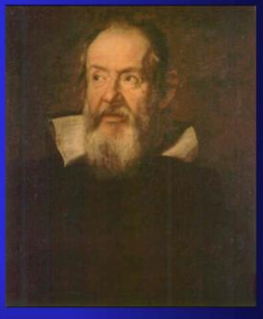
The Shape of the Universe

Questions:

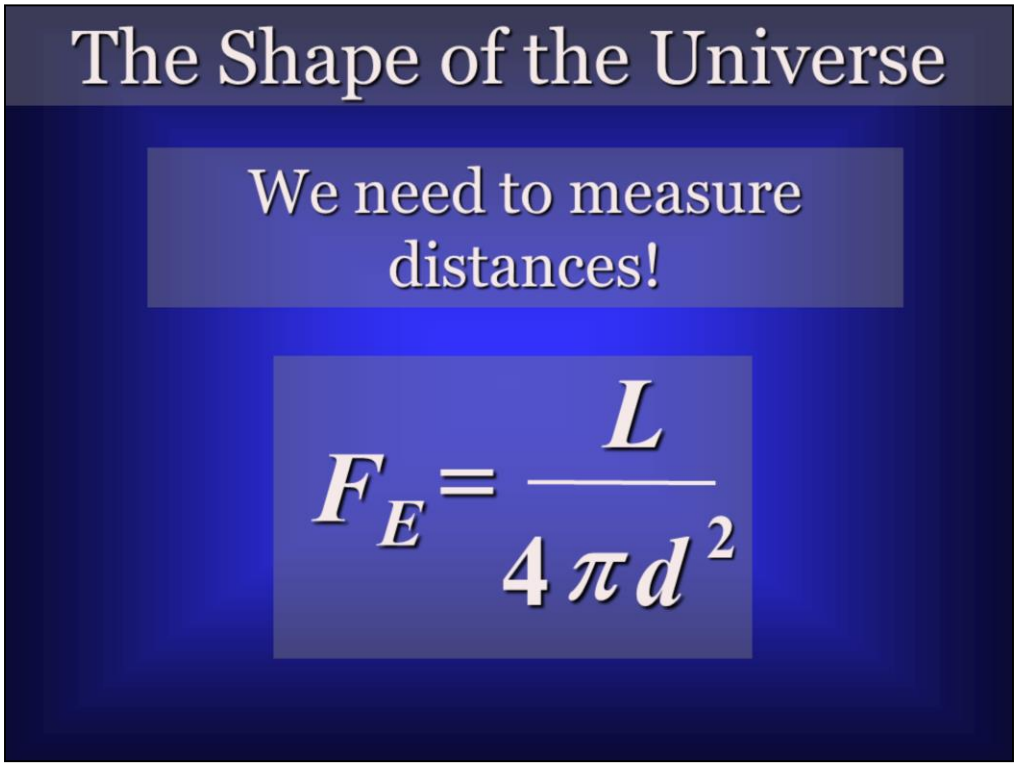
1. What was different between Herschel's Kapteyn's stellar distance measurements?
2. What was Kapteyn/Shapley debate about?
3. Who was the "most" correct?
4. What did they *both* get wrong?

The Shape of the Universe



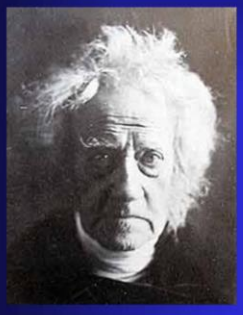
Gallileo

The Milky Way is composed of innumerable stars



We will get the distances to objects by “knowing” their Luminosity and solving this equation

