The Beginning

Using science to explain the beginning of time and space

"I can construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe."

Next Generation Science Standard ESS 1-1

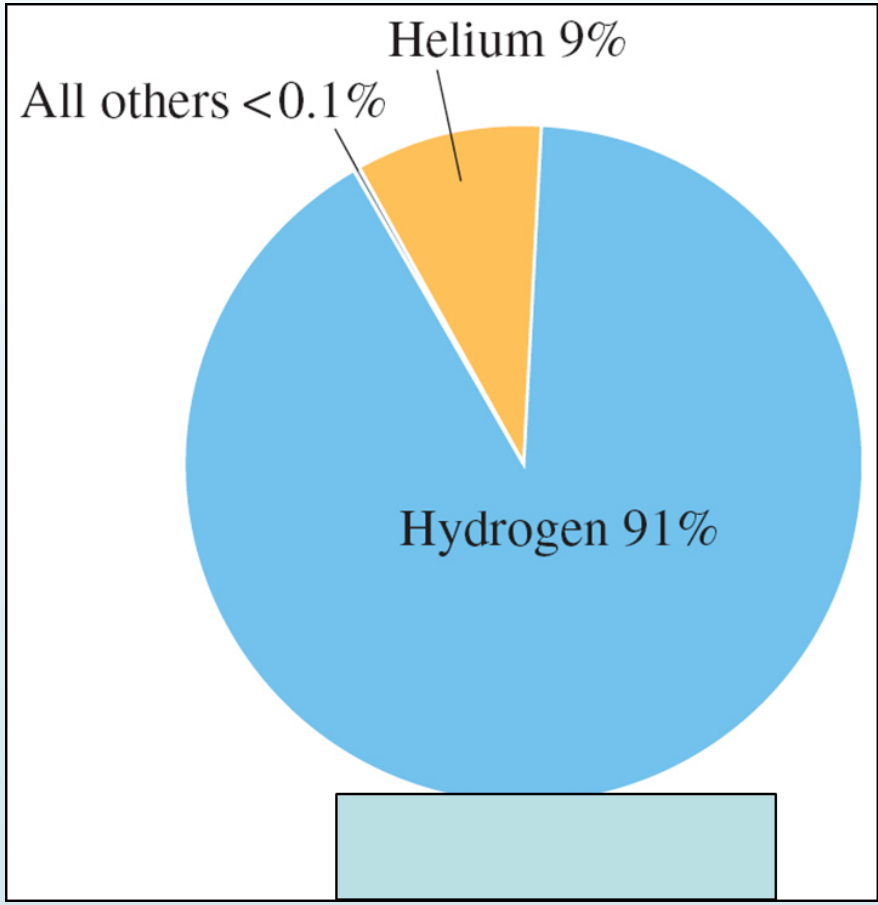
Learning Target 10.1

Cosmic Abundance of Elements

Astronomers look at the Sun's radiation and they find that it is made mostly of hydrogen, some helium, and traces of other gases.

Based on the light from stars and galaxies, the universe appears to be made of approximately 91% Hydrogen, 9% Helium, and less than 0.1% other elements.

A theory of the origin of the universe must account for this abundance of hydrogen and helium.



Cosmic Microwave Background

- In 1964, while attempting to detect faint radio waves bounced off balloon satellites, Arno Penzias and Robert Wilson kept getting interference (like static) in their receiver.
- After attempting to get rid of all possible sources of interference—including removing bird droppings—they determined that the radio noise was coming from space, and in all directions.
- The radiation they were detecting looked like a thermal radiation curve with a peak wavelength of 1.07 mm. ***What does this imply about the temperature of the universe?***

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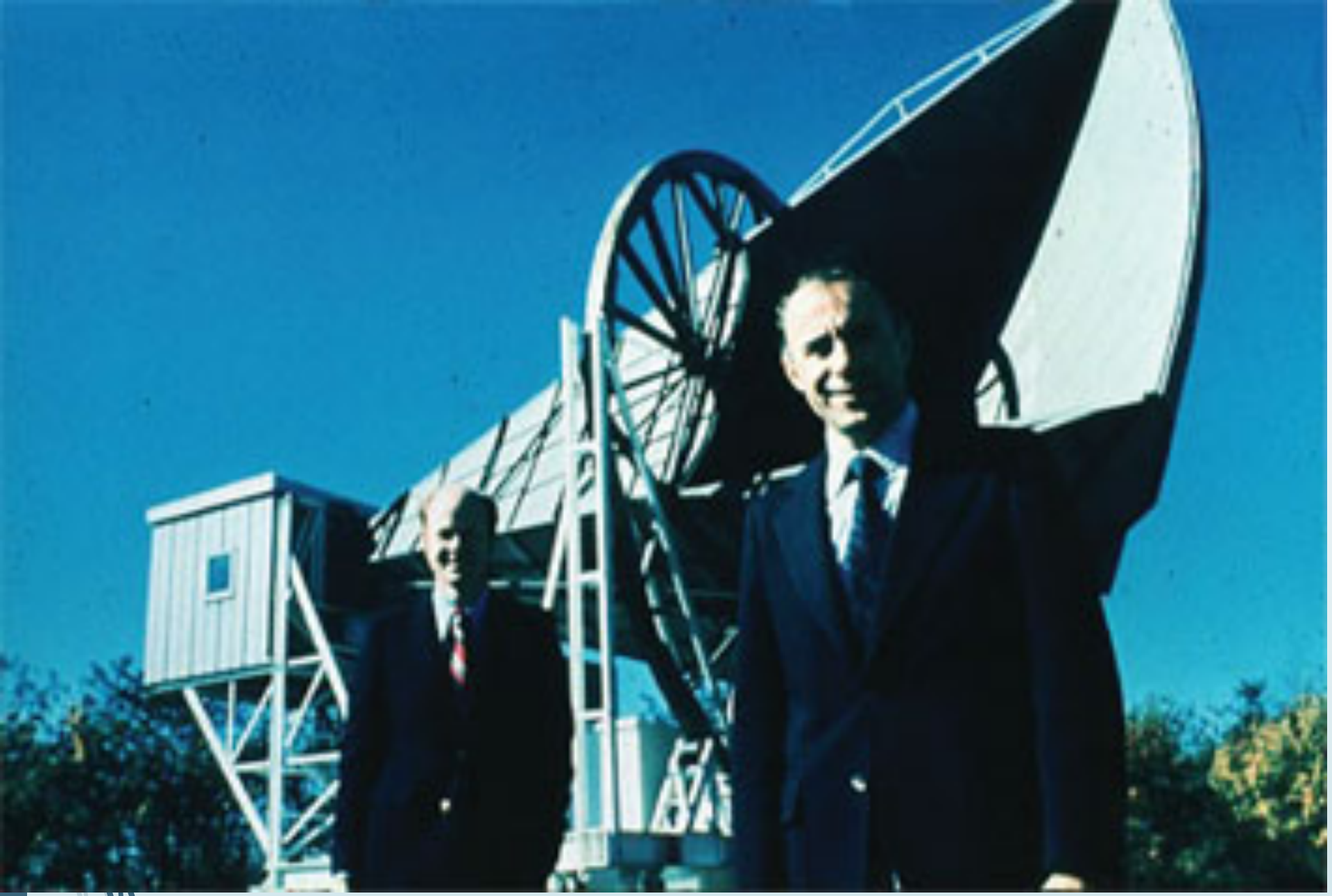
- The radiation they were detecting looked like a thermal radiation curve with a peak wavelength of 1.07 mm. ***What does this imply about the temperature of the universe?***
- ***The universe has a temperature of 2.7 K. Any theory of the universe's origins must account for this fact also.***

