

Astronomy 150: Killer Skies



This Class (Lecture 27):
The Milky Way

Next Class:
The Nearby Galaxies

HW 9 due on Sunday

Music: Space Oddity– David Bowie

Outline



- If a compact object enters the Solar System?
- The structure of the Milky Way (a collection of stars, nebulae, dust, stellar corpses, planets..)
 - The disk
 - The halo
 - The bulge
 - The spiral arms

Water on the Moon!



- The impact of the Moon yielded positive results.
- Significant amounts of water seen in the spectra!
- Can be used for missions (cheaper than bringing it with you), also important to make rocket fuel.



But What If?



- Average distance to a black hole should be ~100 light years!
- That's less common than stars, but sounds close!
- Black hole colliding with the Earth would of course be a disaster.
- At the end, Earth is destroyed by tidal forces, ripped apart.
- Or even if black hole misses, it could throw Earth out of our nice orbit, which is still bad.



Question



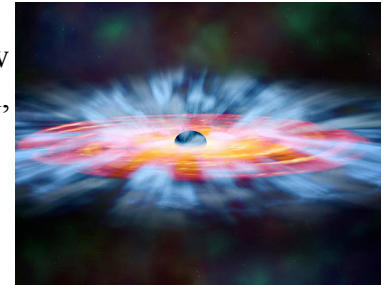
If a black hole collides with the Earth, which of the following is not a consequence?

- a) Spaghettification of the Earth.
- b) Earthquakes.
- c) Earth is either ejected out of the Solar System, falls into the Sun, or falls into the black hole.
- d) Destroys all life on the side of the Earth facing the black hole only.
- e) Tidal waves.

Micro-Black Holes?



- You don't need a lot of mass to make a black hole, just high density.
- What about very low mass black holes?
- Primordial black holes have never been seen, but if a few ton black hole hits the Earth, it is about as bad as a 10 solar mass black hole.
- Smash together nuclear particles at high speed and you perhaps can get high enough densities.



Man-Made Micro-Black Holes?



- What if we make our own?
- The Large Hadron Collider (LHC) near Geneva might be able to make them.
- Takes protons and accelerate them to 99.99% the speed of light, then crash the protons together.



Man Made Micro-Black Holes?



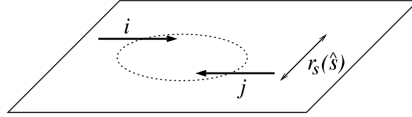
- When the particles smash together new particles are created sometimes, which quickly decay
- Main point of the LHC is to look for the Higgs Boson, which is theoretically expected to be responsible for mass.



Black Holes



- If two particles pass close enough with enough energy, they might form a microscopic black hole
- For 3 spatial dimensions, gravity is too weak for this to happen. But with extra dimensions, gravity becomes stronger, micro black holes can be created in particle collisions!

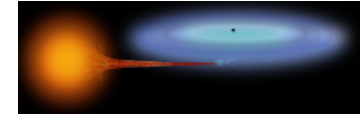


<http://www.youtube.com/watch?v=BXzugu39pKM>

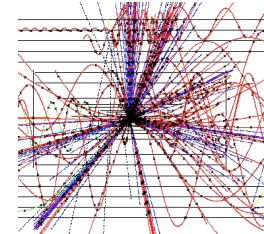
Black Hole Evaporation



- “Normal” black holes:
 Mass: $M_{\text{BH}} \sim M_{\text{sun}}$
 Size: kilometer
 Temperature: 0.01 K
 Lifetime: \sim forever



- Micro black holes:
 Mass: $M_{\text{BH}} \sim 1000 M_{\text{proton}}$
 Size: 10^{-18} m
 Temperature: 10^{16} K
Lifetime: 10^{-27} s



They explode!

Cosmic Rays



- Cosmic rays hit the Earth, Sun, etc with 5x higher energies.
- If black hole can be created, they have been already, and we're still here.
- In fact, LHC black holes would have high velocities, and probably leave the Earth before too much damage.
- Cosmic ray created BHs should have some low velocities ones.