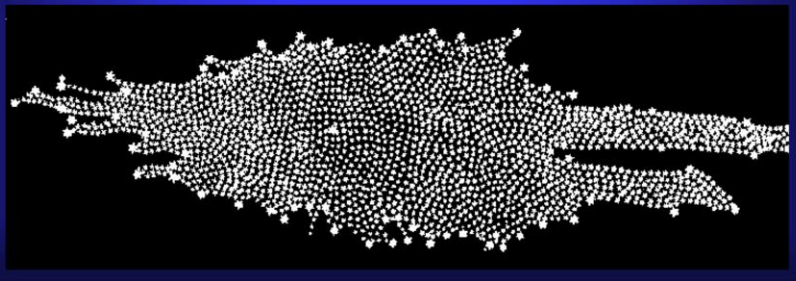
The Shape of the Universe

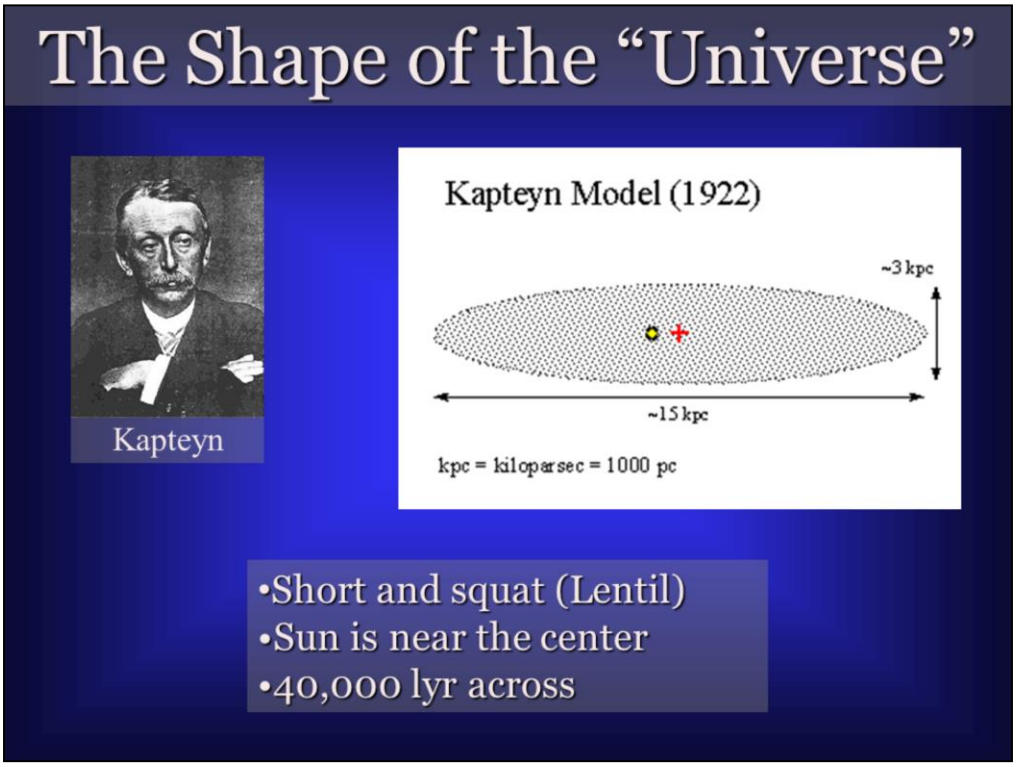


William Herschel

Assumes L=1 for all stars

The "Universe" is a flat disk 5 times wider than thick



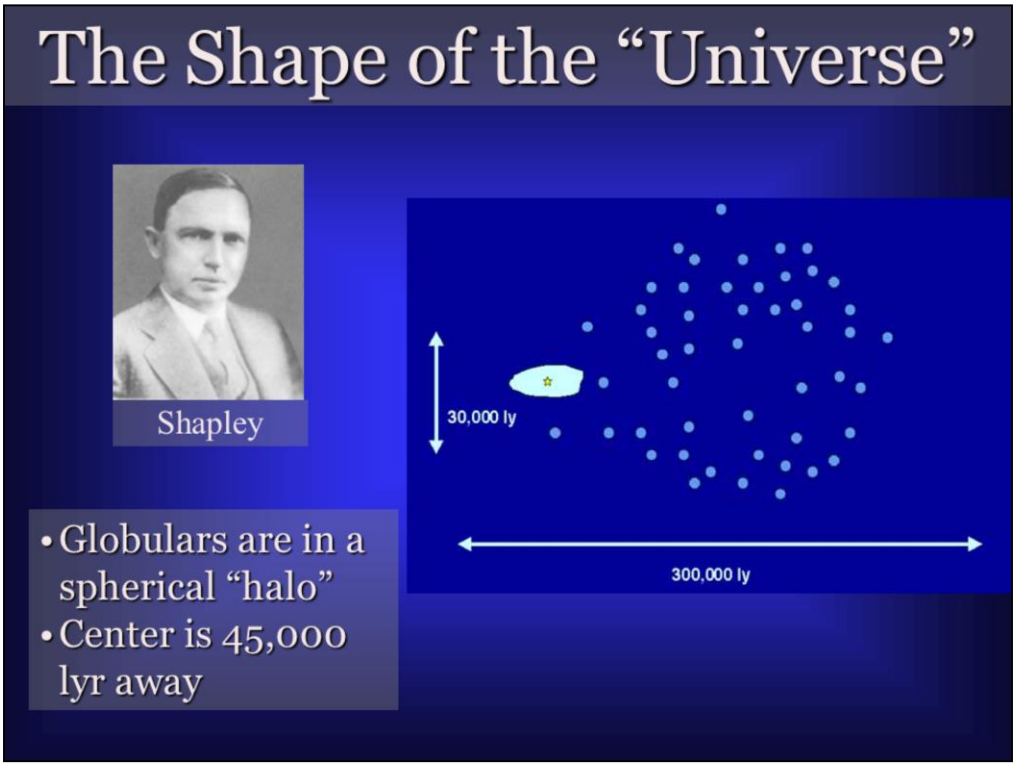


Kapteyn measured the distance to stars in many different directions using main sequence stars as standard candles.

