

About Hubble's Law—1 Nov

- Objectives: To answer and give evidence for these questions.
 - Galaxies move away from us in all directions. Are we at the center of the Big Bang?
 - Why are galaxies moving? Why is the universe expanding?
 - Why are most galaxies moving away from us? Why are some galaxies moving toward us?
 - Is Hubble's Constant a constant? You will answer in Hwk7
 - Is everything expanding? Figure this out yourself.
- Wavelength of light expands the same as the universe.
- No class on Wed. before Thanksgiving.

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Are we at the center of the Big Bang?

- Galaxies move away from us in all directions. (H's Law says so.) Therefore we are at the center of the Big Bang.
- 1. Can an astronomer on some planet in Hoag's Galaxy make the same statement? (Recall our demo from Fri.) Is Hoag's Galaxy at the center of the Big Bang?
 - A. Yes & yes
 - B. YN
 - C. NY
 - D. NN
- Every point is at the center of the BB. This is a special property of Hubble's Law

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Why do galaxies move?

- Why does a baseball move? Two ways to ask the same question:
 1. A baseball is 1 inch from a fan's hands in right field. Miguel Cabrera is trotting toward 1st base. Why did the baseball move from 2in to 1in from the fan's hands?
 2. Coma is 100Mpc from us, and it is moving at 6000km/s. Why did Coma go from 50Mpc to 100Mpc?
- What main idea enables you to answer these?

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Why do galaxies move?

1. Coma is 100Mpc from us, and it is moving at 6000km/s. Why did Coma go from 50Mpc to 100Mpc?
 - The main idea:
 - Newton's 1st Law: Natural motion is motion in the same direction at the same speed.
 - Coma was moving at 6000km/s. It will keep moving at the same speed all by itself. (We must look for the cause only if it slows down or speeds up.)

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Why do galaxies move?

- The main idea:
 - Newton's 1st Law: Natural motion is motion in the same direction at the same speed.
 - Coma was moving at 6000km/s. It will keep moving at the same speed all by itself. (We must look for the cause only if it slows down or speeds up.)
- The Big Bang set material in motion.
 - At some early time proto-Coma was 1cm from us and moving at 6000km/s. Proto-Hoag's Galaxy was 3cm from us and moving at 18,000km/s. (We will find out later if the speeds slowed or increased.)
 - Later, we will discuss early universe.

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Who obeys Hubble's Law?

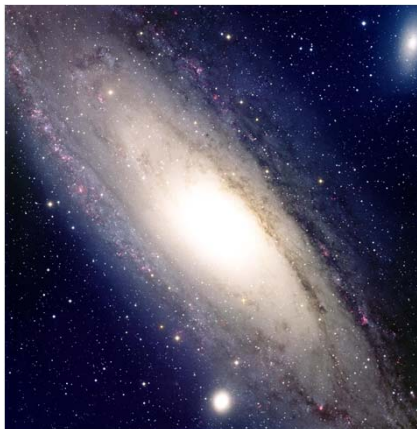
1. Who obeys Hubble's Law? P: Milky Way Galaxy and Hoag's Galaxy. Q: Earth & sun.
 - A. Yes for both cases P & Q
 - B. Y for P. N for Q.
 - C. N for P. Y for Q.
 - D. N for both
- What is different about the two cases that makes one obey and the other violate Hubble's Law?

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- Andromeda & two companions are moving toward us at 200km/s. The distance is 0.7Mpc.
- According to H's Law, what should the speed of Andromeda be? (H=64km/s/Mpc)
 - $v = H D = 64\text{km/s/Mpc} \cdot 0.7\text{Mpc}$
 - $= 45\text{km/s}$ away from us.
- Why does A not obey H's Law?
- Imagine a history
 - Immediately after Big Bang, material follows Hubble's Law strictly.
 - Big Bang is an explosion that happens at the same instant
 - I push against my neighbor; my neighbor pushes against me & my next-door neighbor. Therefore my next-door neighbor moves away faster than my neighbor.
 - Our local group of galaxies was slightly more dense than surroundings.
 - Gravity overcame motion, and caused A to reverse direction and come toward us.

Why do most galaxies move away, but a few move toward us?



Andromeda M31, M32, & M33

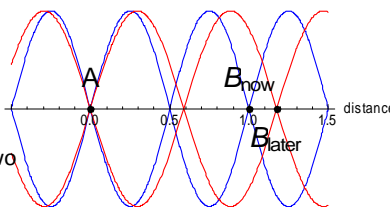
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www.noao.edu/image_gallery/images/d6/m31y.jpg

Expansion stretches wavelength of light

- Principle: Wavelength of light stretches by the same factor as the universe expands.
- Fundamental observation: Universe is observed to be the same in all directions.
- Why?
 - A standing wave permeates the U. (Two waves going left & right add up to a standing wave.)
 - At the present time, galaxies A and B sit on nodes of the standing wave.
 - Later, galaxy B has moved farther away.
 - B must remain on a node. If it is to the left of the node, then the direction toward A is special.
 - Therefore wavelength stretches by the same factor that the universe expands.



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