Sex in Space: Astronomy 330

134 Astronomy Building

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Office Hours:
W: 11- noon
or by appointment

This class (Lecture 3):

Cosmology

Next Class:

Origin of Elements

HW1 & 2 due Sunday.

Music: *Galaxies*– Laura Veirs

Outline

- What does our Galaxy look like?
- Where did HONC come from?
  i.e. where did the atoms in our bodies come from?
- How old is the Universe?

Drake Equation

Frank Drake

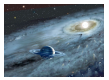
$N =$

# of advanced civilizations we can contact in our Galaxy today

Drake Equation

Frank Drake








$$N = R_* \times f_p \times n_e \times f_l \times f_i \times f_c \times L$$

N	R_*	f_p	n_e	f_l	f_i	f_c	L
# of advanced civilizations we can contact in our Galaxy	Rate of star formation	Fraction of stars with planets	# of Earthlike planets per system	Fraction on which life arises	Fraction that evolve intelligence	Fraction that commun-icate	Lifetime of advanced civilizations

Question

What does the Drake equation really tell us?

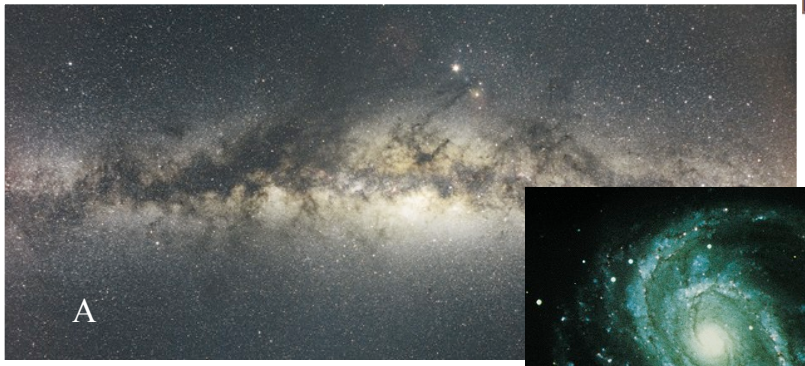
a) It calculates the number of advanced civilizations in the Universe.
b) It means nothing, a fake equation. It is only meant to guide our thinking about the relevant questions.
c) It gives us an exact number of alien life forms (intelligent or not) in the Galaxy.
d) It calculates the number of advanced civilizations in our Galaxy.
e) It allows us to estimate the age of the Universe.

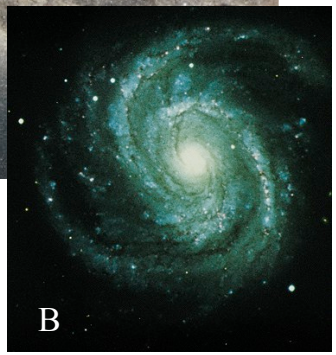
Galaxies are the Fundamental "Ecosystems" of the Universe

Three Main Types of Galaxies:

- Spirals (77%)
- Ellipticals (20%)
- Irregulars (3%)

Which is a picture of the Milky Way?

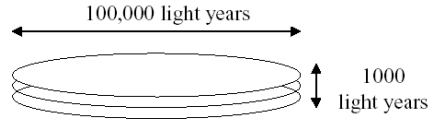


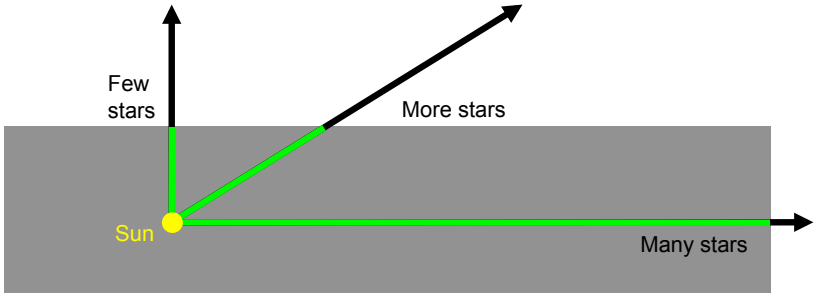


A is what we see from Earth inside the Milky Way. *B* is what the Milky Way "might" look like if we were far away looking back at our own galaxy from some other galaxy

We Are in a Disk of Stars!

The distribution of stars in the Milky Way is in a thin disk. The Milky Way is very thin in comparison to its diameter– imagine 3 CDs stacked.

