



Announcements

- Nothing due on Friday. Study up!
- I will not assign anything over Thanksgiving break
- Test 3 on Friday!
 - All study materials and solutions posted
 - Same format as past tests
 - Email me if you want to borrow a calculator!
- Polling: rembold-class.ddns.net



New Comet!



- Found manually by amateur astronomer Don Machholz
- His 12th discovery!
- Orbit still being determined
- Estimated perihelion in late November to mid December
- Around magnitude 8



Review Question

Through some black magic (obviously), the Sun is converted into a black hole with mass equal to the Sun's current mass. Which of the following is true?

- A. Earth's orbit starts to spiral slowly towards the black hole, owing to the black hole's increased gravity
- B. Earth's orbit travels straight toward the black hole (no spiral)
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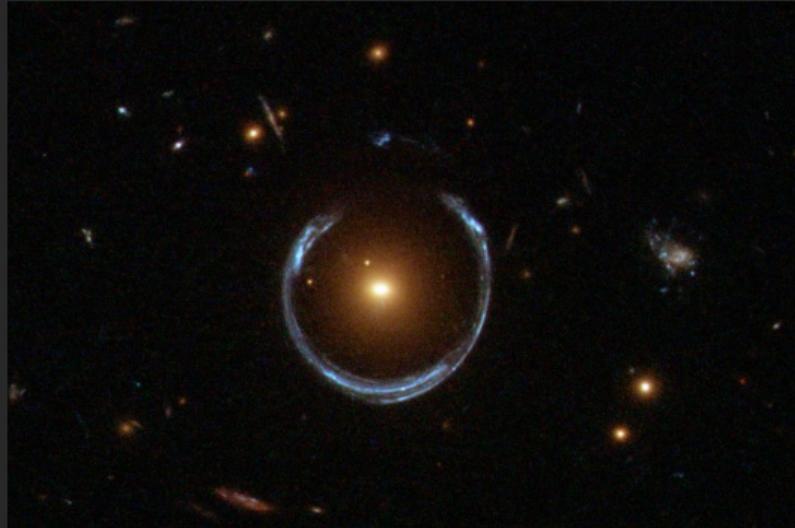
Portals across the Universe

- Supermassive black holes actually have weaker tidal forces
 - Their size means you need to be further away from the singularity
- Could maybe cross without being spaghettified
- Rotating or charged black holes have bizarre properties
- Wormholes to other dimensions?



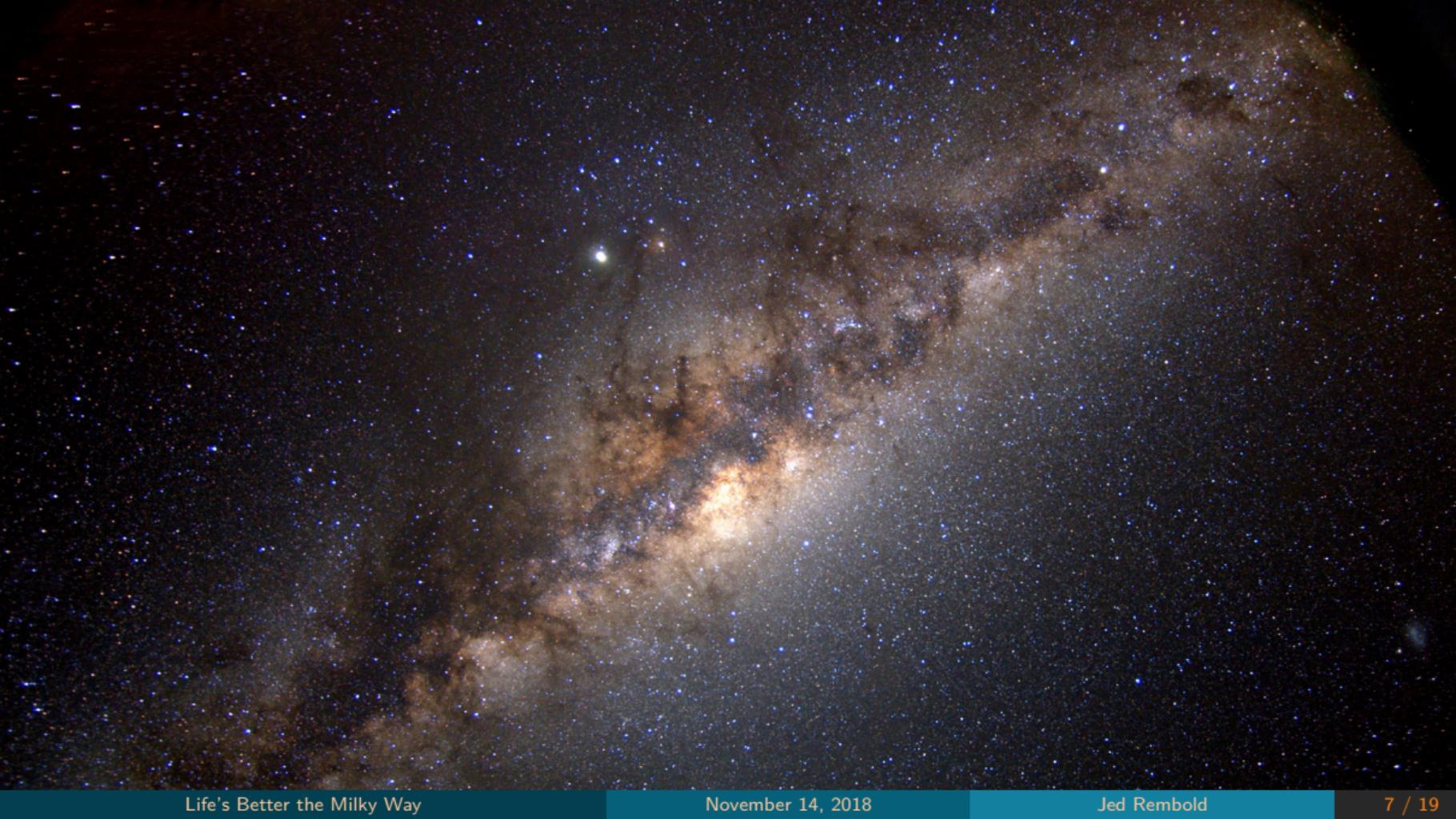
How do we find them?

