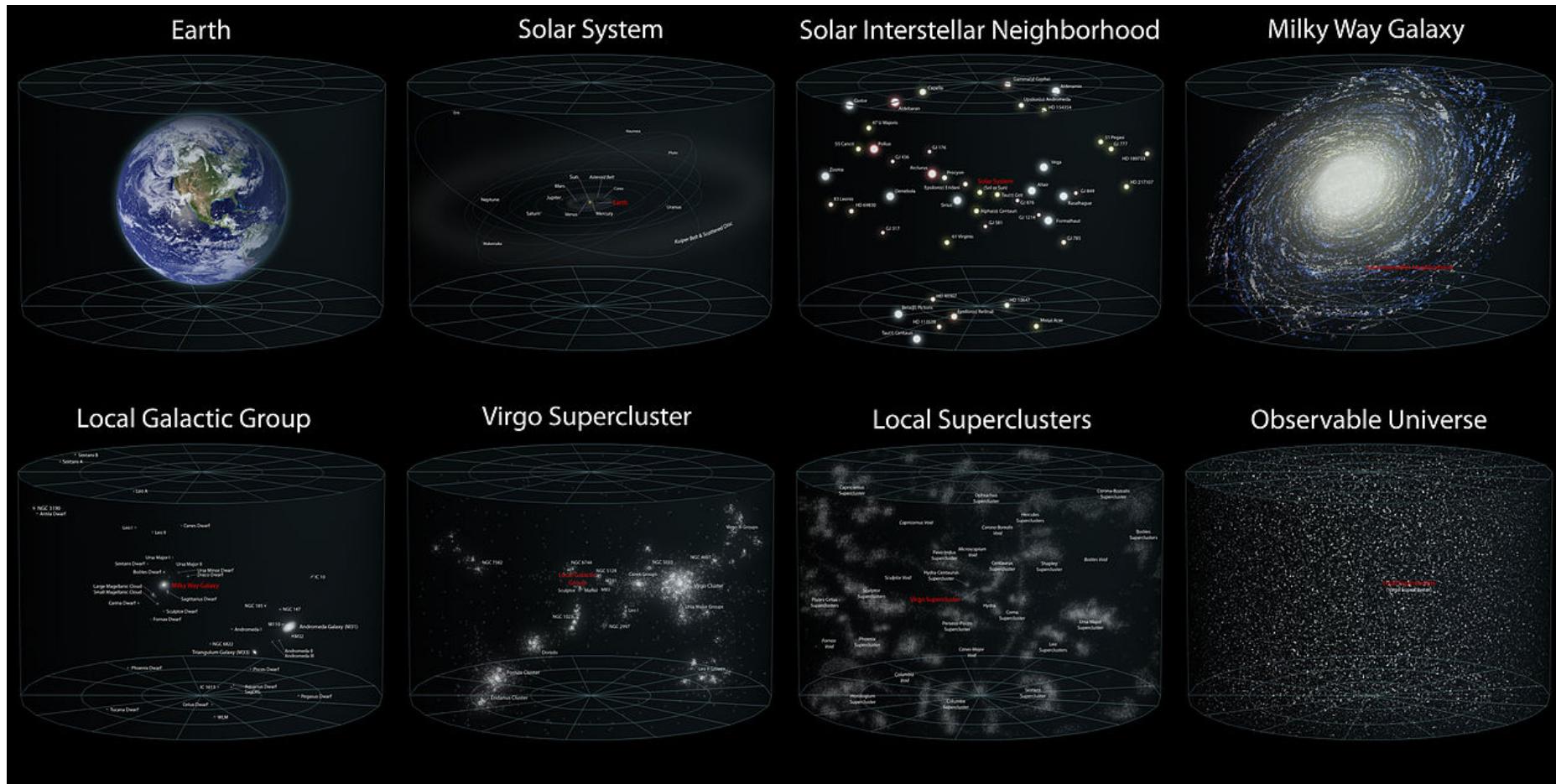
The Virgo Supercluster

The local grouping of galaxies.

Contains the Local Group and the Virgo Cluster, in addition to about 100 other galaxy groups and clusters.



Where are we? (review)



We live on a rocky planet in the inner part of our Solar System that orbits an average size star in the outer part of a large galaxy inside a small group of about 30 galaxies, in our local supercluster, in the Universe.

Where are we videos

<http://htwins.net/scale2/>

[http://www.youtube.com/watch?
v=17jymDn0W6U](http://www.youtube.com/watch?v=17jymDn0W6U)

Carl Sagan's Pale Blue Dot
[https://www.youtube.com/watch?
v=b58SfRphkKc](https://www.youtube.com/watch?v=b58SfRphkKc)

How did we get here?

Steps in your creation:

~14 billion years ago, the Universe was created in a violent explosion called the Big Bang.

