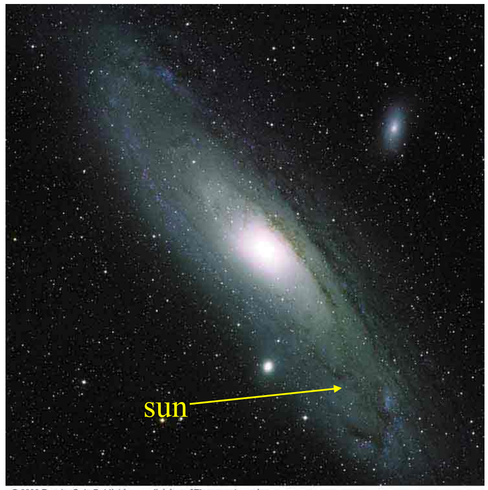
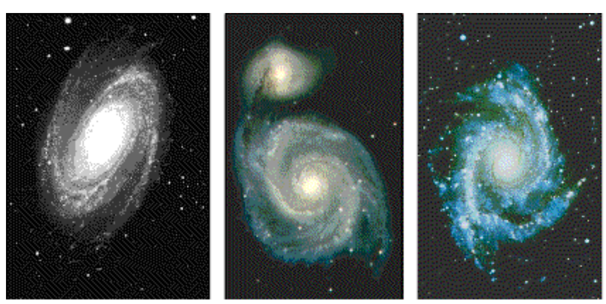
## The Milky Way Galaxy





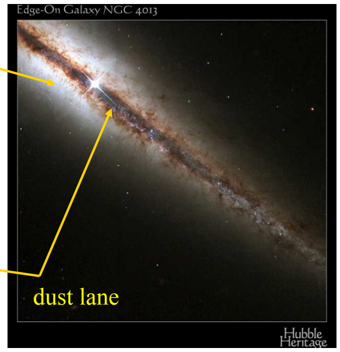

This is what our Galaxy would look like if we were looking at it from another galaxy.

## Examples of three Milky-Way like Galaxies



1. Roughly 100,000 light years across
2. Roughly 100-400 billion stars
3. Roughly 250 million years to rotate

## Edge-on you can see the **dust lane**




The dust lane is thin, patchy disk that is thinner than the stellar disk.

This thin gas/dust disk is the *fuel for the next generation of stars*.

The reason it is in such thin disk is because of the "friction" between gas clouds.
This friction is due to the collisions between gas clouds, whereas stars do not collide

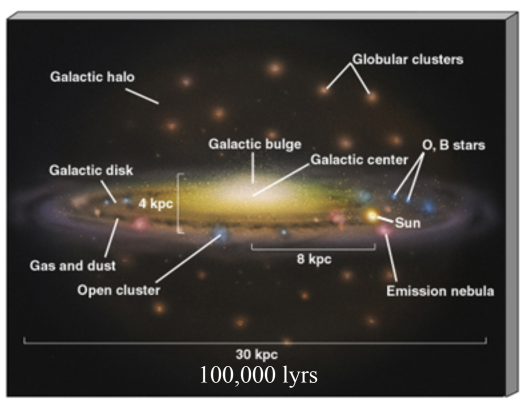
## Anatomy of Our Galaxy

1. Galactic Disk
2. Galactic Bulge
3. Galactic Halo

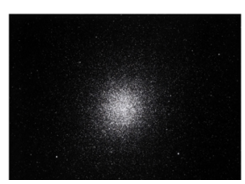
**Disk**
• young and old stars
• open star clusters
• gas & dust clouds (ISM)

**Bulge**
• old stars

**Halo**
• old stars
• globular clusters
• gas

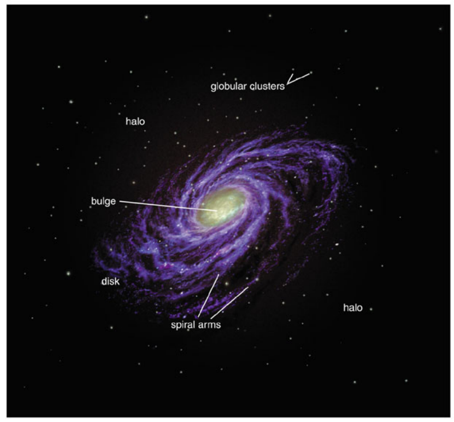



open cluster



globular cluster

## Another view of our galaxy….



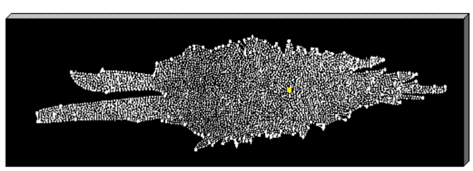



Note the colors; the globular clusters and bulge are reddish (cool low mass stars that are old) whereas the disk stars are ***both*** blue (hot high mass that are young) and reddish.

