

Astronomy 150: Killer Skies



HW2



- Only a few graded so far, but I have been impressed with the quality of work.
- Some of you did an excellent job.
- Save them, and maybe I can set up something, where we can show the best ones to the class.
- I'll keep you informed.

This Class (Lecture 30): Next Class:
How Galaxies move The Origin of the Universe

HW 10 due on Nov 29th

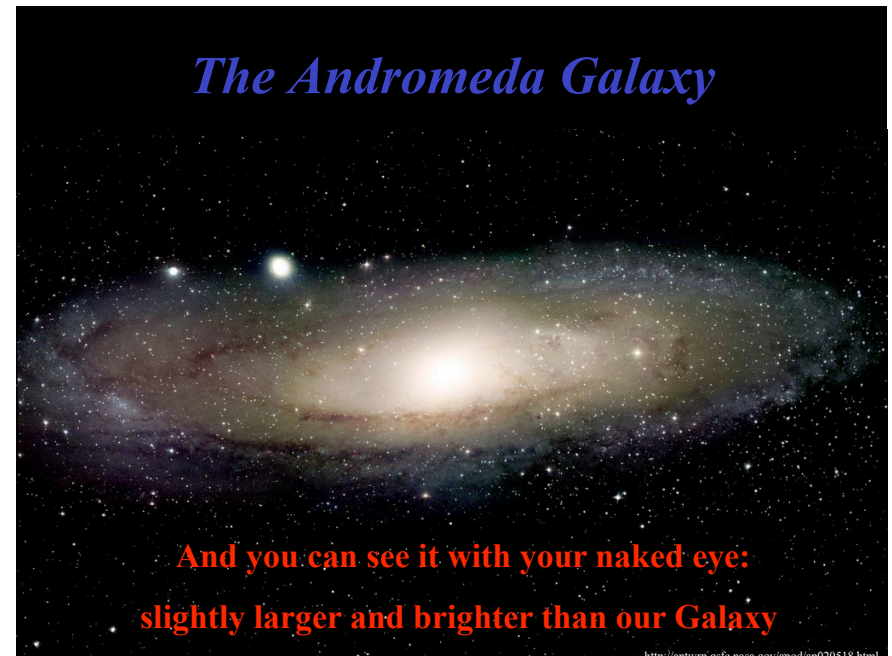
Music: The Universe is You – Sophie Ellis-Bextor

Outline



- When we collide!
 - Not exactly sure what happens, but we can predict some outcomes.
- The Universe is expanding!
 - What does this imply?

The Andromeda Galaxy



**And you can see it with your naked eye:
slightly larger and brighter than our Galaxy**

<http://antwrp.gsfc.nasa.gov/imagedata020518.html>

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



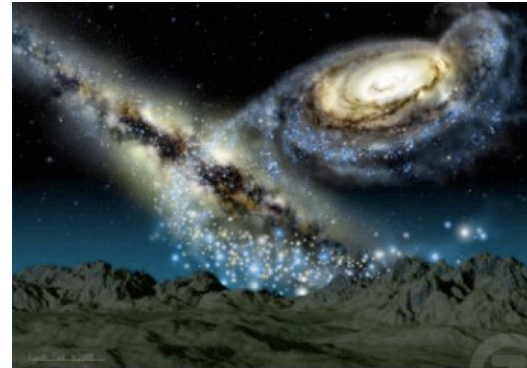
- What will happen to the Milky Way?
 - It will continue to grow as it cannibalizes the nearby smaller satellite galaxies.
 - The Andromeda galaxy is on a collision course– 300 km/s.



Milkomeda



The Milky Way and Andromeda merge to become an elliptical galaxy in about 5 billion years!



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



A Possible Future



- Simulation of what that may look like
- Assuming we have not died and can fix the increased brightness of the Sun as it ages
- So, 3 billion years in the future..