- Noting their orbital effects
 - Their huge mass makes an obvious effect on their surroundings
 - Look for everything orbiting something that can't be seen!
- Gravitational Lensing
 - Light can be bent as it passes the black hole





- Can now use gravity waves to look for energetic events from black holes!
 - Swallowing of neutron star by black hole
 - Merging of two black holes
- Stretches are TINY!
 - Like measuring differences in a human hair from here in Alpha Centauri!
- Earth stretches and squeezes as the wave moves past us





Origins

- To the Greeks appeared as a ribbon of milk across the sky
 - Likely the source of its name
 - Greek word for milk: galactose
- Galileo was the first to turn his telescope on it
 - Learned that it was composed of stars

"The galaxy is, in fact, nothing but a collection of innumerable stars grouped together in clusters. Upon whatever part of it the telescope is directed, a vast crowd of stars is immediately presented to view. Many of them are rather large and quite bright, while the number of smaller ones is quite beyond calculation."

-Galileo Galilei, The Starry Messenger (1610)



Shaping a Picture

- Determining the shape of an object that one is **interior** to can be tricky
- How would you estimate the size and shape of Collins, without leaving this room?
 - We can't see through walls, so visible obstructions are a serious problem



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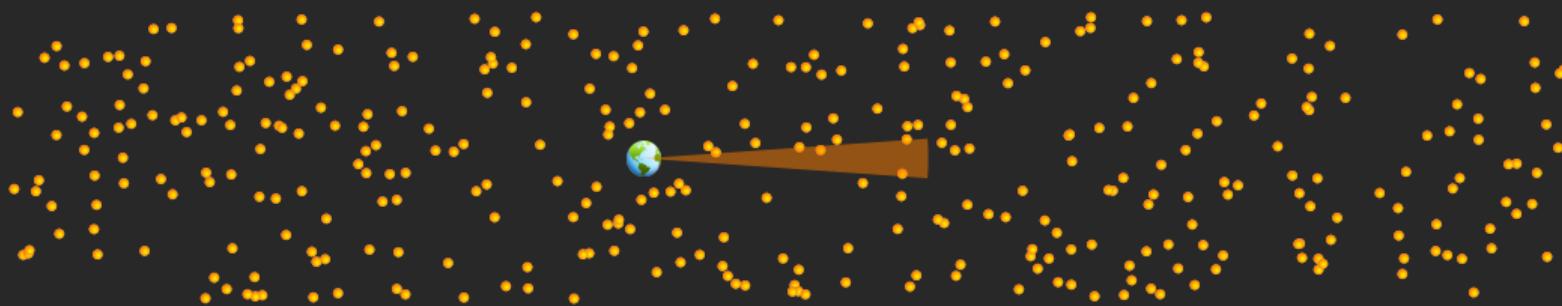
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 - Exterior windows don't give us a view of the building
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 - Interior window:
 - Portion of a hallway
 - Doors indicating other rooms?
 - Stairs indicating some height?