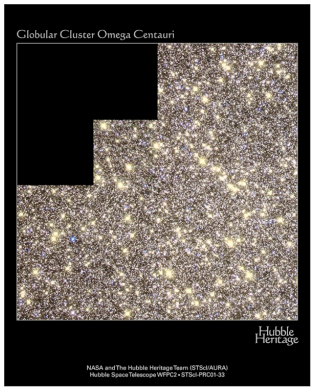


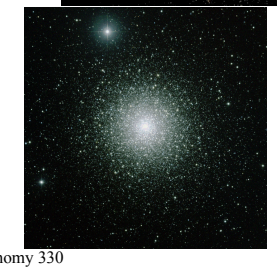


The Milky Way?

Globular Clusters

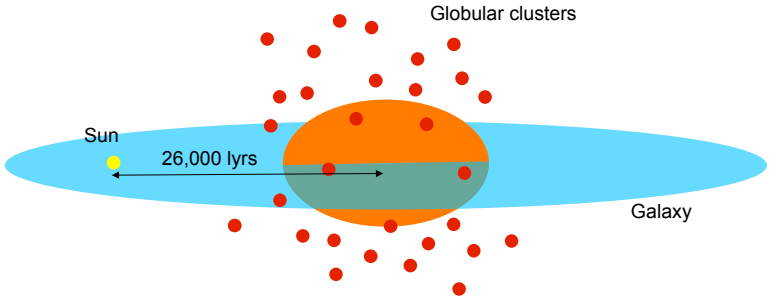
- Large groups of stars (about 150 in the MW)
- Old population of stars





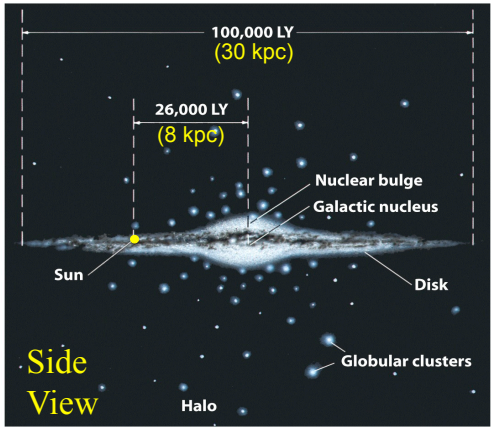
Our Place in the Galaxy

- We realized that we are not the center of the Galaxy in the 1920s.
- All of the globular clusters are orbiting around a point in Sagittarius– 26,000 lyrs away.
- That must be the center of our Galaxy.



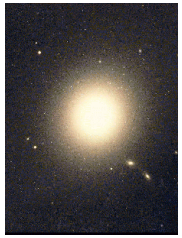
Our Galaxy

- Globular clusters– oldest stars
- Galactic nucleus– dense collection of stars (center of Galaxy)
- Nuclear bulge– mostly old stars, but very densely packed
- Spiral arms and the disk– mostly young stars and lots of dust
- Note position of the Sun, just over half way out.



Fate of the Milky Way: It's coming right for us!

- What will happen to the Milky Way?
  - It will continue to grow as it cannibalizes the nearby smaller satellite galaxies.
  - The Andromeda galaxy is on a collision course– 300 km/s.
  - Eventually (3 billion years). we will probably end up a combined galaxy.
  - An elliptical galaxy.