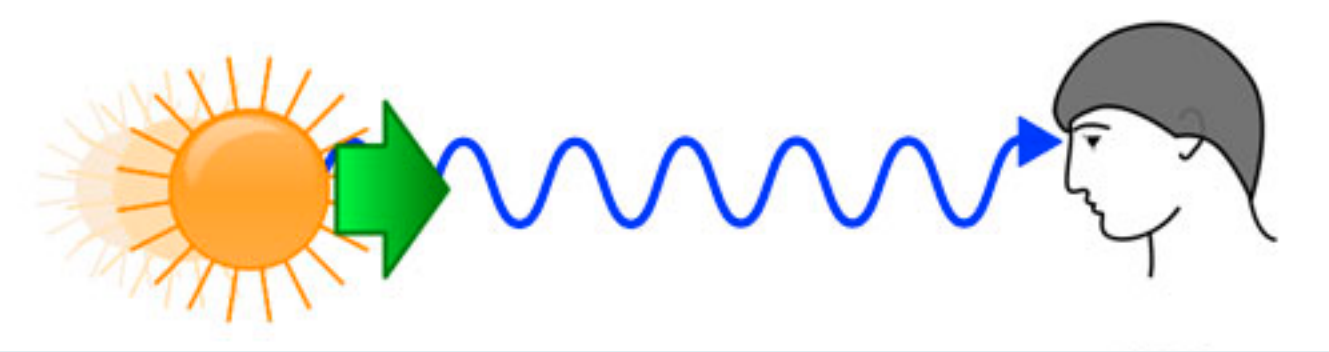


The Doppler Effect

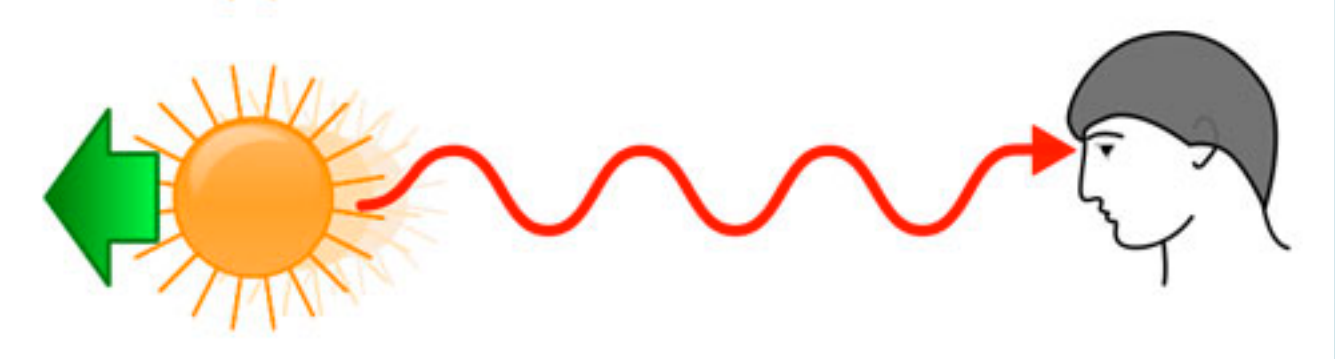
https://youtu.be/imoxDcn2Sgo

Light Changes Shape

- **If the source is coming closer, the light wave gets <u>compressed</u>.**



- **If the source is moving away, the light wave gets <u>stretched out</u>.**



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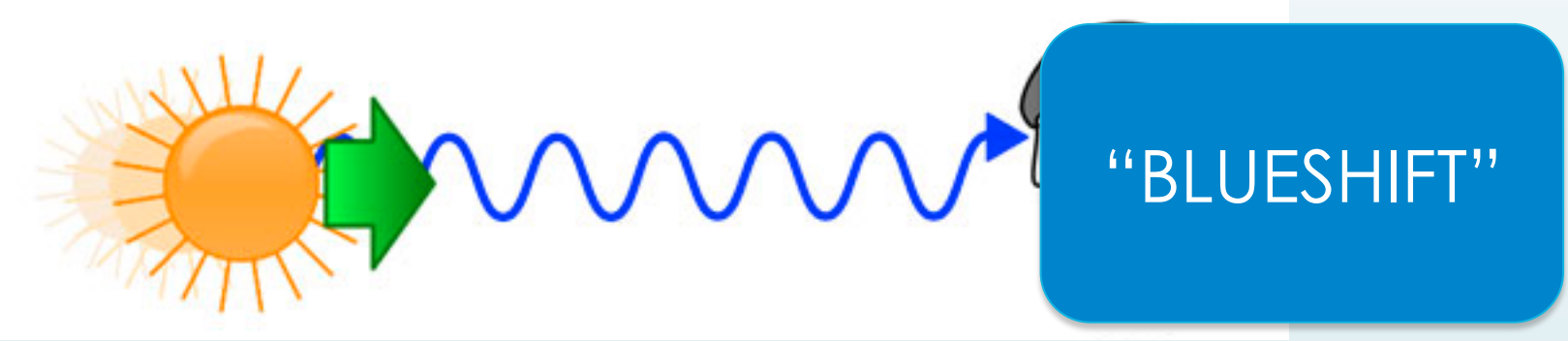