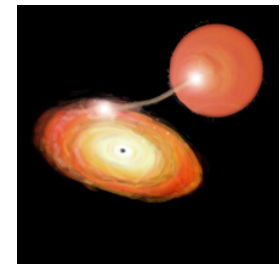


<http://www.thedailyshow.com/watch/thu-april-30-2009/large-hadron-collider>

Other Compact Objects?



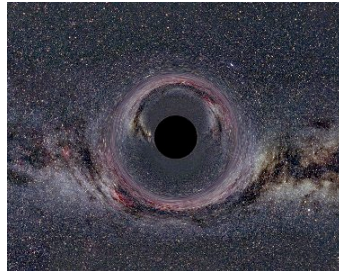
- There are a lot of white dwarfs or other non-black hole compact objects in the Galaxy.
- Still not very likely to interact with one.
- Collision is very unlikely, but could eject us or destroy the Sun.
- Very, Very unlikely, but probably more likely than a black hole.



Mitigation



- None or very little warning.
- For some objects much more warning.
- Try to play general relativity engineer?
- Can we predict accurately enough the orbits?
- Leave the Solar System.



Imagine

- An amateur astronomer trying to see Uranus is the first to notice. It's in the wrong place!
- Later, Jupiter is in the wrong place, then Mars!
- Even the Sun has moved!
- What is happening?! Oh, the Earth has moved.
- Panic spreads as scientist realize that a compact object has entered the Solar System and its mass is throwing off the orbits!
- Once the orbit was fixed for the object, telescopes looked for the object, but nothing— a black hole!

Imagine

- A black hole coming right at us at 500 miles/sec.
- As it gets closer tidal effects— floods, earthquakes, and tsunamis.
- As the 10 solar mass black hole reaches 7 million miles away, its gravitational pull equals that of Earth, everything on Earth is weightless.
- Then, the pull of the black hole is more than Earth.
- As the Earth gets shredded, you try to remember what Leslie said about black holes!

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.

Top 10 Ways Astronomy Can Kill you or your Descendents



7. Galaxy Collisions.

Milky Way vs. Andromeda.

Our sibling galaxy Andromeda is heading right for us, on a collisions course at 120 miles/second! In about 2 billion years, they will collide. Train wreck!

Remember Galaxies mostly empty space, so stars will not impact.

<http://www.youtube.com/watch?v=dJRc37D2ZZY>

http://www.youtube.com/watch?v=jexMI2SO6_I

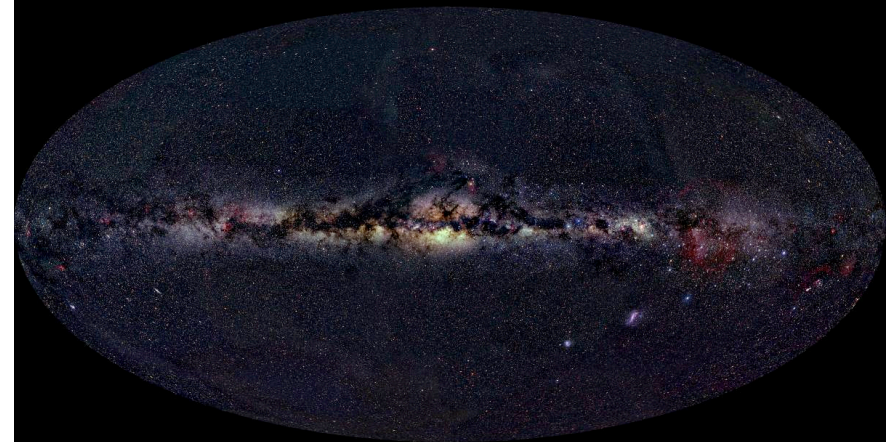
Imagine

- 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.

