

Uniformly Expanding Universe- [REDACTED]

Red Shifts in spectra tell astronomers both the velocity (V) and distance (D) of distant galaxies. Hubble's Law describes further the relationship between V and D : the velocity of a galaxy as it recedes from another galaxy is proportional to the distance between them. From this, astronomers conclude that if the galaxies are moving away from one another, at rates related to distances, then the universe is expanding, and the expansion is uniform throughout the universe.

Objective:

What is the relationship between the distance between galaxies and the velocity at which they are moving apart?

Hypothesis:

If the distance between galaxies increases, then _____,
because _____.

Procedure:

Each arrow on the diagram represents a galaxy at two different points in time. The arrow tip (Time 2) is the galaxy position one second after the arrow end (Time 1).

- A. Choose any arrow from the explosion diagram to be your home galaxy. Your lab partner should choose a different arrow.
 - B. Measure the distance (in mm) between the non-tip end of you arrow and the same of any other arrow. This represents the distance between two galaxies at Time 1. Record the distance between the two arrows at Time 1.
 - C. Measure the distance between the two arrows again, but from arrow tip to arrow tip, Time 2, after one second has elapsed. Record this distance at Time 2.
 - D. Repeat for at least 4 additional arrows/galaxies, as they recede from your home galaxy.
 - E. Calculate the change in distance (distance at time 2 – distance at time 1)
 - F. Calculate the velocity of the expansion (Change in distance/ 1 second)
 - G. Graph the relationship between each galaxy's original distance from the home galaxy and the velocity at which it moves away from it. Use both you and your lab partner's data. **Graph a total of 10 galaxy comparisons.**
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Data:

Home Galaxy	Other Galaxy	Distance at T ₁ (mpc)	Distance at T ₂ (mpc)	Change in Distance (d at T ₂ -d at T ₁)	Velocity (mpc/ sec) (Change in Distance / 1 sec)

Analysis: *(Write out in complete sentences in your lab notebook)*

- What is the relationship between distance and velocity of galaxies in the expanding universe?
- Give two examples from your data to support this relationship.
- Infer the cause of this expansion.
- Reflect on your hypothesis: does the data support or reject your hypothesis?
- Were the results conclusive? (Was there a consistent relationship? Did all galaxies follow the same pattern of change in velocity with increased distance?)