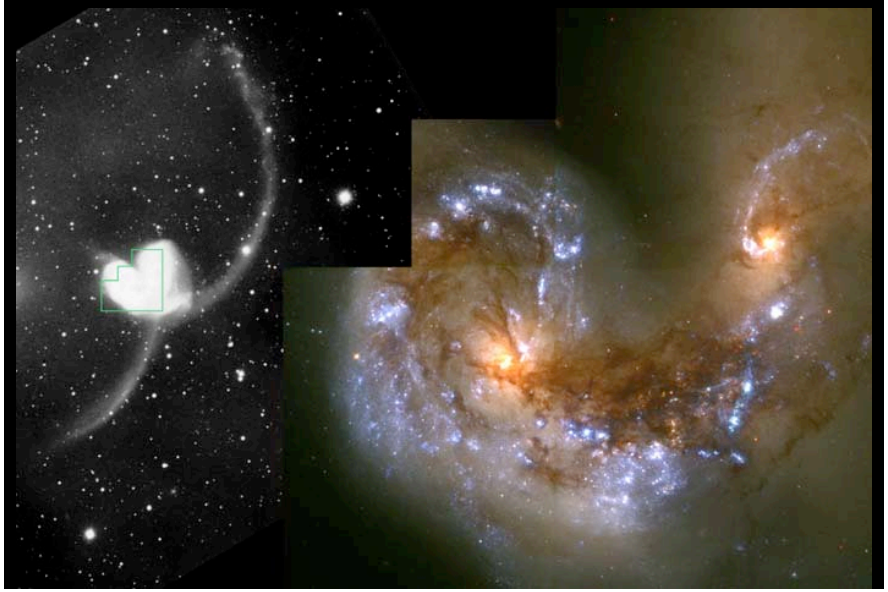


http://www.seds.org/messier/small/m87.gif

What it Might Look Like

 http://www.galaxydynamics.org/future_sky.html

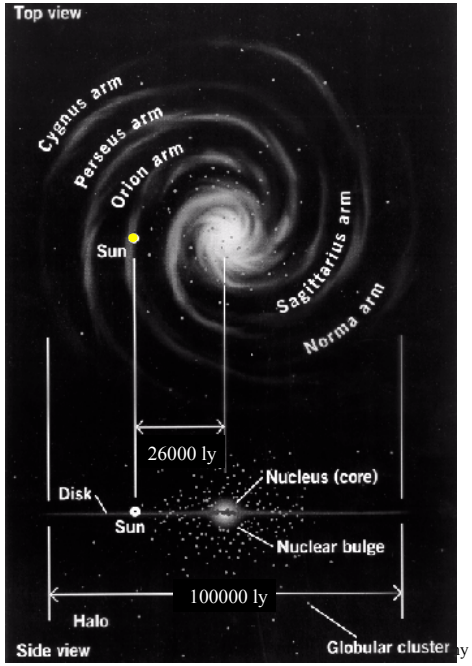
The Antennae: Colliding galaxies trigger bursts of star birth



Question

In about 3 billion years the Andromeda galaxy and the Milky Way galaxy will collide, should we worry about the Earth being splattered by a star?

a) Yes, we're all going to die!
b) No, in about 1 billion years the oceans will likely boil.
c) Yes, due to a new estimate of the Milky Way mass, it will probably happen sooner, so live it up furball.
d) No, galaxies are mostly empty space so the Sun is safe, except for the possibility of our orbit being messed up.
e) Yes, galaxies collide and form black holes.



Our Galaxy

(movie)

Galaxy Song

Monty Python's The Meaning of Life (1983)

Question

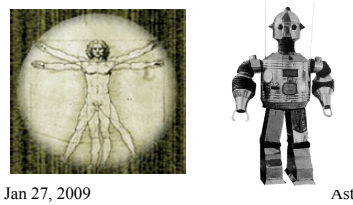
In the Milky Way, the Sun is located

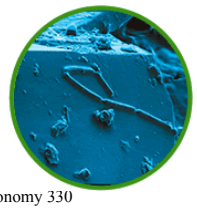
a) in the halo.
b) in the disk.
c) in the center.
d) in a globular cluster.
e) in the bulge.

Defining Life

Defining life is very difficult. Traditional attributes of life define it as:

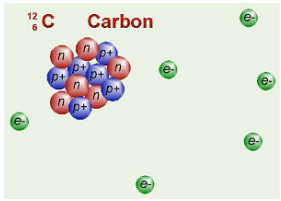
1. Comprised of organic molecules.
2. Engaged in metabolism– exchange of matter and energy.
3. Engage in reproduction– sex in space!
4. Able to mutate– offspring are not identical to parents.
5. Sensitivity to environment.





Elements of Life

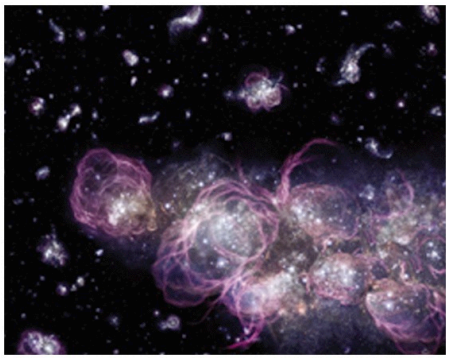
- Carbon is the most important element in life on Earth with oxygen and nitrogen coming in a close second. And there is a lot of hydrogen. **HONC**. But where did they come from?
- To understand this question, we need to address the origin of the Universe and the elements crucial to life.
- In other words, Cosmology.



http://biology.clc.uc.edu/courses/bio104/atom-h2o.htm

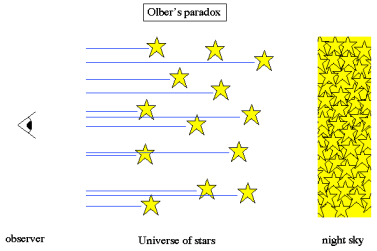
Cosmology

- What is the Universe?
  - All the matter, energy, and spacetime we can ever detect
- **Cosmology** is the study of the origin, structure, and evolution of the Universe