The Story of a Band

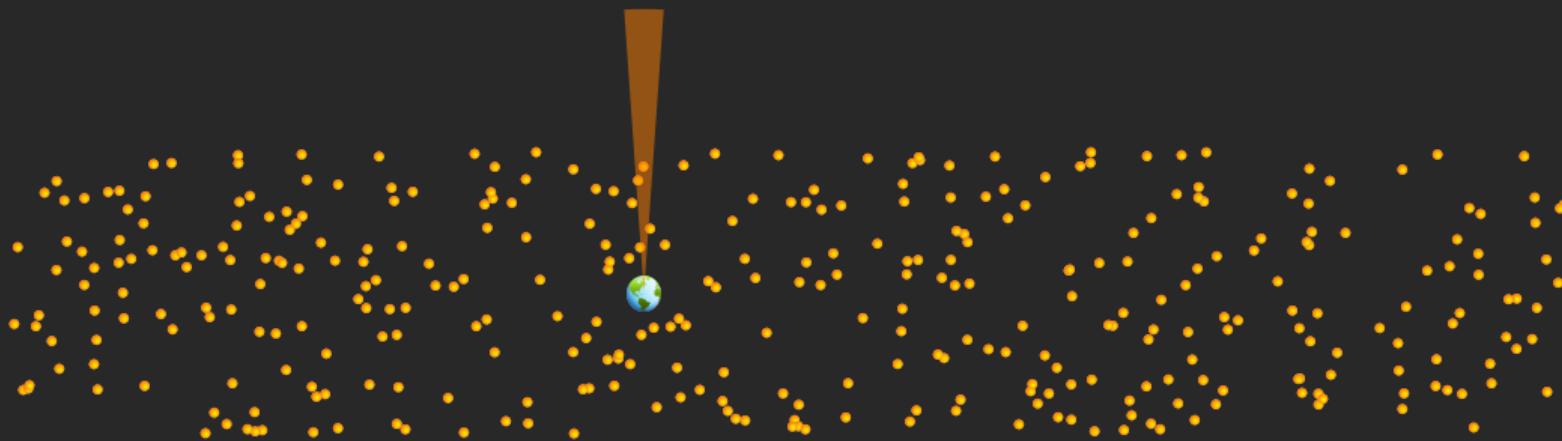
- If the Milky Way appears as a band across the sky, what does that tell us?
 - See way more stars when looking in one direction than nearly any other
- The galaxy must be fairly flat