The Milky Way

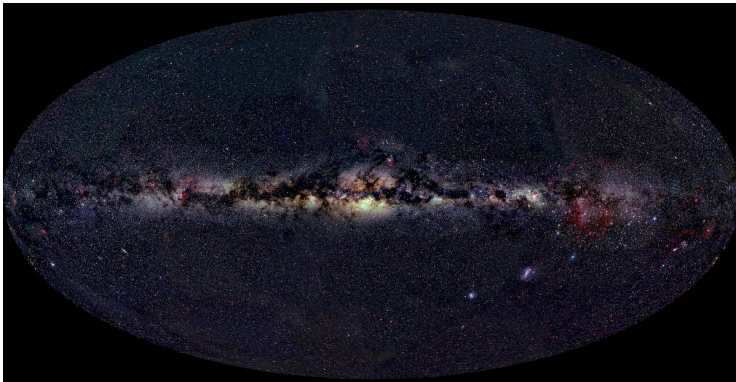


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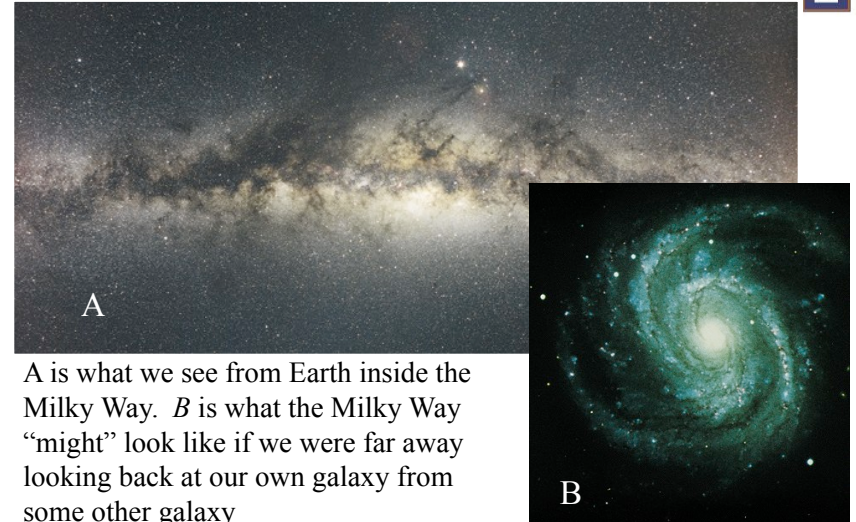
The Milky Way



- Our galaxy is a collection of stars, nebulae, molecular clouds, and stellar remnants
 - All bound together by gravity
 - Connected by the stellar evolution cycle



Which is a picture of the Milky Way?



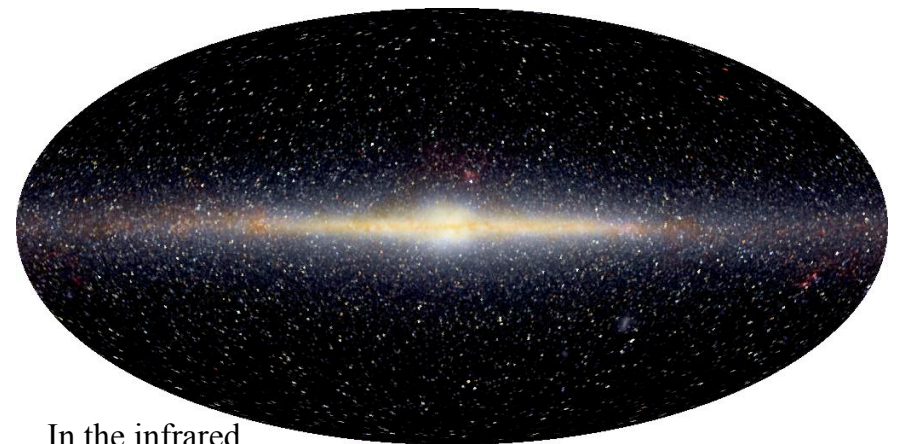
A is what we see from Earth inside the Milky Way. B is what the Milky Way “might” look like if we were far away looking back at our own galaxy from some other galaxy

The Milky Way is made of all the stars in our galaxy— about 100 billion. All the stars you can see in the sky are in our Galaxy.