What it Might Look Like

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

Question



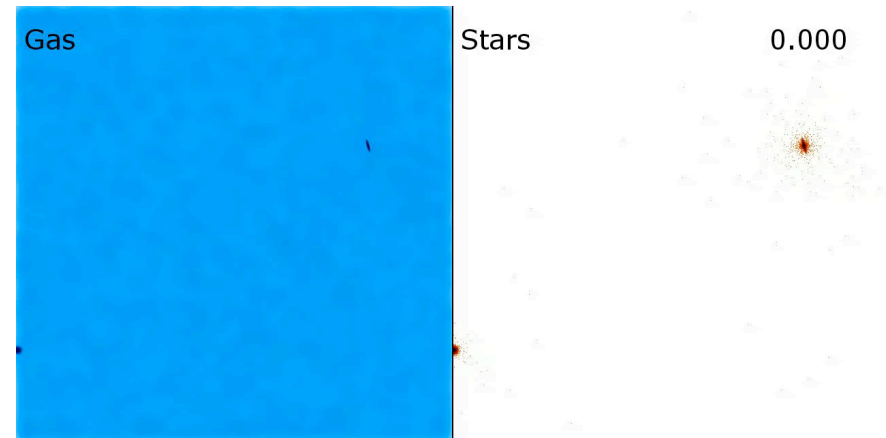
In about 2-3 billion years the Andromeda galaxy and the Milky Way galaxy will collide, should we worry about the Earth being splattered by a star?

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

Collision

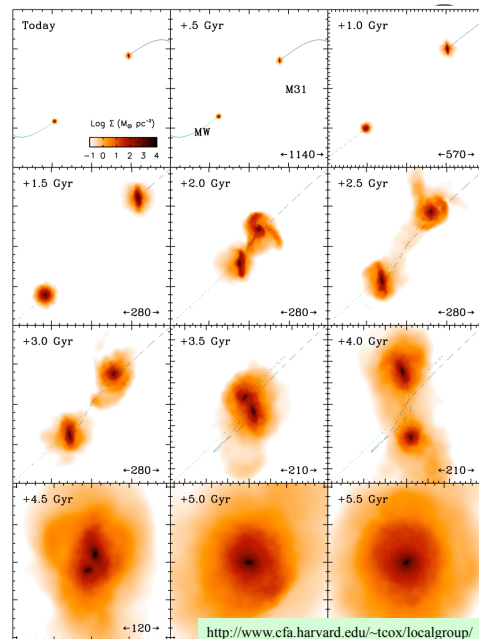


New simulation of collision (Cox & Loeb)



Collision-Time

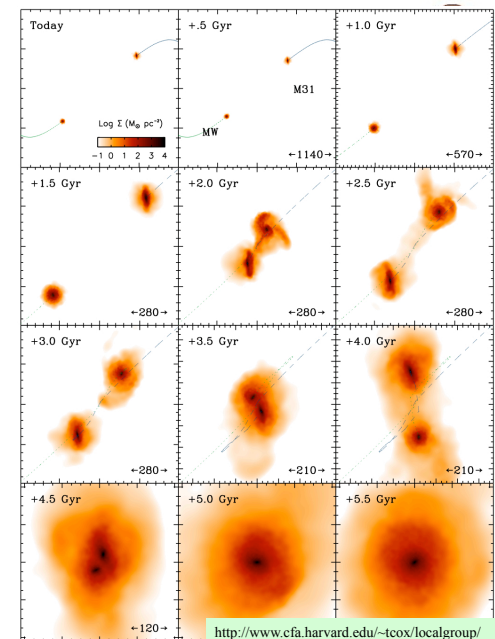
- Collision in 2 billion years
- Chances of two stars colliding is zero.
- Unlike most collisions we see in other (younger) galaxies, the two galaxies have used up a significant amount of their gas, so no starburst



<http://www.cfa.harvard.edu/~tcox/localgroup/>

Collision-Time

- NO starburst makes it safer for us.
- Less young massive stars irradiating their environment or supernova-ing.
- Over millions of years, we will get amazing view of one of the most amazing astronomical shows!
- I hope humans are still around.