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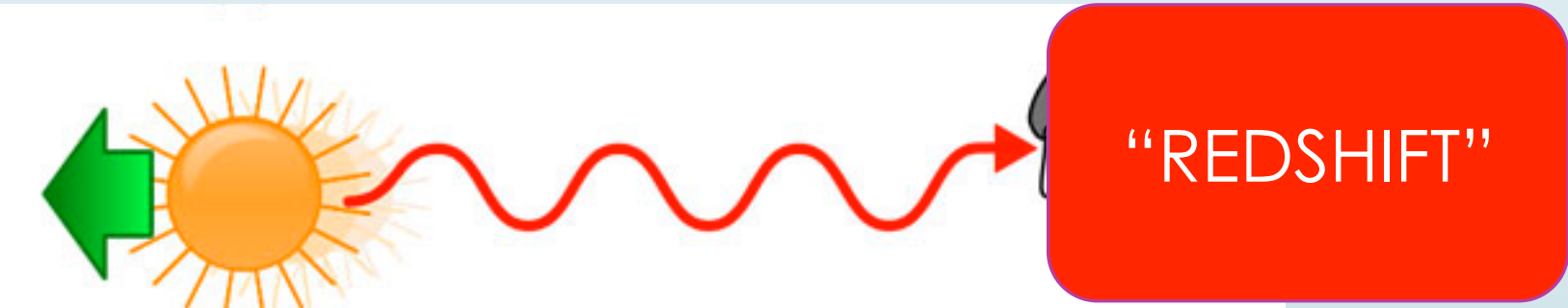

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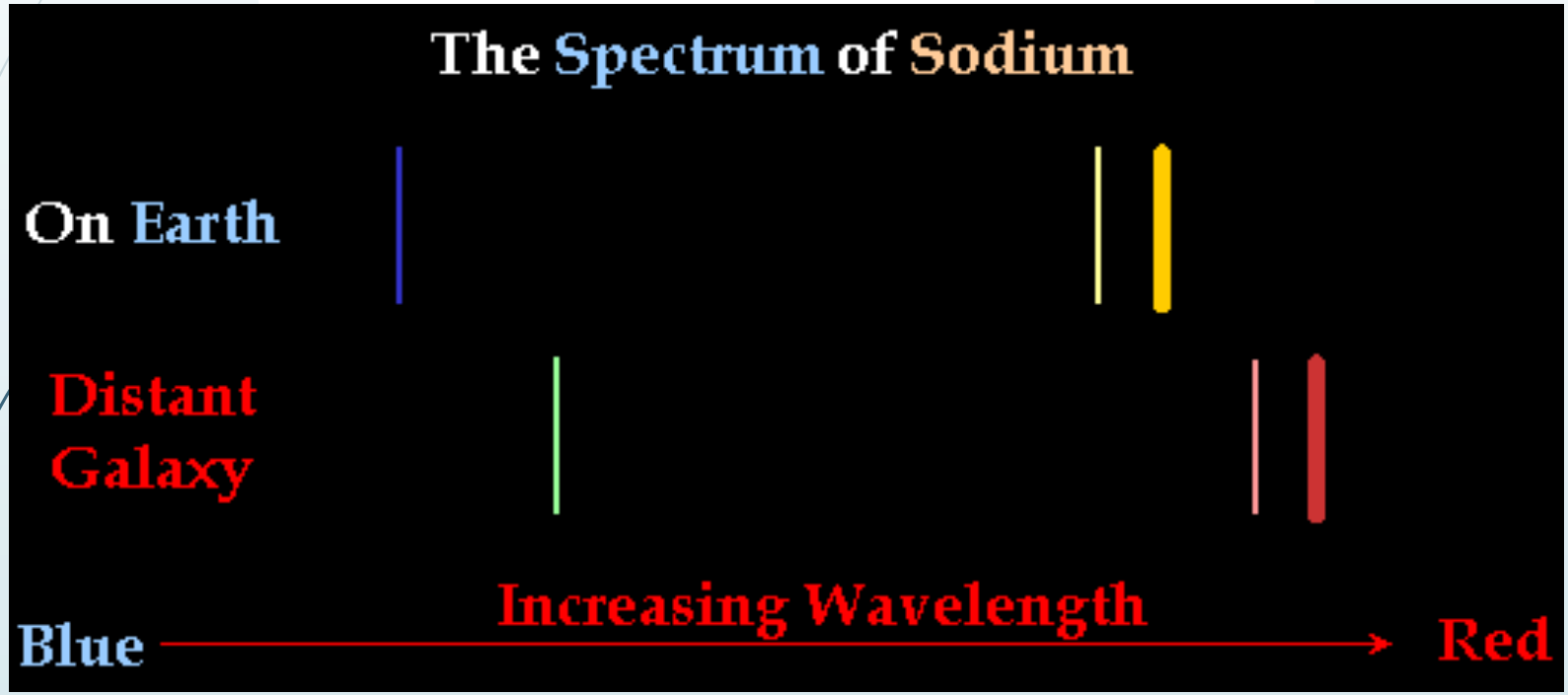

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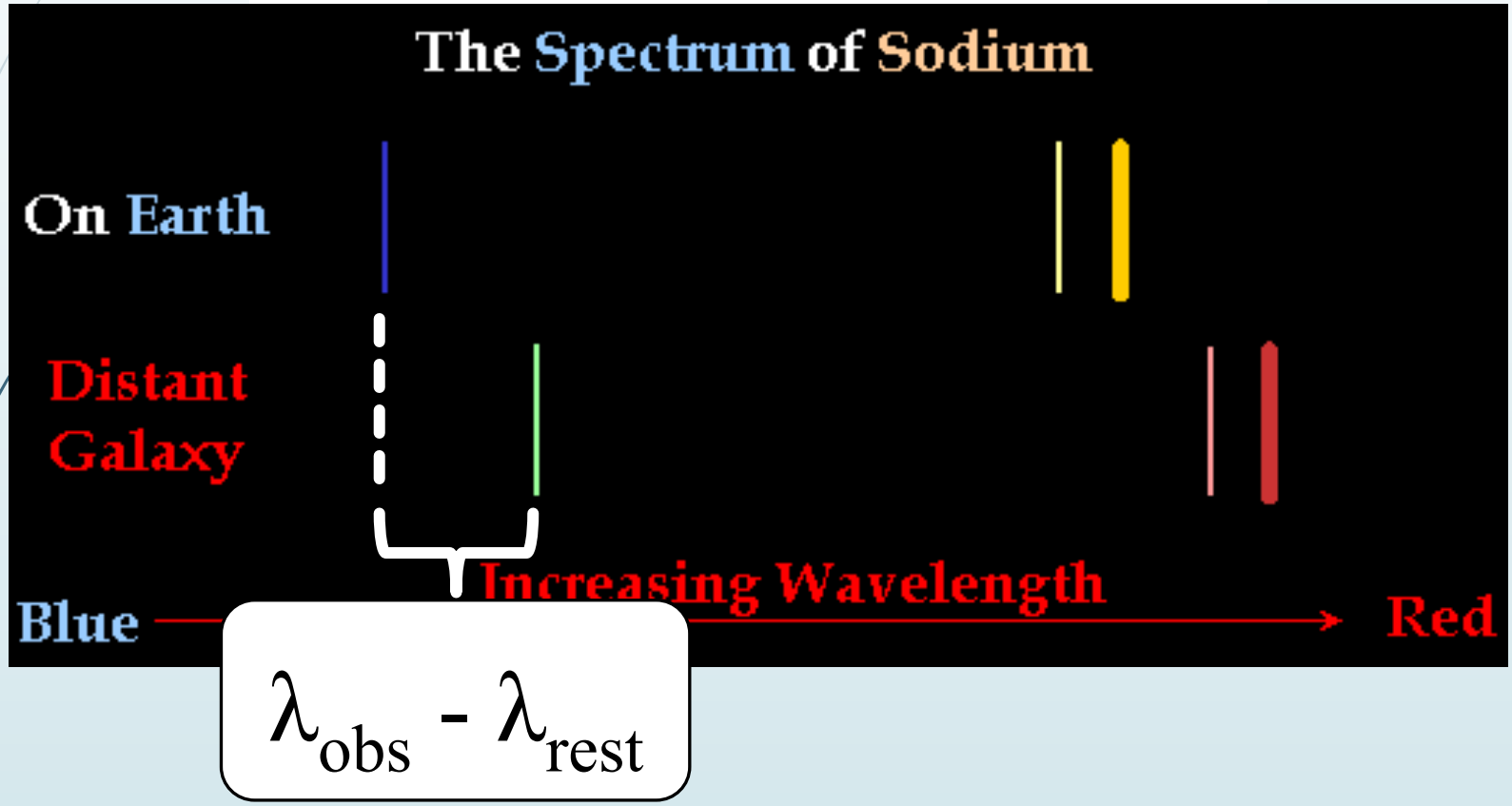