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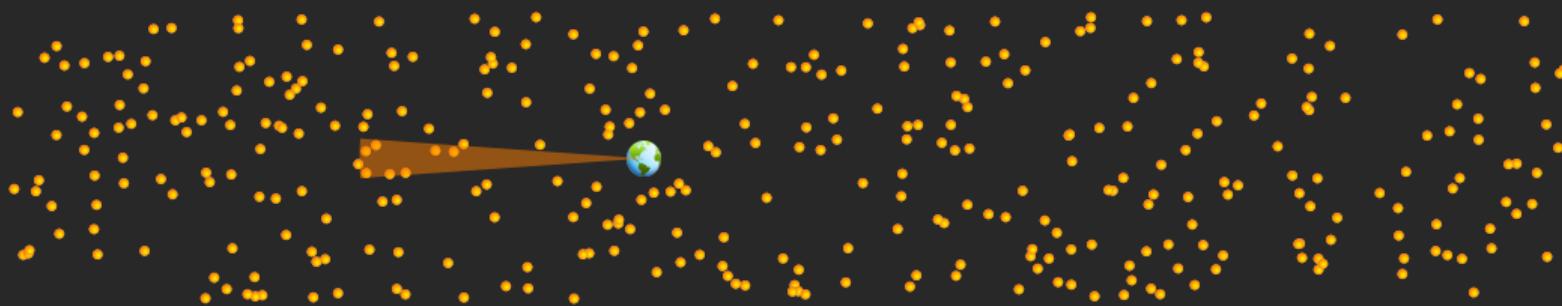
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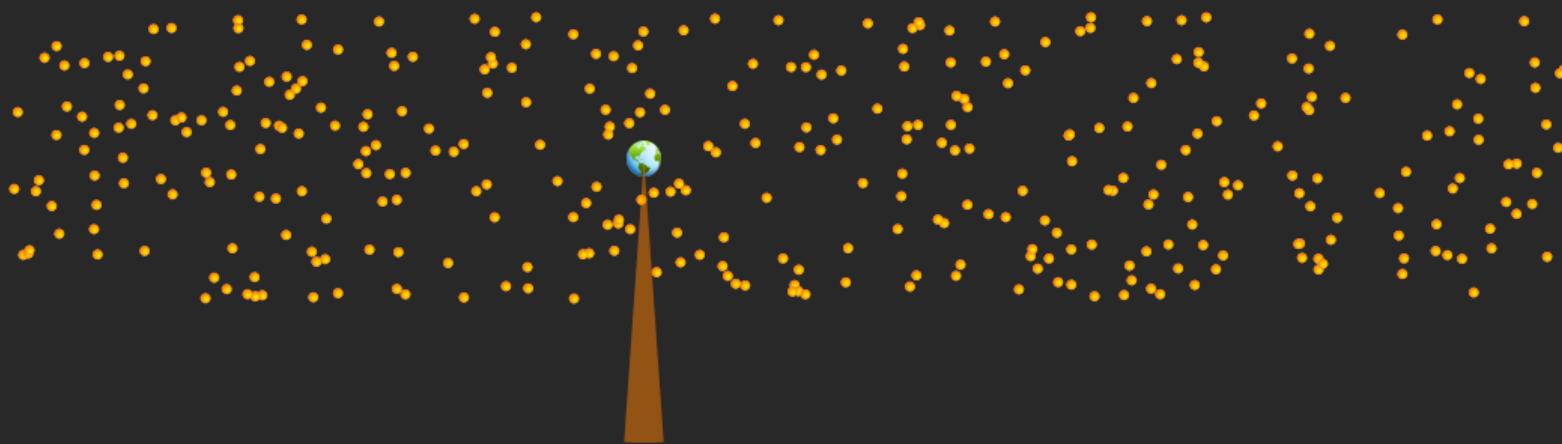
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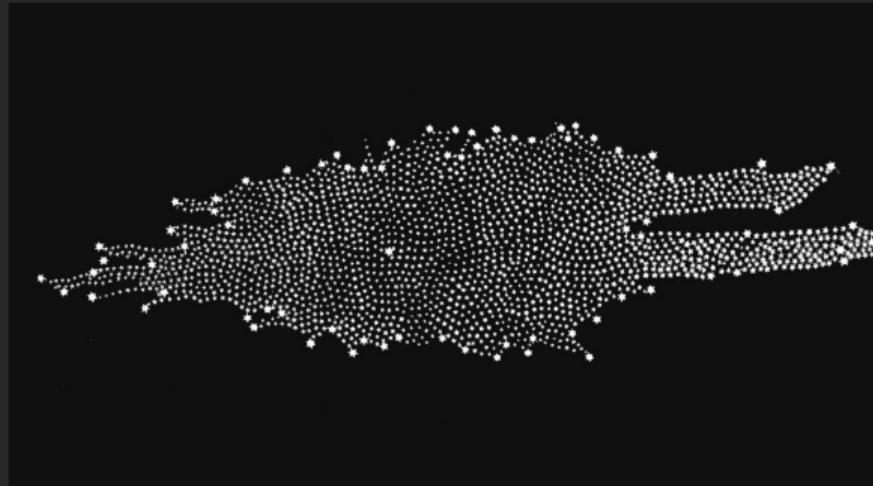
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Need a Larger Ruler

- So how does one attempt to measure the galaxy?
- In the early 1800's, William and Caroline Herschel tried counting stars
- They concluded:
 - The Milky Way was 5 times as wide as it was thick
 - Sun was near the center
 - Had several branches





What Went Wrong?