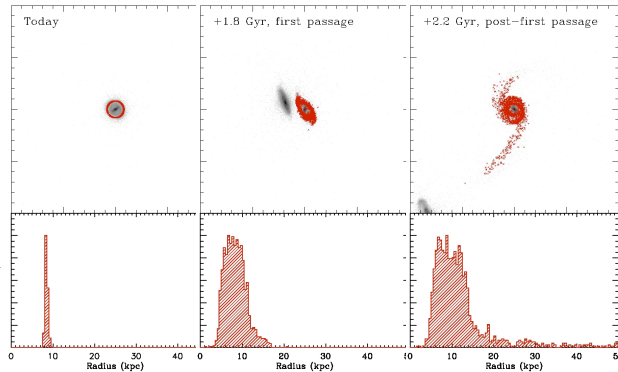


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- After first passage, there is a small chance that the Earth gets thrown out into the tidal tails, about 12%



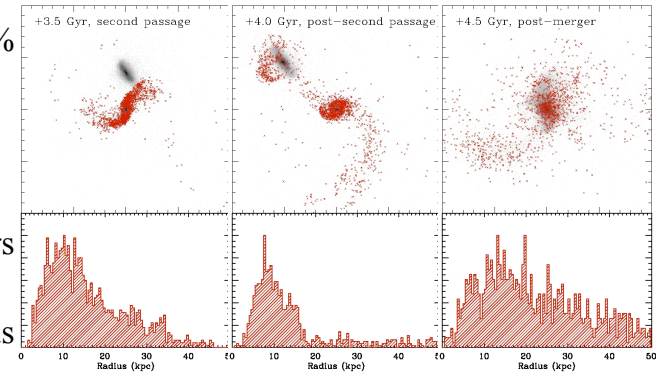
- Not a bad place... get really good view!

<http://www.cfa.harvard.edu/~tcox/localgroup/>

Milkomeda



- By the end, there is 50% chance we end up further out than 100,000 lyrs
- Small chance of us switching sides (to Andromeda) during the merger ($< 3\%$)
- Less than 1% chance that we will fall into the center of the Galaxy.

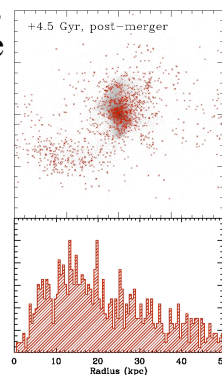


<http://www.cfa.harvard.edu/~tcox/localgroup/>

Milkomeda



- The supermassive black holes are merging, so falling to within 1000's of lyrs would be very, very bad.
- Think about accretion disks around black holes... but that is a different way to die, which I'll come back to.
- Nonetheless, there is a good chance that we get closer to the center of the Galaxy (higher stellar densities), more chance of bad things.
- So in about 5 billion years, when the Sun is about to become a red giant, we may, or may not, go for an interesting ride.!



<http://www.cfa.harvard.edu/~tcox/localgroup/>

Imagine

- After getting flung 1 billion years into the future in a DeLorean, you notice that the sky is different.
- The sky is full of a galaxy, up close and personal.
- As you keep traveling into the future, you notice that it is changing position as it interacts with the Milky Way. You sigh in hope as you notice that the Earth and Sun are fine.
- Actually, the sky is prettier than before. This ain't so bad!

Imagine

- But, in a few million years you realize that the Solar System has been knocked out of its usual Galactic orbit.
- And the Solar System is headed straight for the center of the Galaxy..... And there are many dangers there..
- As you die from a supernova, you wonder why Leslie didn't mention the beauty of the event.

Top 10 Ways Astronomy Can Kill you or your Descendents



6. Rogue compact objects–White Dwarfs/Black Holes.
Black Holes don't suck, but if they hit you it sucks.
7. Galaxy Collisions.
Milky Way vs. Andromeda.
8. Cosmology!
This is the way the Universe ends..