Using Newton's laws, Shapley measured the orbits of globular clusters to find the center of mass of the galaxy.

Kapteyn underestimated the obscuring effects of interstellar dust.

He imagined a lens shaped galaxy.



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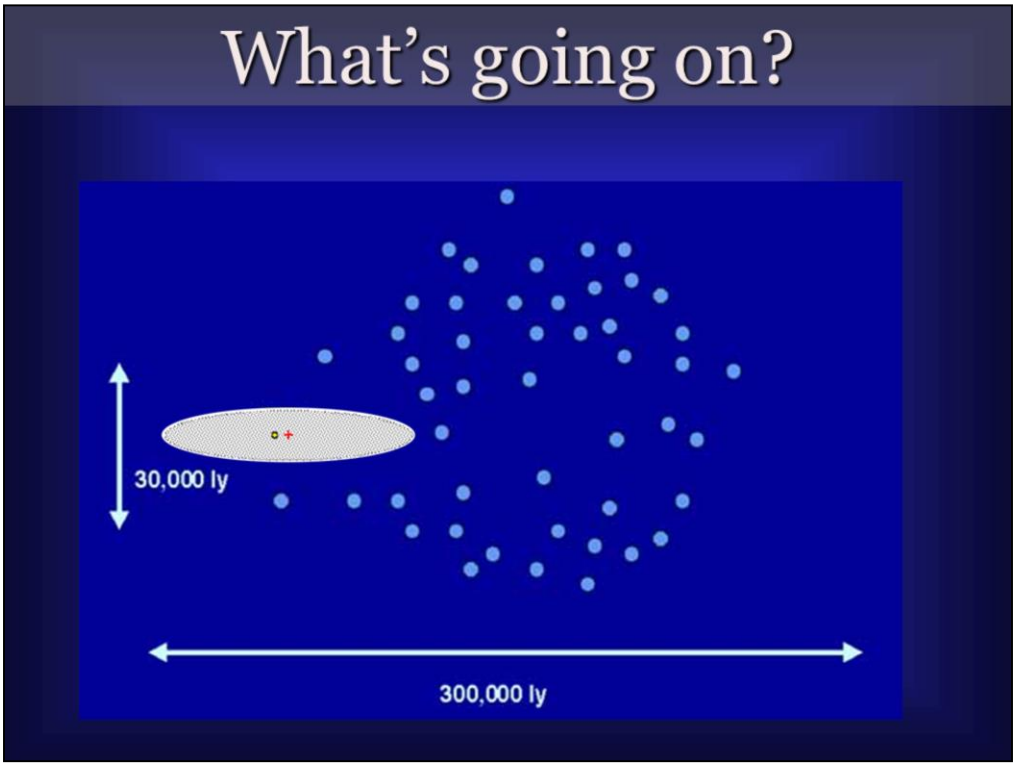


The Kapteyn and Shapley Universes superimposed on one another.