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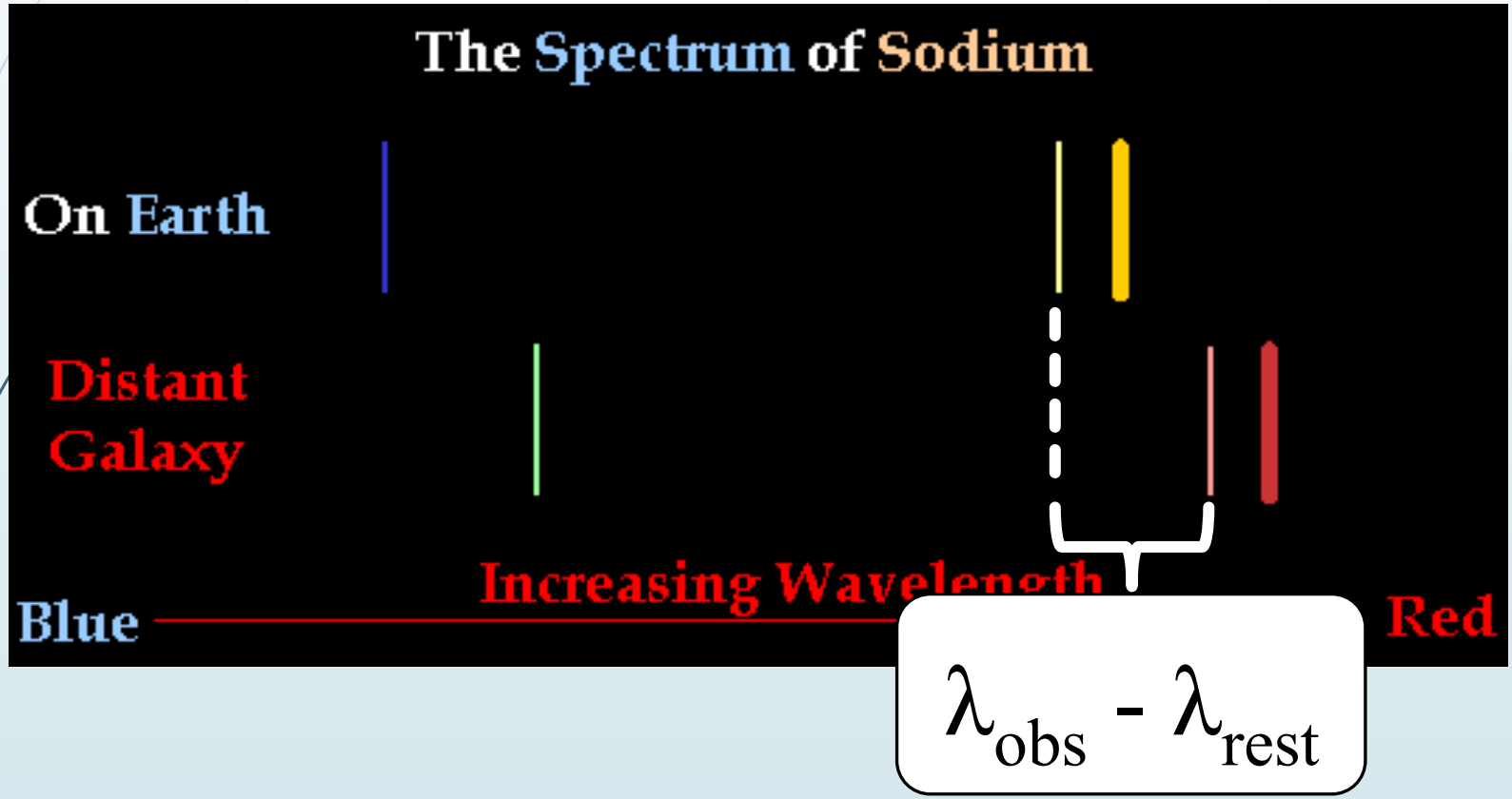