Top 10 Ways Astronomy Can Kill you or your Descendents



8. Cosmology!
This is the way the Universe ends..

Our Universe started about 13.7 billion years ago. But what will happen to it?

Stars all die, sky becomes dark? Galaxies all collapse back crushing all life? The Universe rips apart?

<http://www.youtube.com/watch?v=oGVYG0ce1Ps>

Imagine

- After getting flung a few billion years into the future in a British police box, everything seems normal.
- Humans must have moved the Earth.
- But something isn't right.
- Suddenly, the Earth rips apart..
- Then your body rips apart.
- As your body's atoms get ripped apart, you wonder why Leslie didn't mention how painful it would be.

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

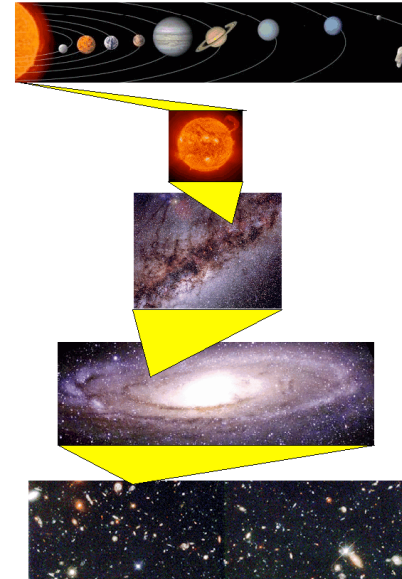


Astronomy: The Big Picture



Arguably, the biggest fish of all: *Cosmology*

- What is the Universe made of?
- How big is it?
- How old is it?
- How did it form?
- What will happen to it?



The Night Sky: Group



- What is special about the night sky?

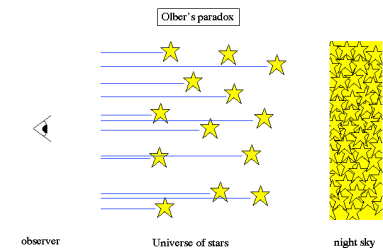
What would it look like in an ageless and infinite Universe?

- Press A on your iclicker when your groups has a guess.

The Night Sky: Olber's Paradox



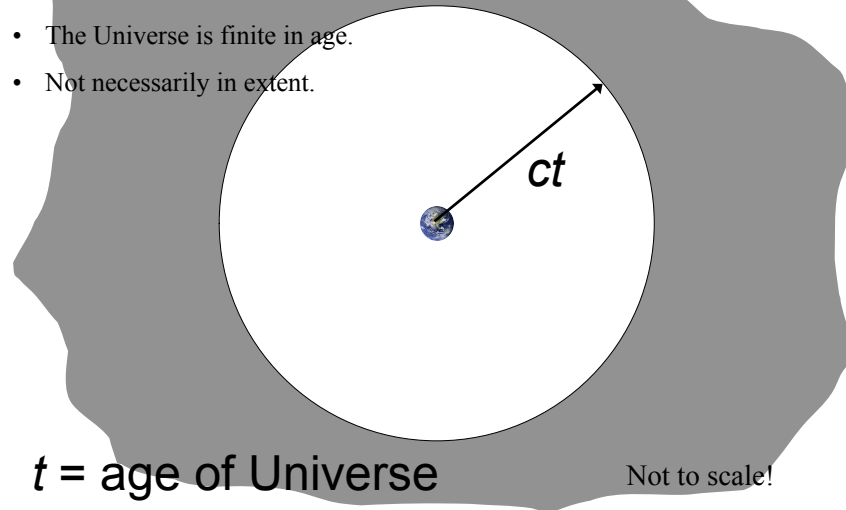
- What is special about the night sky?
- Why isn't the night sky bright?
- If the Universe is infinite and ageless, why don't we see light everywhere from all the stars.
- Even if dust blocked the light, it would heat up and emit in the optical too.
- The Universe has not existed forever. It must have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



Looking Back in Time: The Observable Universe!