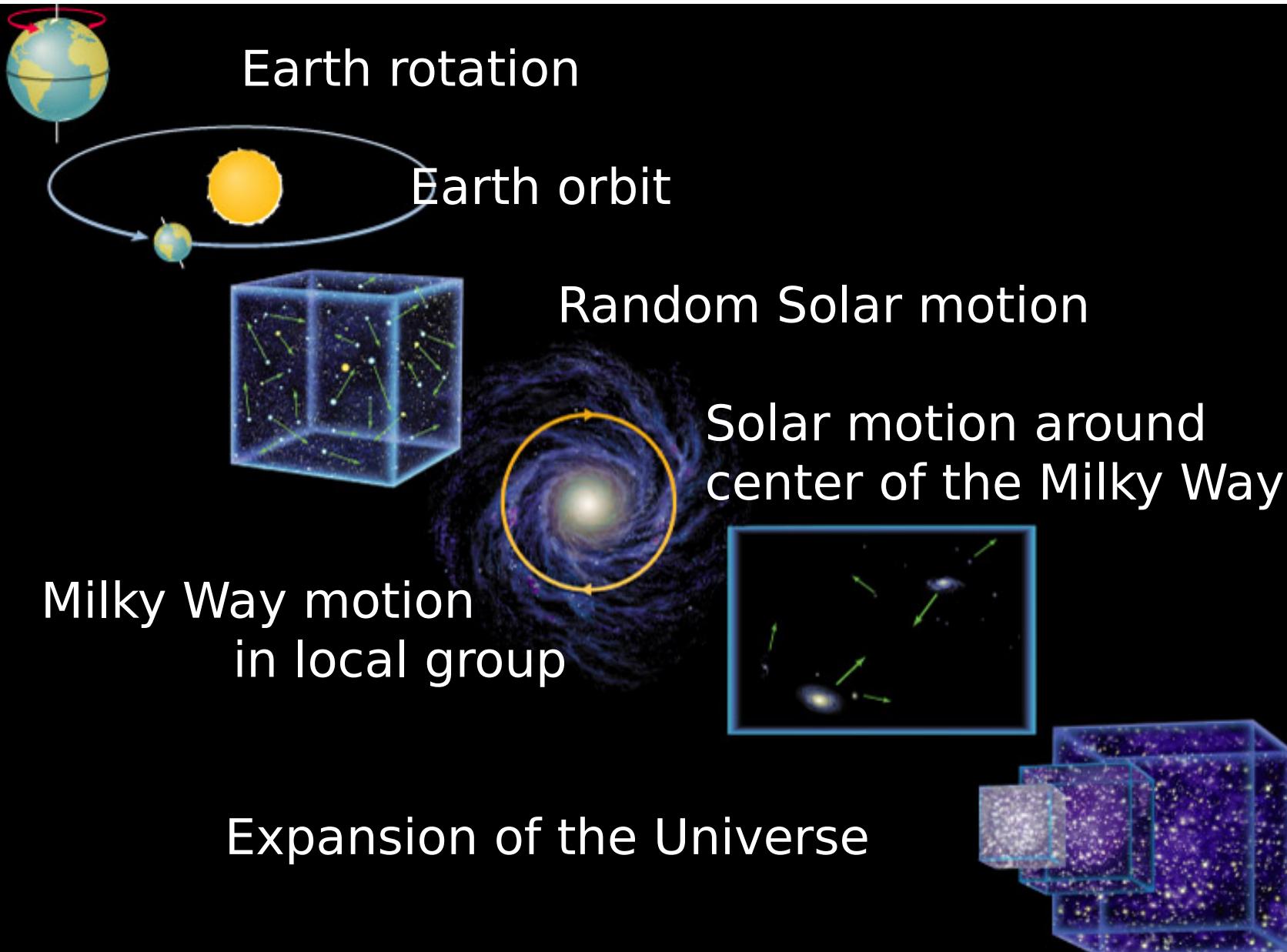
- Our Milky Way Galaxy formed ~2 billion years after the Big Bang.
- Five billion years ago (9 billion years after the Big Bang) the Sun and the solar system forms.
- 4 billion years ago the most primitive life forms on Earth.
- 100,000 years ago modern humans evolved in Africa.
- Some decades ago, you gained consciousness (finally!).

How did we get here? (Cosmic Timeline)

January 1		Big Bang
February 1		Milky Way forms
September 3		Earth forms
September 22		First life on Earth
December 26 th		Dinosaurs evolve
December 30 th		Dinosaurs die off
December 31 st		
	11:58 pm	Modern humans
	25 seconds ago	Agriculture arises
	11 seconds ago	Pyramids built
	0.05 seconds ago	You were born

[https://www.youtube.com/watch?
v=ShTxGumvbno](https://www.youtube.com/watch?v=ShTxGumvbno)

How are we Moving?



Review

Goals for Today

1) Scientific notation and units

Know them!

2) Where are we?

We are in the Universe, in the Local Group, in the Milky Way, in the Solar System, on Earth

3) How did we get here?

Universe created 14 GYr ago, Milky Way 12 GYr ago, Earth 4 GYr ago, man 100,000 yr ago, and you ~20 years ago.

4) Everything is in motion!

The Light Year

A LIGHT YEAR IS A DISTANCE!!!!!!!

The speed of light is a constant – it is not infinitely fast

- The speed of light is the fastest that anything can travel!

A light year is the distance light travels in one year

It is 9×10^{15} m

Also, A LIGHT YEAR IS A DISTANCE!