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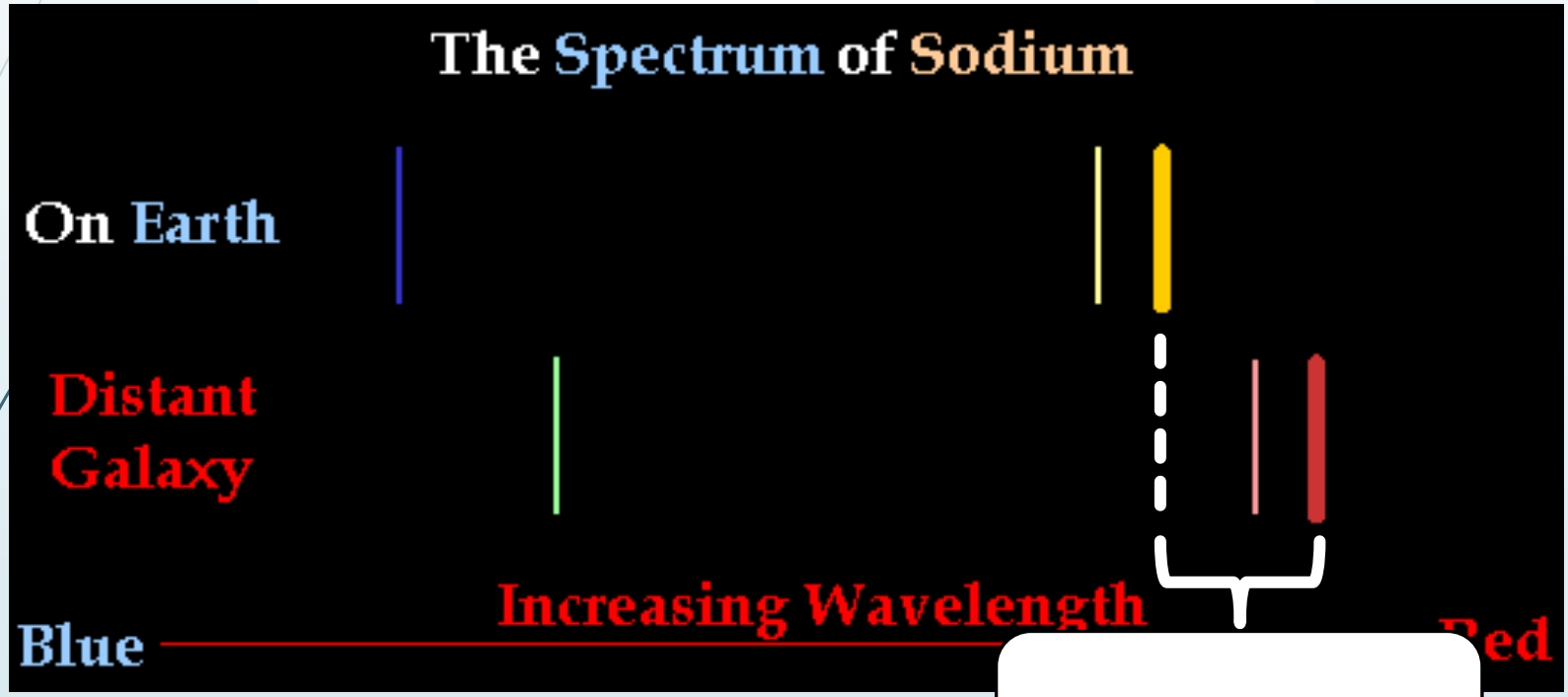