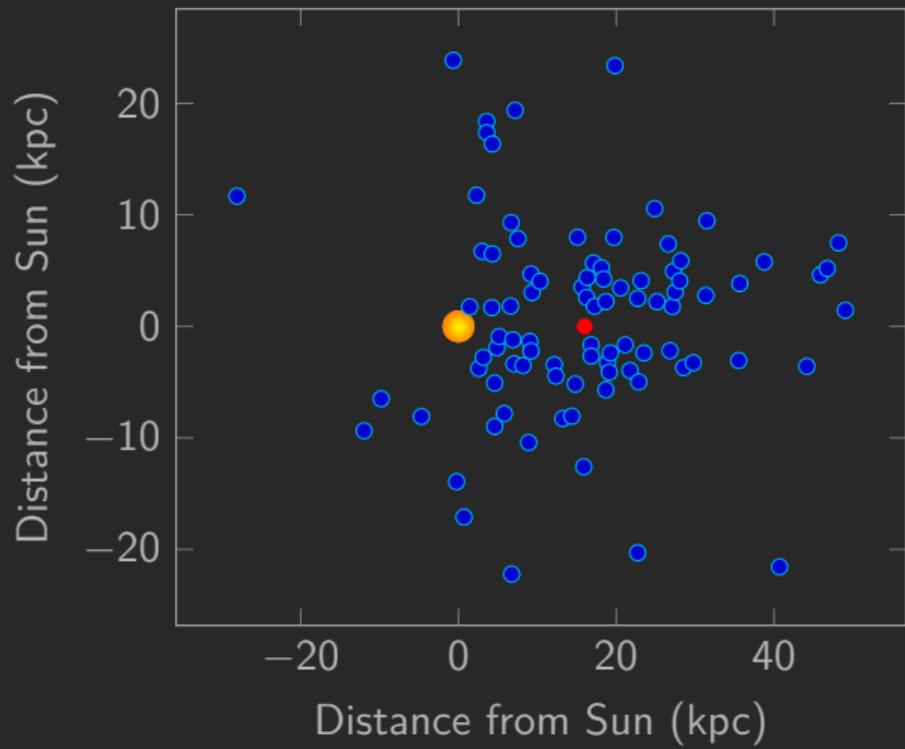
- Herschel had no way of knowing about stellar distances
 - First parallax measurements were gotten 15 years after his death
- He also didn't realize it was impossible to "see" to the edge of the galaxy
 - Many stars would be too faint to see with his telescope
 - Much of the galaxy is obscured by dust!





Attempt Numero Dos

- Harlow Shapley attempted to use globular clusters
- Globular clusters live mostly above or below the dust cloud
- Many stars so brighter and easier to see
- Findings:
 - Found a spherical distribution
 - Definitely not centered on the Sun





Galactic Distances

- Note most precise methods of determining shape rely on accurate distance measurements
- But we can only measure parallaxes for nearby stars...





Galactic Distances

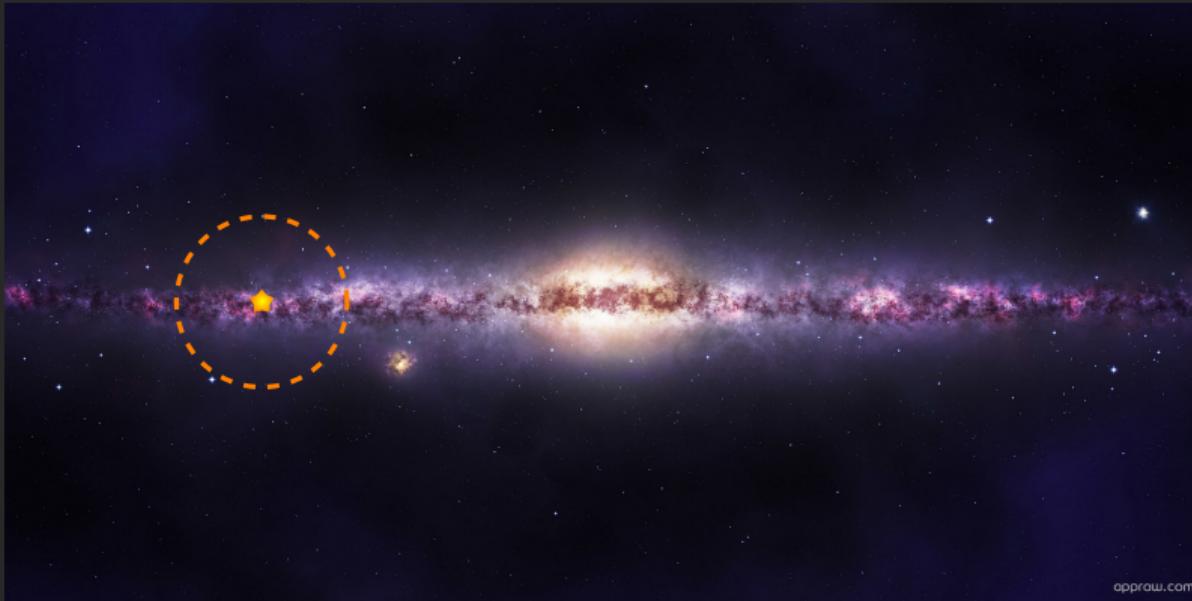
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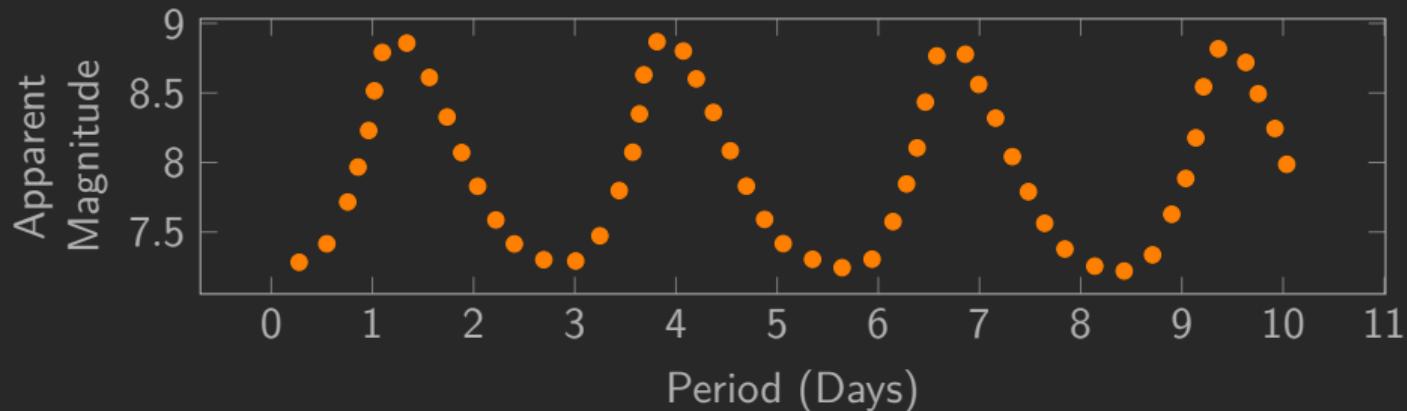
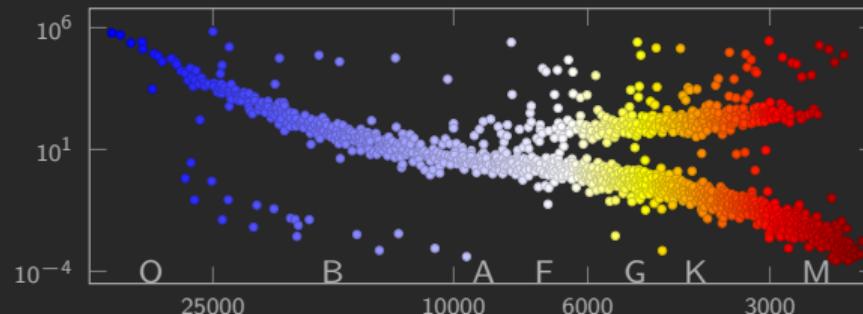