Kapteyn and Shapley disagree about nearly everything…

- The overall size.
- The shape
- The distance to the "center"

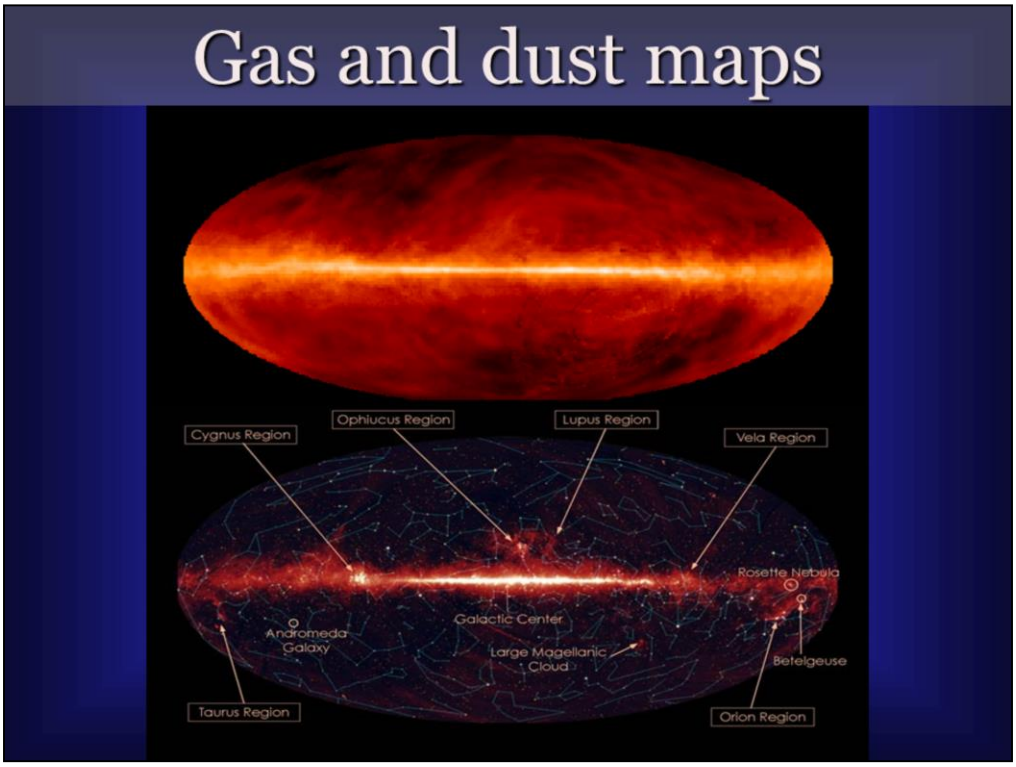
What's going on?

Facts

- Kapteyn is looking at *resolvable* stars.
- Shapley is looking at Globular Clusters
- They disagree about the size by a factor of 10
- They disagree about the location of the Sun
- The dust is concentrated in the midplane of both Kapteyn's and Shapley's distributions.