Enormous clouds of dust obscure our view of most of the stars in our Galaxy

What is it?



In the infrared

Question



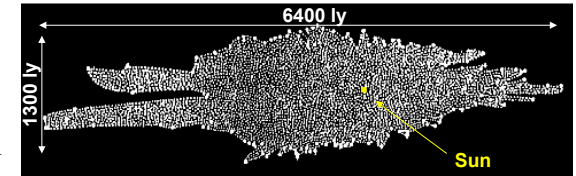
The Milky Way is

- a) effectively the observable Universe
- b) a galaxy made up of stars, stellar remnants, dust, and gas.
- c) a tasty treat.
- d) the beautiful band of light seen in the night sky with an unknown origin.
- e) all of the stars you can see with a telescope.

The Discovery of the Milky Way!



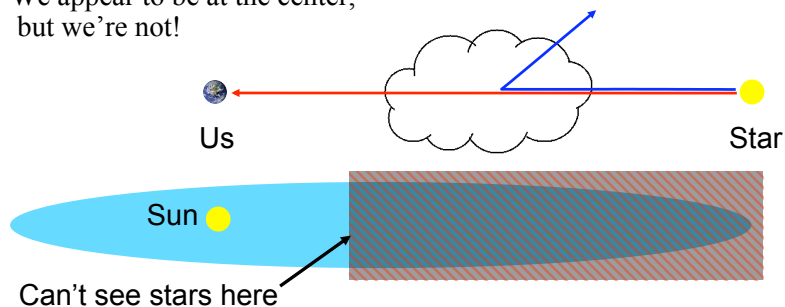
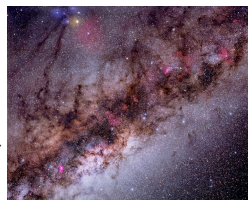
- The number of stars were counted in all directions from the Sun by William Herschel (the guy who discovered Uranus) and his sister Caroline
- They assumed that all stars have the same brightness – **Bad assumption!** and that space is completely transparent – **Nope!**
- They concluded that the Sun is at the center of the Universe



The Importance of Being Earnestly Dust



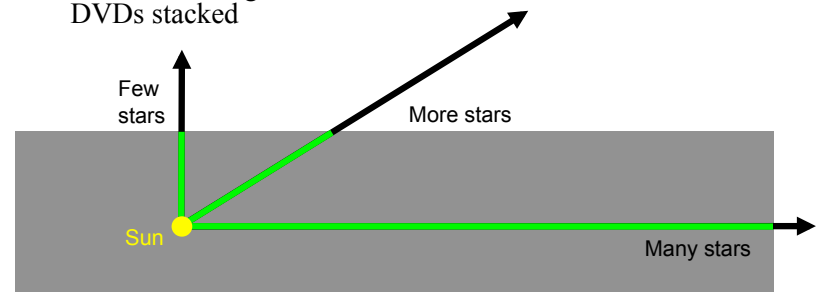
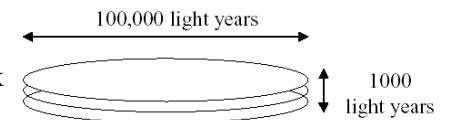
- There is clearly dust in the Milky Way disk.
How does dust effect the measurement?
– Makes stars dimmer and redder
- There is more dust toward Galaxy center.
- Consequence: Under-estimation in the number of stars in one direction
- We appear to be at the center, but we're not!



But, We Are in a Disk of Stars!



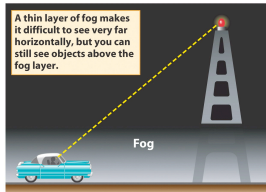
- But they were correct in determining that the distribution of stars in the Milky Way is in a thin disk
- The Milky Way is very thin in comparison to its diameter – imagine 3 DVDs stacked



How Do We Find the Center?



- If dust blocks our view, how do we find the center?
- We need to look outside of the disk!
 - Get around the dust
- A collection of relatively bright objects, outside the disk.