appraw.com



Enter Cepheid Variables

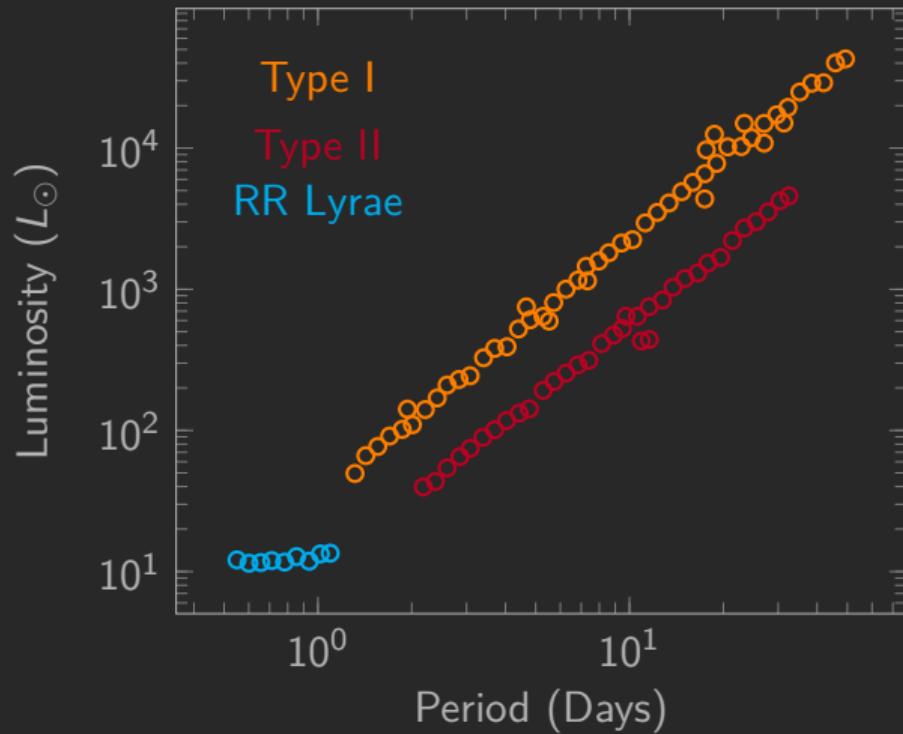
- Section 19.3
- Giant Stars with very predictable pulsations





Time = Power!