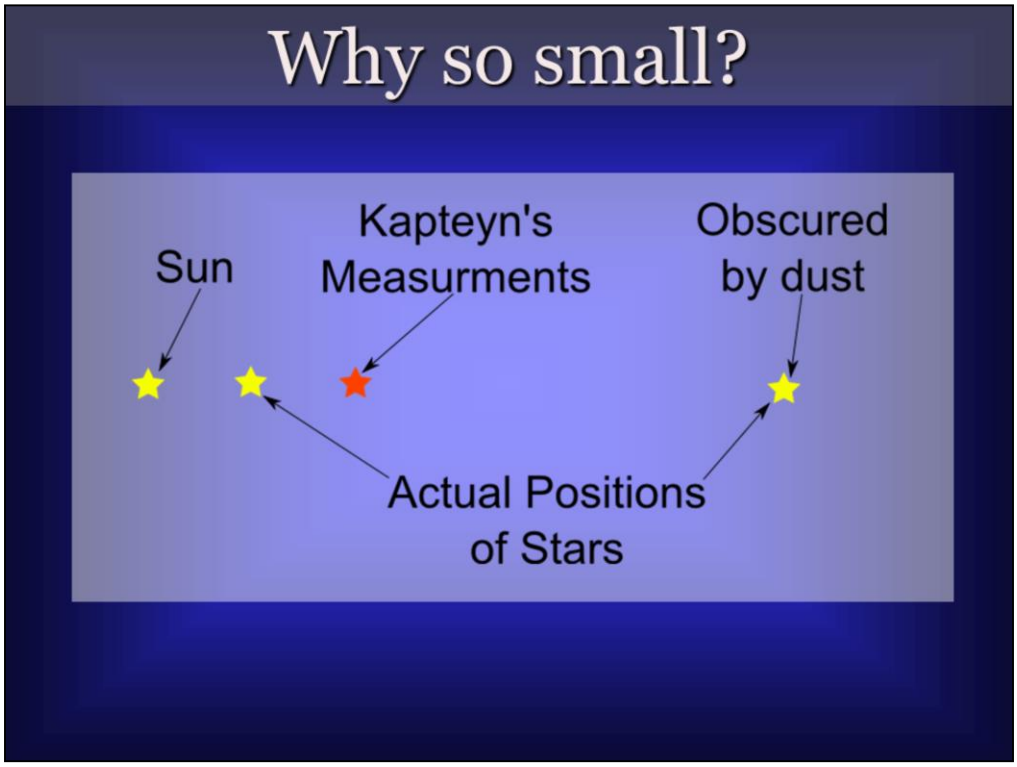
Questions

- Why is Kapteyn's Universe so small?
- Why can Shapley see so far?
- Why is Kapteyn's disk so thick and why does it extend so far "behind" us?



In modern times, we have built all sky maps that trace out the dust in the galaxy.

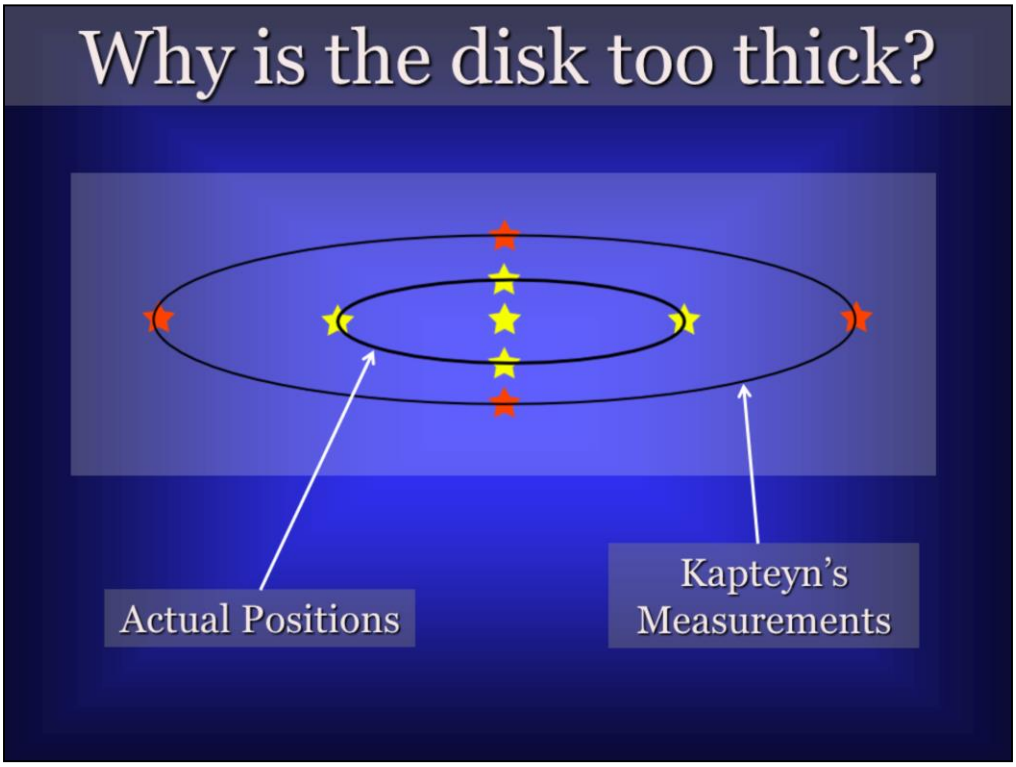
We have noticed that the dust is concentrated in a narrow band and is the most dense towards the constellation of Sagittarius.
Both Kapteyn AND Shapley found that the galactic center lies in the direction of Sagittarius.