## HOW DID WE LEARN ALL THIS FROM OUR VANTANGE POINT?

William Herschel (late 1700s) tried to measure the shape and size of the Galaxy and the sun's position.

He measured the direction and "distances" to visible stars. He came up with this…



Herschel didn't know about different kinds of stars, he thought they were all the same (like the sun) and therefore all the same luminosity. Using this assumption, he could just simply compute the distance from the brightness.

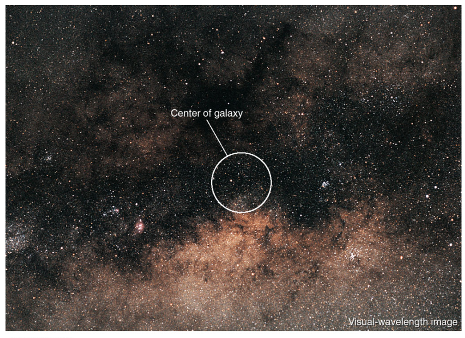
Brightness = Luminosity/(distance)$^2$

$d=(L/B)^{1/2}$

*This was before we knew how to measure stellar parallax.*

Two errors:
1. assumed all stars identical (same L) so that brightness gave distance
2. did not know about dark clouds and interstellar extinction which dimmed or blocked stars

## Interstellar Extinction

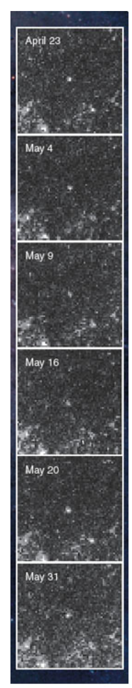



The stellar disk appears as a bright band across the sky from our vantage point.

The reason  Hershel incorrectly deduced that the sun is in the center is due to the presence of dark nebulae and dust in the Galaxy.  In each direction on the sky, he could only see so far, so it ended up looking like we are in the center.

Because Interstellar extinction blocks out most all the star far away from the sun.

## Getting Distance – more powerful than parallax is variable stars




Need a tool to measure distances to stars throughout the Milky Way…

Need to be able to measure distances greater than what stellar parallax can do (about 100 pc = 325 light yrs maximum).

The Milky Way is 100,000 light years across!  How do we measure distances that far!??

***Turns out… there is a method    VARIABLE STARS!***

(Hershel didn't know about this, since it wasn't discovered until about 1910)

## Cepheid Variable Stars

Distance Indicator beyond Parallax

- The brightness of these stars varies in a very periodic way.
- The period is directly proportional to the star's luminosity!

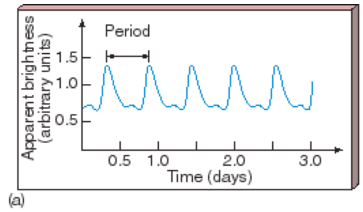
So…

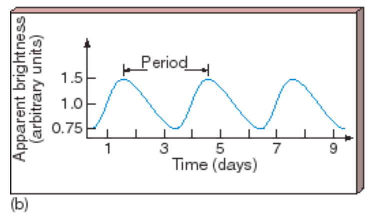
- Measure the period and get luminosity
- Measure the average brightness