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



How are Galaxies Moving?



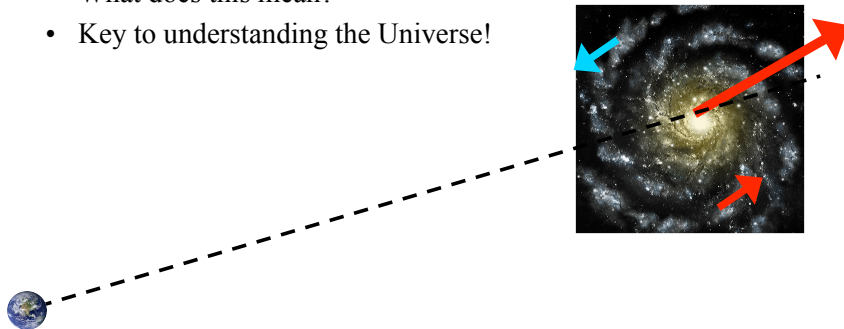
It's 1928 and Edwin Hubble is measuring how galaxies move. What does he find?

- 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 $V = H_0 \times D$
 - $H_0 = 72 \text{ km/s / Mpc}$
- What does this mean?
- Key to understanding the Universe!

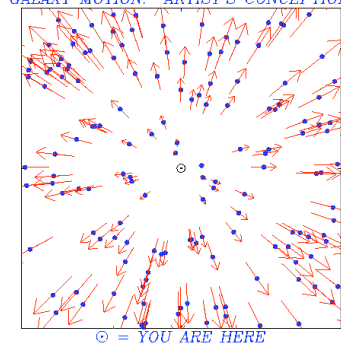


Apply it?



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

GALAXY MOTION: ARTIST'S CONCEPTION



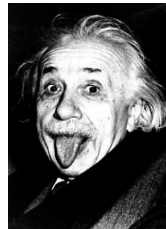
Interpretation: View of the Universe



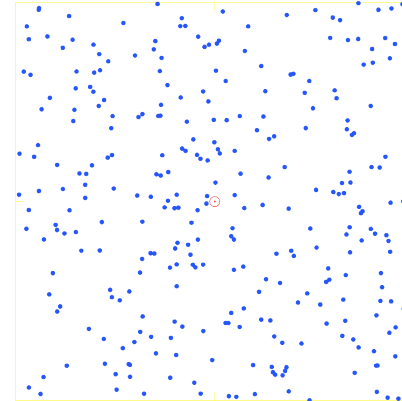
Egoist view— We are at the center of the Universe.



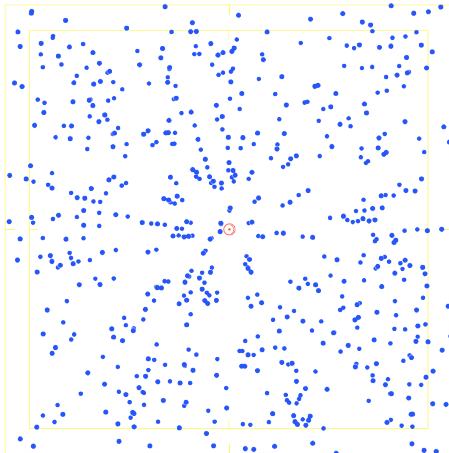
Einstein's view— The Universe is expanding, and there is no center!