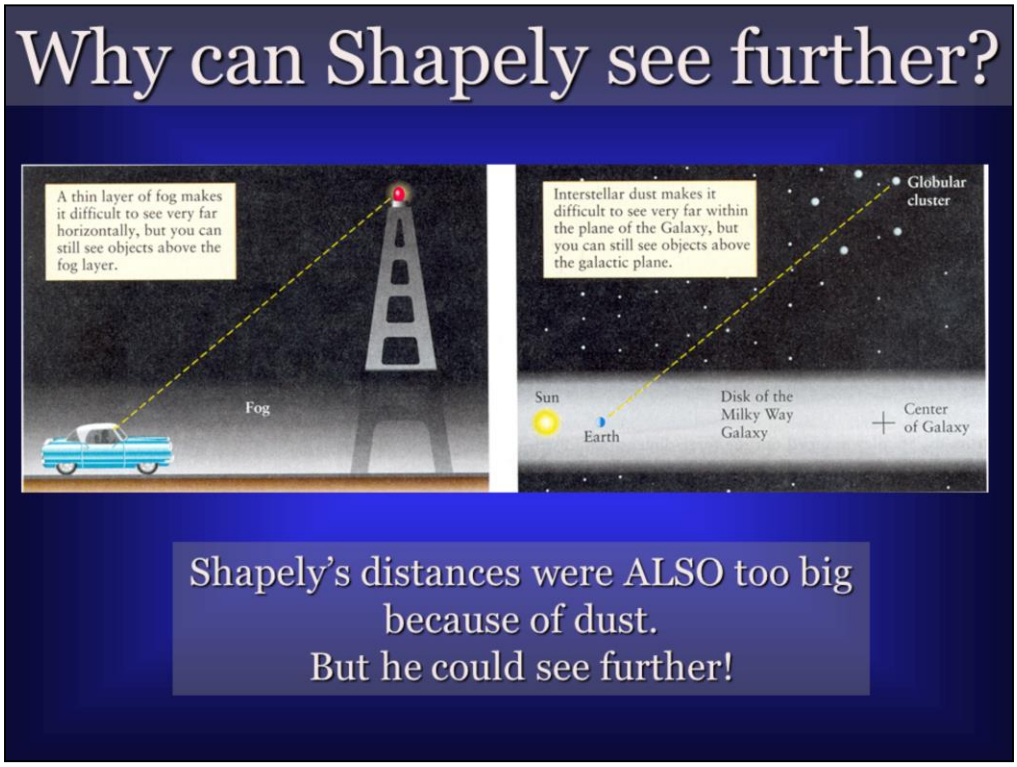


Kapteyn couldn't SEE all of the stars in the galaxy because of dust in the galactic plane.

The most distant star in this image would have been blocked from his view.
The nearby star that he COULD see was dimmed by dust causing him to get the wrong distance.

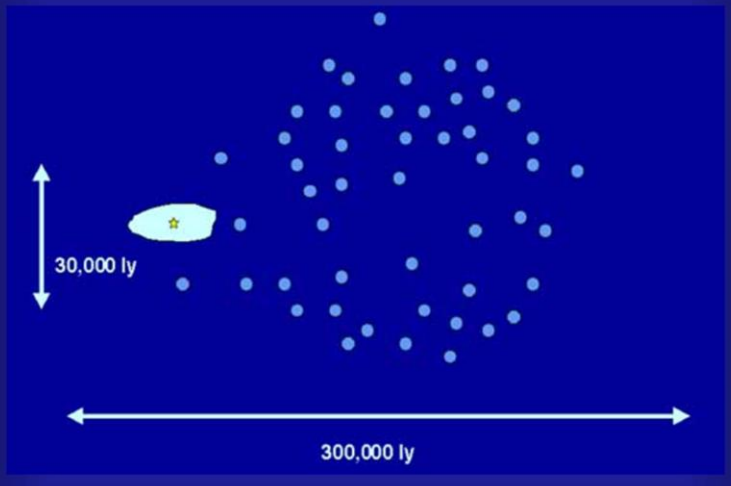
Why is the disk too thick?