- In 1912 Henrietta Leavitt noticed that Cepheid variables in the Small Magellanic Cloud:
 - Higher Luminosities
 - Had longer pulsation periods
- This gives us an easy method to find luminosities!
- Which gives us distances!

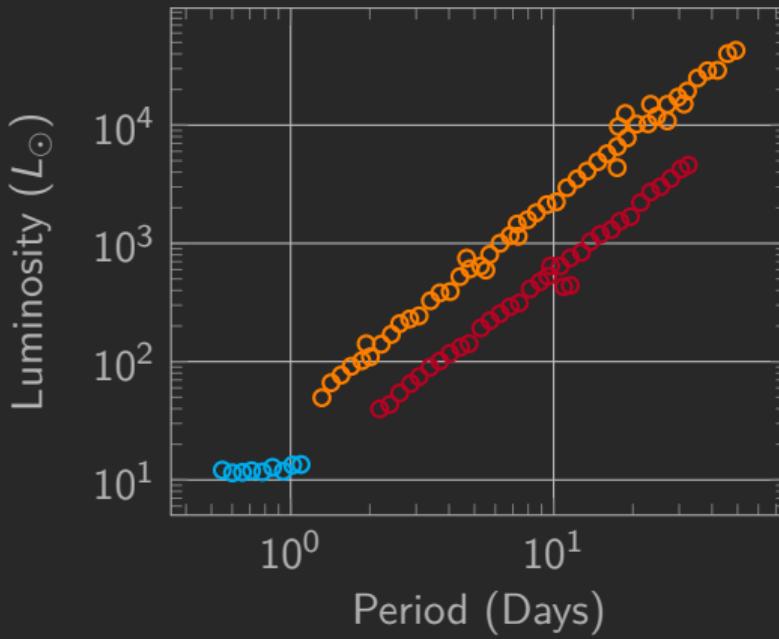




Understanding Check!

A Type I Cepheid variable star is measured with a pulsation period of 20 days. What is the star's maximum luminosity?

- A. $10L_{\odot}$
- B. $2000L_{\odot}$
- C. $10,000L_{\odot}$
- D. $50,000L_{\odot}$