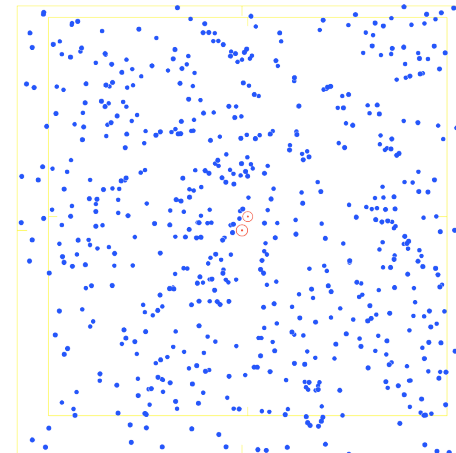
Gives the Impression of Being Special



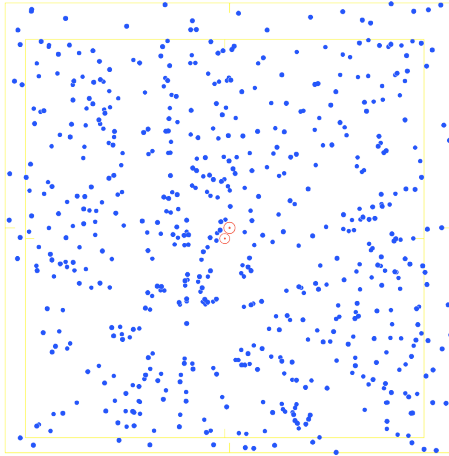
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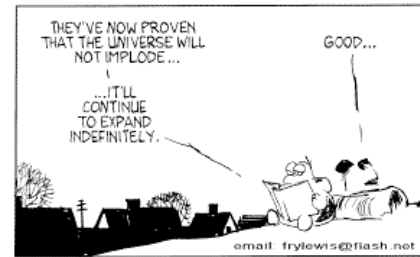
Gives the Impression of Being Special



The Expanding Universe



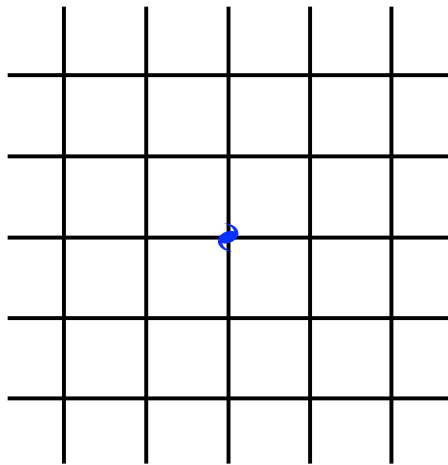
- To describe the motion of all the galaxies in the Universe, we use General Relativity (due to gravitation effects)
- General Relativity predicts that we live in an *expanding Universe*.
 - Einstein didn't buy it at first, so made a cosmological constant to get rid of it.
- In other words, space is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



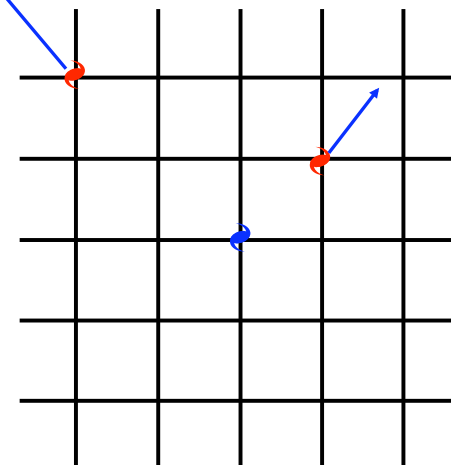
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Dude, The Universe is Expanding.



Wow. The Universe is Expanding.



Hold on a minute there!



- Why don't we expand with the Universe?
- Other forces hold us together
 - Atoms - nuclear forces
 - Molecules & living beings – electromagnetic forces
 - Planets, stars, and galaxies – gravity
- But gravity can't hold galaxy superclusters together
 - Expansion grows stronger with distance (more expanding space)
 - Gravity grows weaker with distance (inverse square law)
- **Brooklyn isn't expanding!**



Brooklyn Is Not Expanding

Directed by
Woody Allen

Annie Hall (1977)

What do you think?



The Universe is expanding, how do you feel about that?



<http://www.calresco.org/ewp/confuse.htm>

A)



B)



C)