He could see further because he was looking through less dust AND the globulars are BRIGHT

Who's Correct?



They were both wrong, but Shapely was closer.

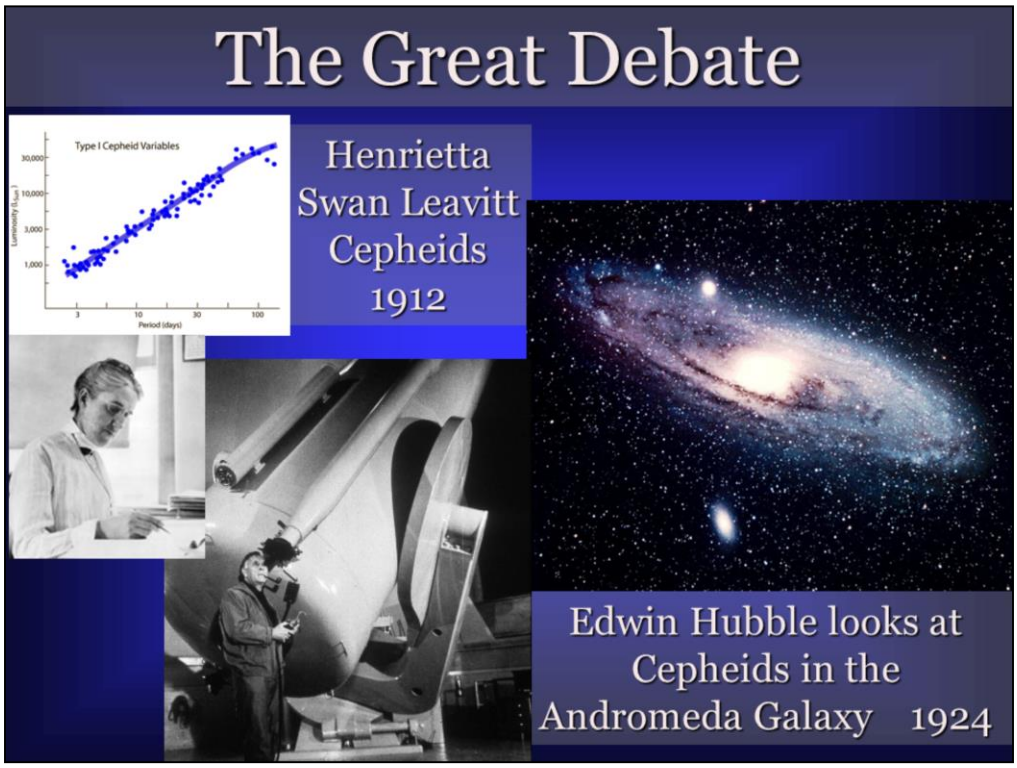
Milky Way Scales

Lecture Tutorial p 135

Shapley said that the Milky way is very large. In fact the entire universe is taken up by the Milky Way and the 'spiral nebula' are nearby gas clouds within the Milky Way.

Curtis said that the Milky Way is smallish and the Sun is nearly in the center (40,000 ly across). The 'spiral nebula' are other galaxies like the Milky Way.

Note: They are BOTH wrong about one thing and right about one thing.



Way farther away than even Shapley's estimates of the size of the galaxy!

Cepheids have a period luminosity relationship. We measure the period and derive the luminosity.

We them measure the flux and calculate the distance.

Turns out that M31 is 2.9 million light years away. This really blew their minds.

But… Shapley was right about the overall size of the Milky Way. It's much larger than Kapteyn and Curtis thought. It turns out that the Universe is a lot larger than *anyone* thought.

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