Once you have average brightness and luminosity, you solve for distance from

Brightness = Luminosity/(distance)$^2$

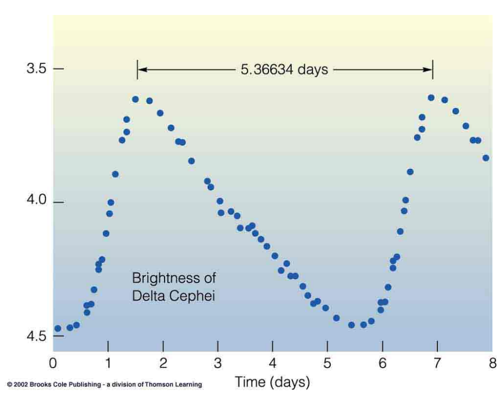
>> $d = (L/B)^{1/2}$

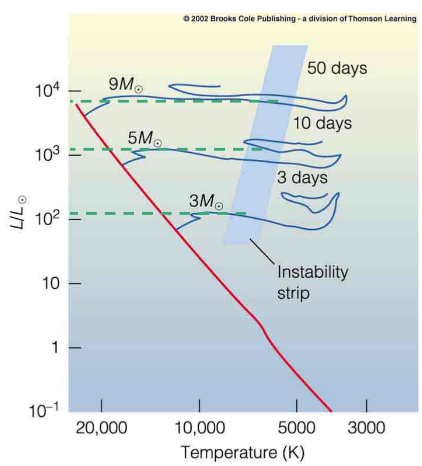



## Cepheid Variable Stars

These stars are aging stars. They lie in a region of the HR diagram called the Instability Strip. A star becomes a Cepheid variable star (unstable to oscillations) several times before it dies. These stars are more massive than the sun.

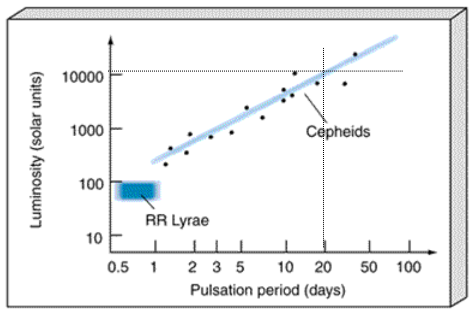


How it Works…

## Luminosity-Period Relation

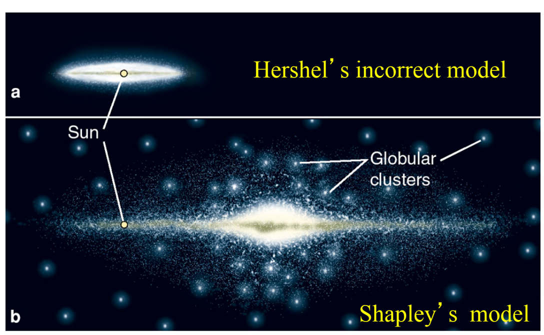
Once you measure the period of variability you can then just read off the luminosity.




Example. A star with a 20 day period has a luminosity 10,000 times that of the sun.

## Harlow Shapley's Realization… (1920s)

Globular clusters seen in all directions, but most of them are on one side of the sky!





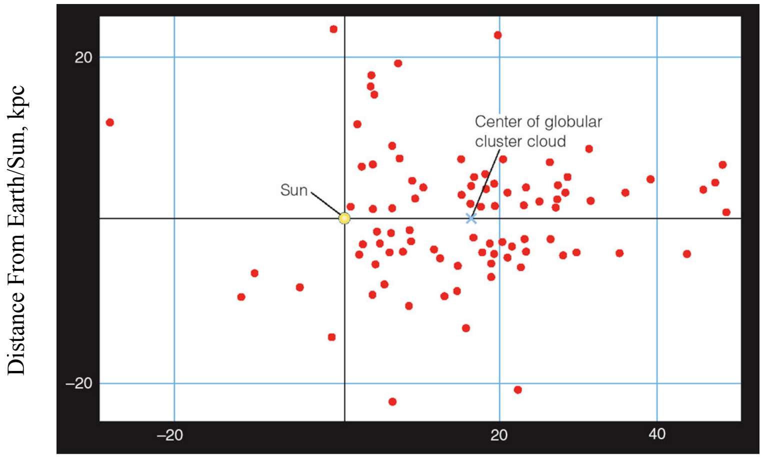

globular cluster
*(has lots of Cepheid variable stars in it!)*

*Globular clusters must orbit around the center of mass of the galaxy*!

Thus, assuming the clusters are distributed uniformly around the galaxy, he measured the 3D distribution of clusters (using Cepheid variables) and then assumed that the center of that distribution was where the center of the galaxy was.

CORRECT! He measured both the direction and distance to the galaxy center!

Shapley's Map of the Galaxy






Shapley's Map of the Galaxy