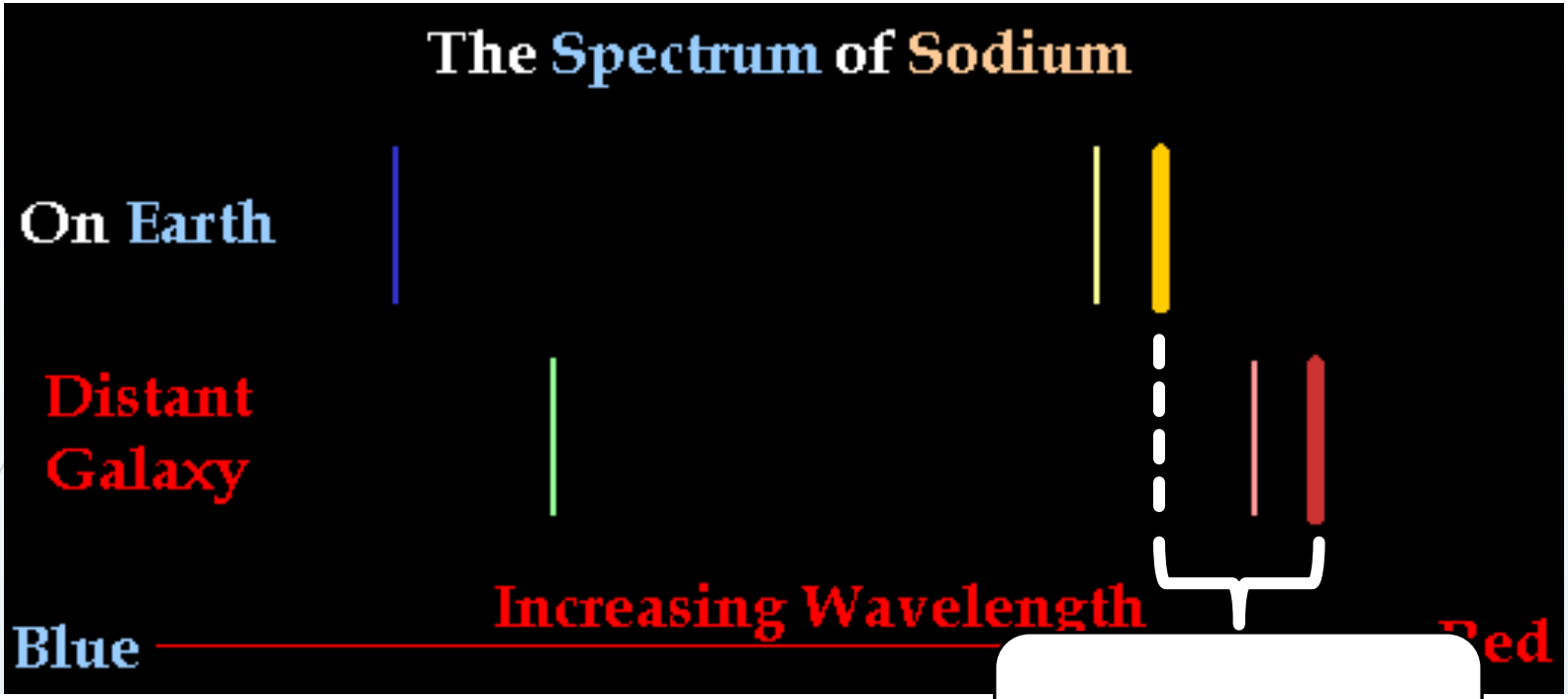

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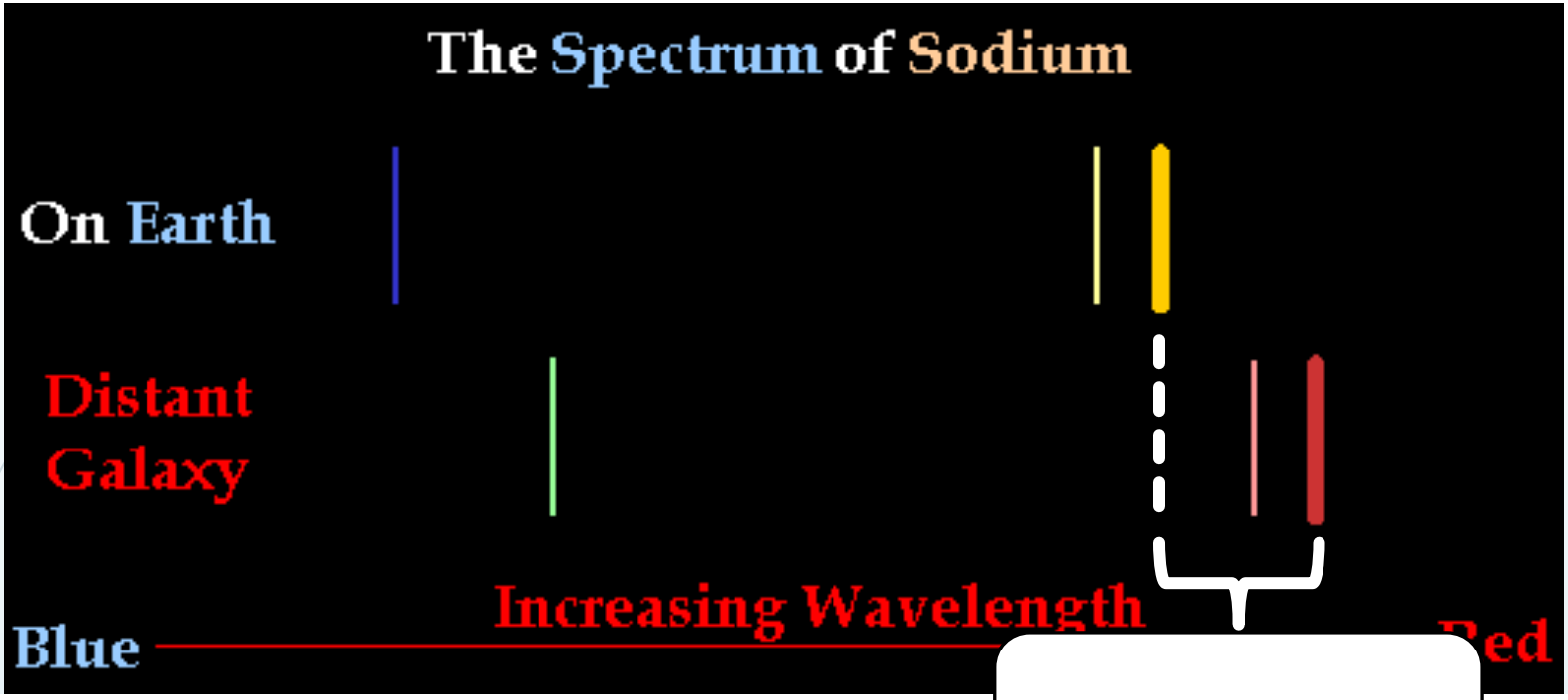
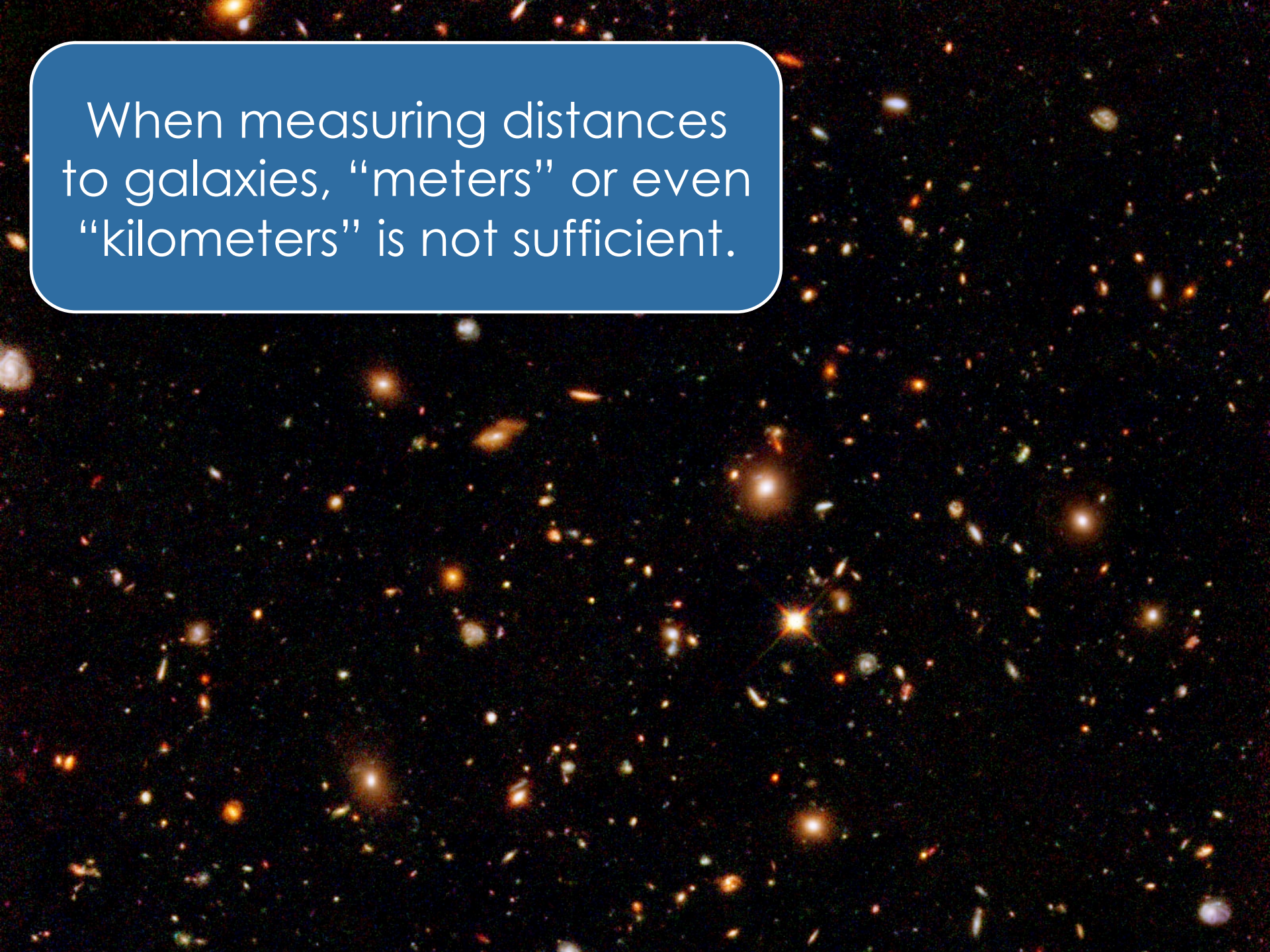