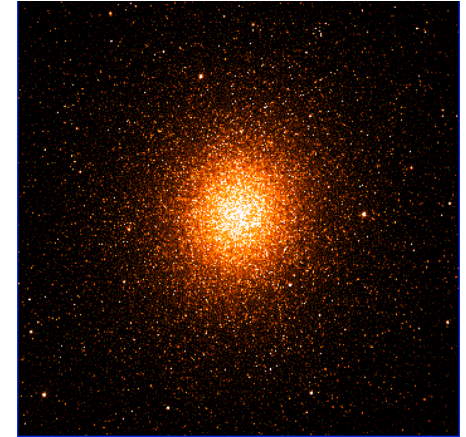
Determining your position in the fog



Globular Clusters



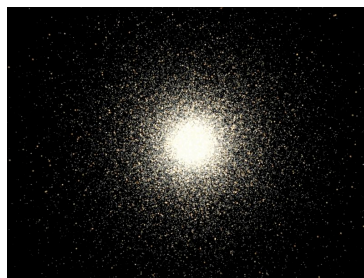
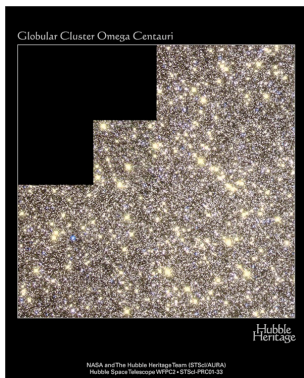
- Extremely regular, gravitationally bound groups of stars– very dense
- About $10^5 - 10^6$ stars each
- HR diagram of these groups of stars show that they are very old– 10 billion years!
- Generally outside disk of the Galaxy.



Globular Clusters



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

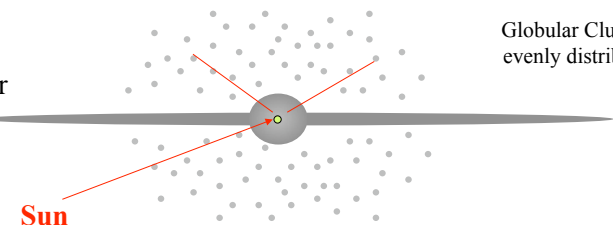


Finding Our Place!



Early view
Sun at center

Globular Clusters
evenly distributed

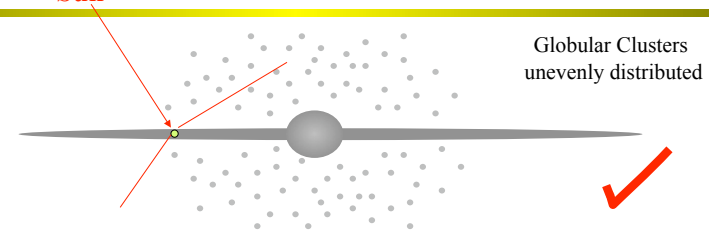


Sun

Globular Clusters
unevenly distributed



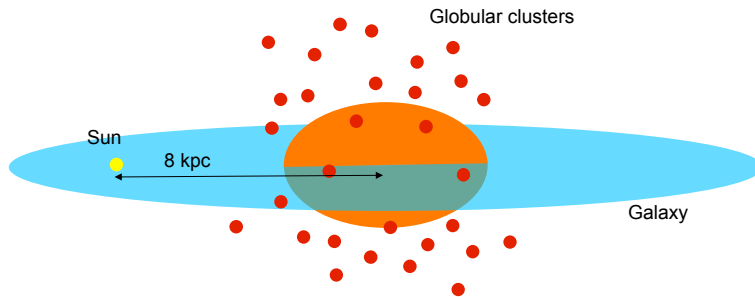
Harlow
Shapley



Our Place



- Shapley showed that we are not the center of the Galaxy in the 1920s.
 - **2nd Copernican revolution!**
- All of the globular clusters are orbiting around a point in Sagittarius– 25,000 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.

