

Investigating Redshift

Galaxy Distance and Wavelength Shift

Aim:

You are investigating whether the shift in wavelength of a galaxy's light depends on how far away the galaxy is.



Method:

1. Select Galaxy A using the Galaxy buttons.
2. Drag the cursor onto the dark hydrogen line in the *laboratory reference* spectrum and read its wavelength. This is λ_0 .
3. Drag the cursor onto the dark line in the *galaxy* spectrum and read its wavelength. This is λ .
4. Click Add Row and record the galaxy's name, its stated distance, λ_0 and λ in your results table.
5. Calculate the change in wavelength ($\lambda - \lambda_0$) and the fractional change ($\text{change} \div \lambda_0$) and add them to your table.
6. Calculate the speed at which the galaxy is moving away using **speed = speed of light $\times$ fractional change in wavelength** (the speed of light is 3×10^8 m/s), and add it to your table.
7. Select Galaxy B and repeat steps 2–6, then do the same for Galaxy C.

Prediction:

Galaxy D, at 1000 Mly, is the most distant galaxy in the list. Based on the pattern in your table so far, do you predict its wavelength shift will be bigger or smaller than Galaxy C's?

Now measure Galaxy D and complete steps 2–6 for it to test your prediction and finish your table.

Results:

Galaxy	Distance (Mly)	Reference λ_0 (nm)	Galaxy λ (nm)	Change in λ (nm)	Fractional change	Speed (m/s)

Analysis:

For each galaxy, is its line at a shorter or longer wavelength than the reference line? Towards which end of the spectrum has the light shifted?

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As the stated distance to the galaxy increases, what happens to the size of the wavelength shift?

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Plot speed (m/s) on the vertical axis against distance (Mly) on the horizontal axis for your four galaxies. What shape is your graph? Does doubling the distance double the speed?

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Explaining why:

Astronomers see this same pattern for distant galaxies in every direction they look. What does your table say about the direction all four galaxies are moving — towards us or away from us?

If more distant galaxies are receding faster, what does that suggest is happening to the space between galaxies?

Imagine running your graph backwards in time. Where would all the galaxies have been long ago, and which theory of the universe's origin does your data support?