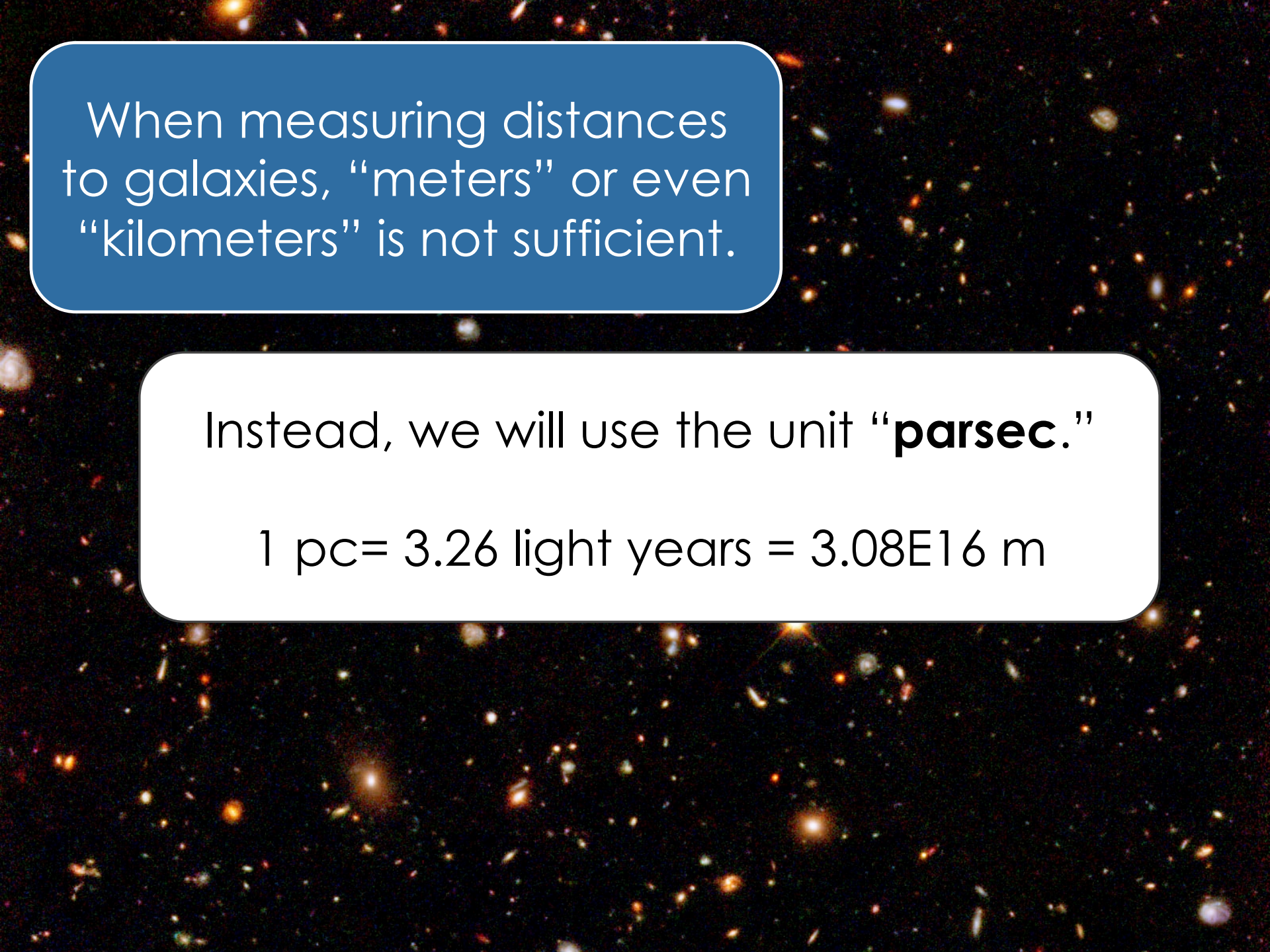
$$\frac{(\lambda_{observed} - \lambda_{rest})}{\lambda_{rest}} = \frac{v}{c}$$

$$\frac{650\ \text{nm} - 575\ \text{nm}}{575\ \text{nm}} = \frac{v}{3.00\text{x}10^{8}\ \text{m/s}}$$

Looking at Redshift and Blueshift of Galaxies

Observational data collected by astronomers


When measuring distances to galaxies, “meters” or even “kilometers” is not sufficient.



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1 pc= 3.26 light years = 3.08E16 m

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Parsecs are not even enough to measure the distance to galaxies, so Megaparsecs (Mpc) are used.

Observation #1: ALL GALAXIES ARE REDSHIFTED

What does this observation imply about the motion of galaxies relative to us?

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What does this observation imply about the motion of galaxies relative to us?

- The majority of galaxies are moving away from us.

Observation #2: RELATIONSHIP BETWEEN DISTANCE AND VELOCITY (REDSHIFT)

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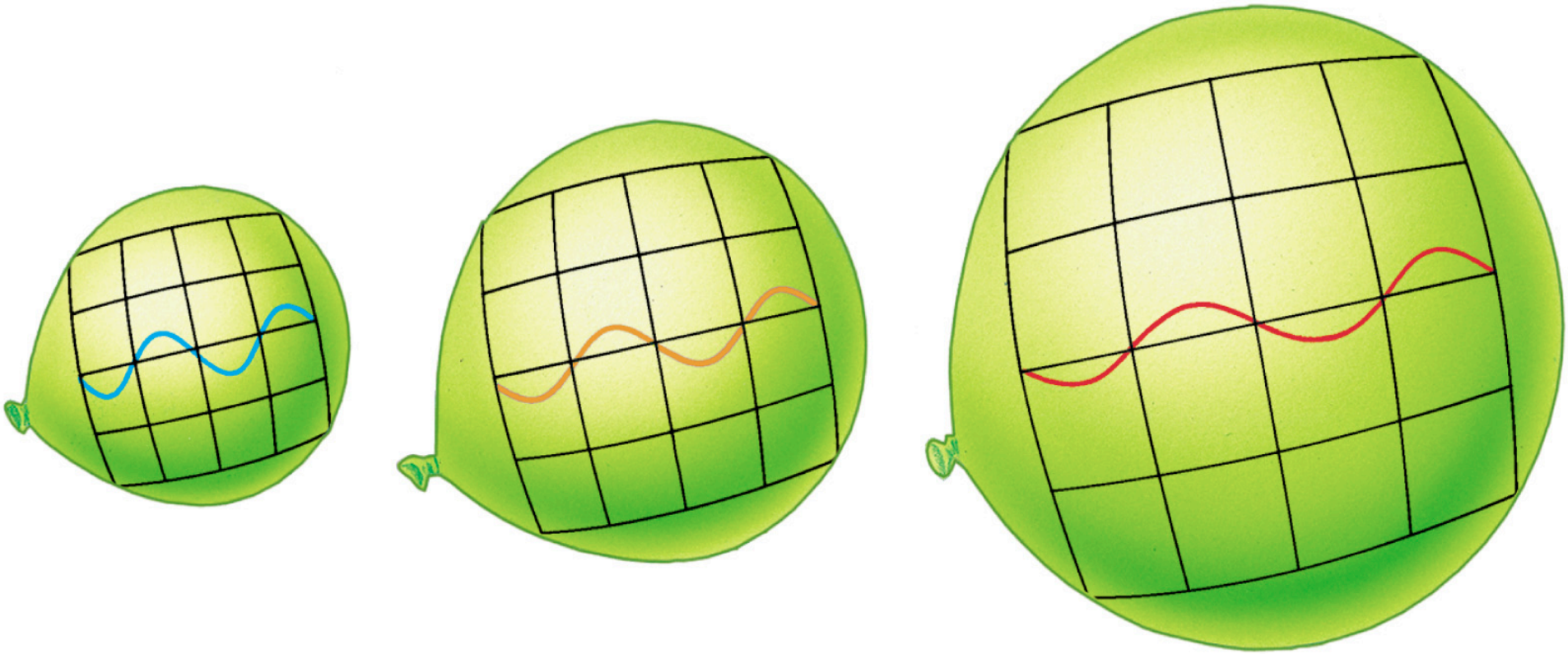
What does this observation imply about the motion of galaxies relative to us?