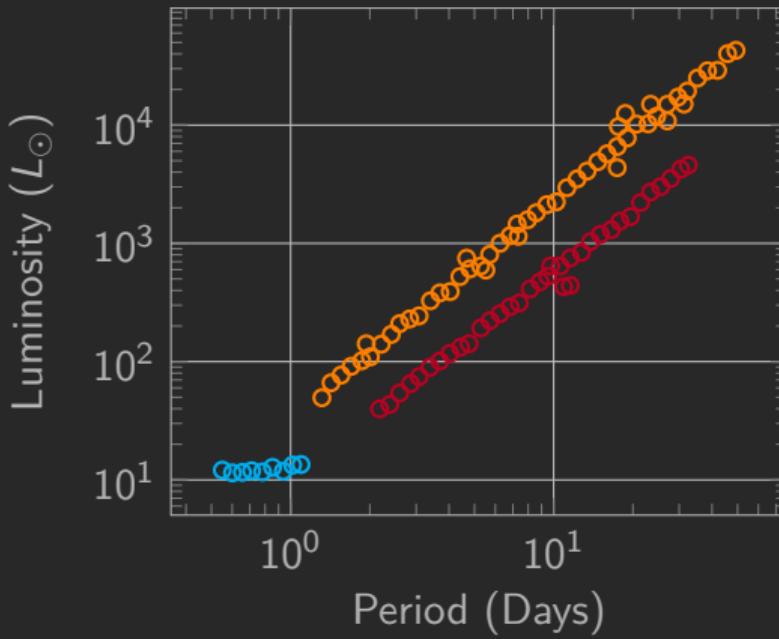




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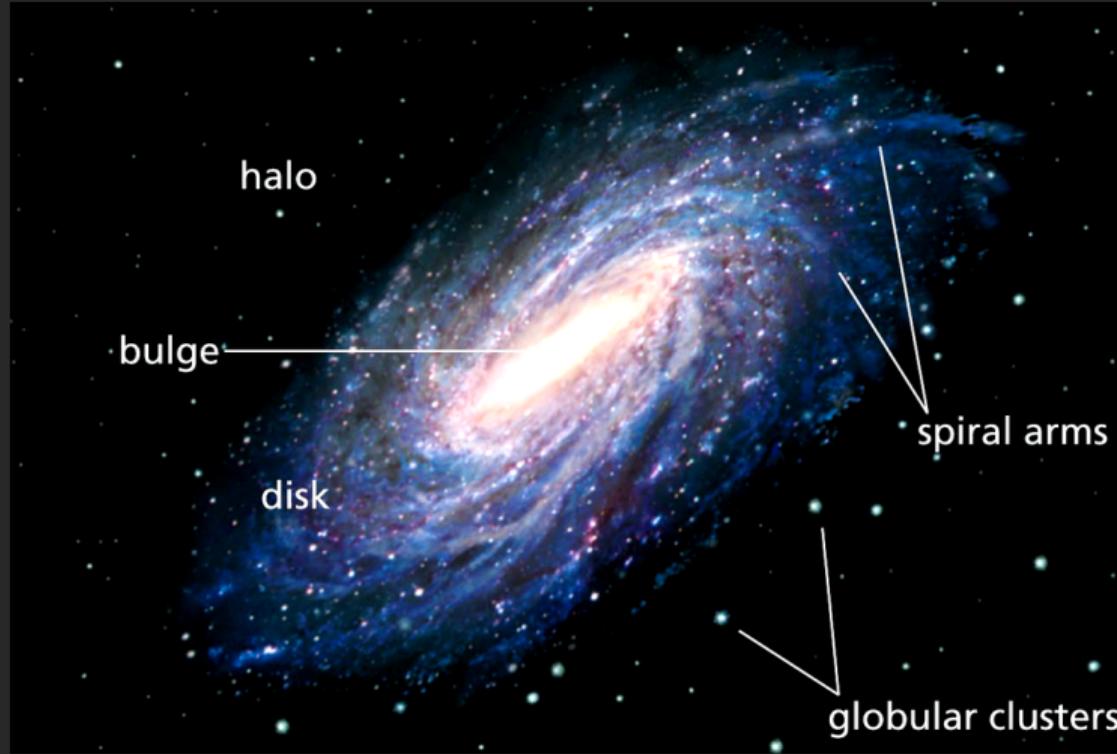
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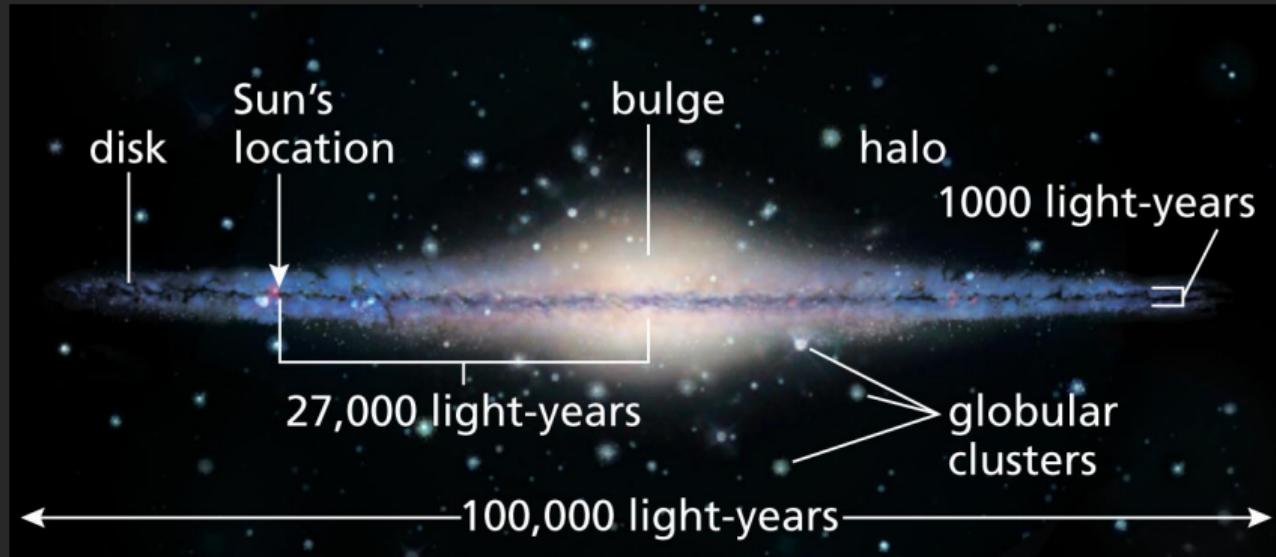


It all takes shape...





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Orbital Paths