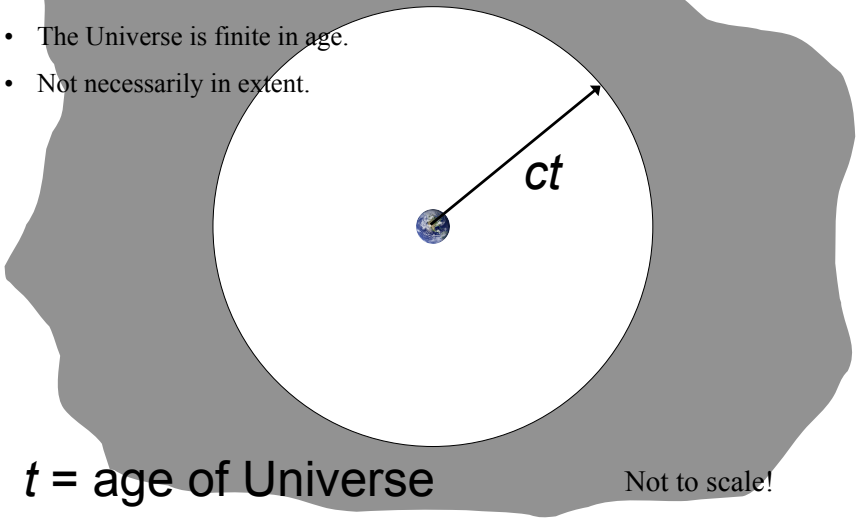
The Night Sky: Olber's Paradox

- What is special about the night sky?
- Why isn't the night sky bright?
- If the Universe is infinite and ageless, why don't we see light everywhere from all the stars.
- Even if dust blocked the light, it would heat up and emit in the optical too.
- The Universe has not existed forever. It must have started from something.



Looking Back in Time: The Observable Universe!

- The Universe is finite in age.
- Not necessarily in extent.



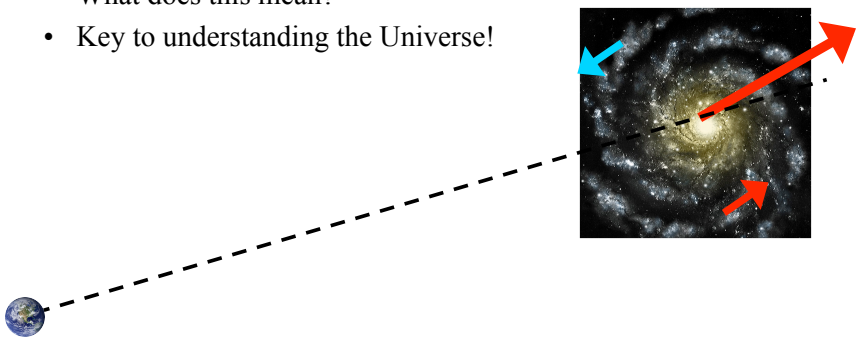
How are Galaxies Moving?

It's 1928 and Edwin Hubble is measuring how galaxies move. What does he find?

a) More galaxies receding than approaching.
b) More galaxies approaching than receding.
c) About equal numbers of each.

What Does This Mean?

- Most galaxies are moving away from us.
- The farther away, the faster they are moving away.
- Or $V = H_o \times D$
  - $H_o = 72$ km/s /Mpc
- What does this mean?
- Key to understanding the Universe!



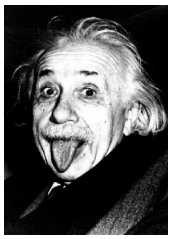
Apply it?

- In a homogenous Universe, what does the farther away the faster the galaxies move away mean?
- Draw it.

Interpretation: View of the Universe

Egoist view– We are at the center of the Universe.

Einstein's view– The Universe is expanding, and there is no center!



The Expanding Universe

- To describe the motion of all the galaxies in the Universe, we use General Relativity (due to gravitation effects)
  - We'll talk about General Relativity more later, but it describes how the mass of objects (in this case all of the matter in the Universe) can distort space/time.

The Expanding Universe

- To describe the motion of all the galaxies in the Universe, we use General Relativity (due to gravitation effects)
- General Relativity predicts that we live in an *expanding Universe*.
  - Einstein didn't buy it at first, so made a cosmological constant to get rid of it.
- In other words, space is stretching in all directions. This completely explains Hubble's Law.