- The farther away the galaxy is from us, the faster it is moving away.

How is this possible?



A Simple Explanation

Explaining the Observations: Space Must Be Expanding

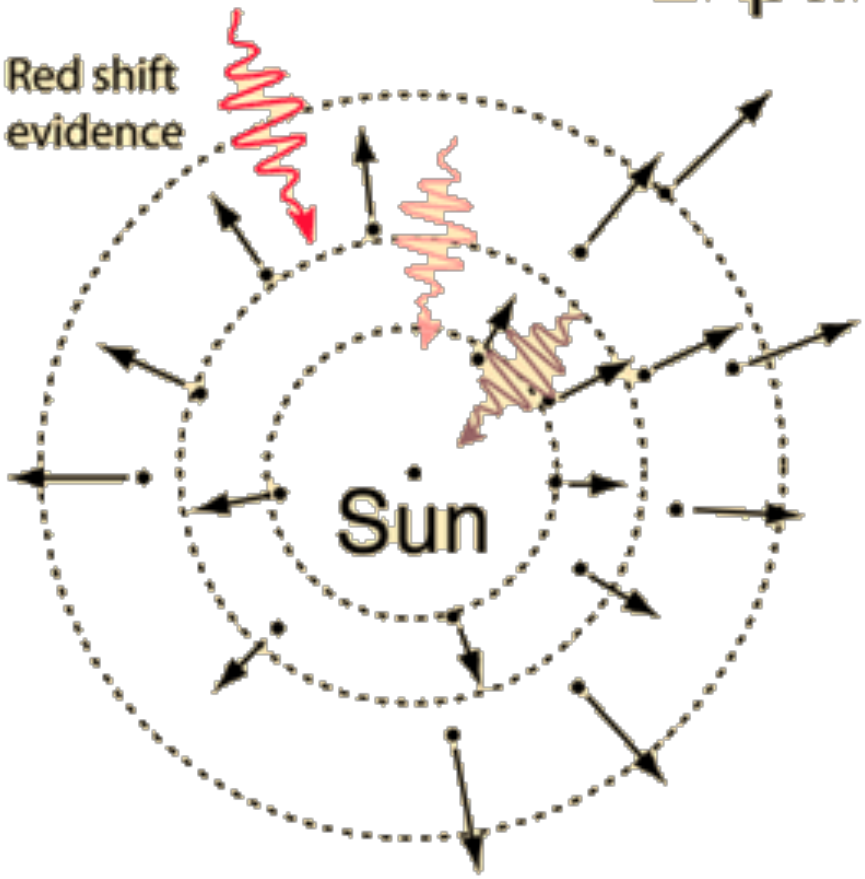
- All galaxies appear to be moving away and the more distant galaxies appear to move away faster.

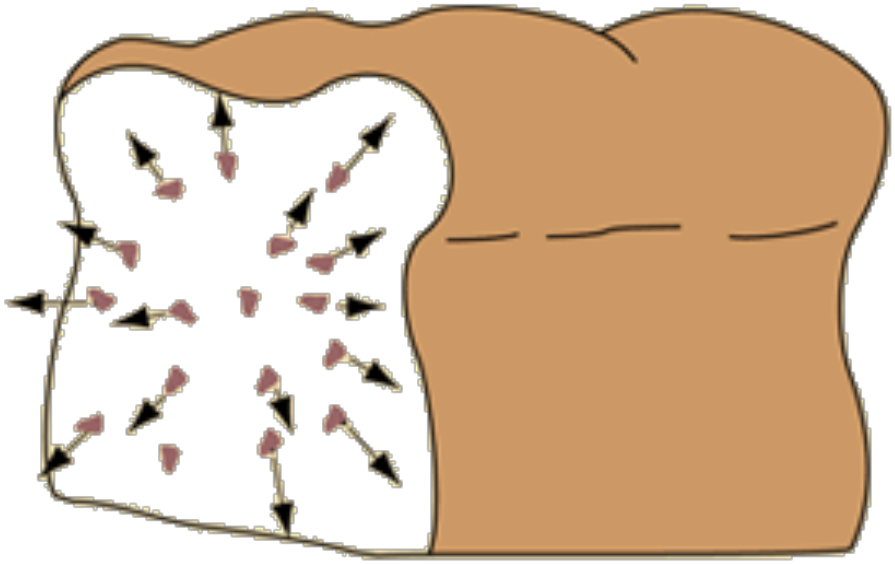
The same effect is analogous to a balloon with galaxies drawn on it.

- Imagine standing on one of the galaxies.
- As the balloon expands, all the other galaxies move away from your galaxy.
- The more distant galaxies move away faster in the same amount of time.

With this analogy in mind, explain why the galaxies we see are moving away from us.

Expanding universe





Every raisin in a rising loaf of raisin bread will see every other raisin expanding away from it.

The Conclusion:

Galaxies are not moving; space itself is expanding between them.

Conclusions About The Beginning

Based on scientific observations and interpretations, we can construct an explanation of the beginning of the universe:

(1) Space is expanding.	
(2) The temperature of space is 2.7 Kelvin.	
(3) There is an abundance of hydrogen and helium.	

Conclusions About The Beginning

Based on scientific observations and interpretations, we can construct an explanation of the beginning of the universe:

(1) Space is expanding.	**(1) Space used to be much smaller, as small as a single point.**
(2) The temperature of space is 2.7 Kelvin.	**(2) The temperature used to be hot but has cooled down as space expanded.**
(3) There is an abundance of hydrogen and helium.	**(3) Mostly small atoms were formed in the beginning, and bigger atoms formed through other processes.**