

Doppler effect · supported focus

International Baccalaureate · IB Diploma · Physics · HL

Scope and prerequisites

Supported HL focus. First assessment 2025; full Physics guide acquired (84 PDF pages). Remaining guide, assessment and practical requirements retain their recorded holds.

Prerequisites: read the stated quantities and units, use arithmetic and the model conditions below. Each lesson develops its own method before independent transfer.

These are original or explicitly fictional teaching examples, not actual measurements or completed assessed learner investigations.

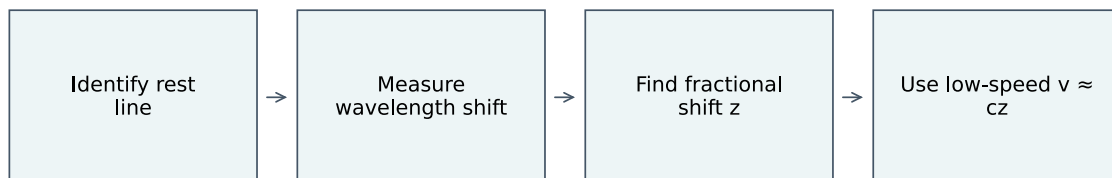
Spectral shifts: a low-speed astronomical estimate

■ What would explain this observation?

- A recognizable spectral line appears at a longer wavelength in a distant source. Its shift can provide evidence of recession along the line of sight.
 - Start with a prediction. State the quantities or features you would compare, then decide what evidence could distinguish two explanations.
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■ Build the model

- Relative source-observer motion changes observed frequency or wavelength. For light at a relative speed much smaller than c , the magnitude of the fractional wavelength shift is approximately v/c . Recession corresponds to longer wavelength, and approach to shorter wavelength.
- **redshift** : Shift of an identified line toward longer wavelength; **rest wavelength** : Wavelength of the line measured with no relative source motion.



■ Choose evidence that can test it

- Compare a identified line with its laboratory rest wavelength. Use $z = (\text{observed} - \text{rest})/\text{rest}$, then v approximately cz in the stated low-speed model. Do not apply this approximation without checking the regime or treating a cosmological redshift as a simple exact velocity.
 - Use attributed spectra with calibration and line identification. Compare several lines for a consistent shift. State uncertainty and distinguish relative line-of-sight motion from an unmeasured transverse component.
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■ Work from known quantities

- State the known values and their units. Choose the relation because its assumptions fit this case, then rearrange before substitution.
- Known: a 500 nm rest line is observed at 501 nm. $z = (501 - 500)/500 = 0.002$. With $c = 3.0 \times 10^8$ m/s, v approximately 6.0×10^5 m/s away. The sound-source denominator formula is not the required SL light approximation.

Example:

A 600 nm rest line is observed at 601.2 nm. Find $z = (\text{observed} - \text{rest})/\text{rest}$. Use the same sequence: known quantities $\rightarrow$ model $\rightarrow$ relation $\rightarrow$ substitution $\rightarrow$ unit and interpretation.

■ Check the conclusion and its limits

- The approximate shift relation does not show that light travels faster from an approaching source. A single unidentified line cannot safely establish a redshift.
- Return to the original observation. Explain what the result supports, which conditions it assumes, and one way to test a competing explanation.

Warn:

An observed redshift means light speed increased. This claim is false: The approximate shift relation does not show that light travels faster from an approaching source. A single unidentified line cannot safely establish a redshift.

Key:

Spectral shifts: a low-speed astronomical estimate: Compare a identified line with its laboratory rest wavelength. Use $z = (\text{observed} - \text{rest})/\text{rest}$, then v approximately cz in the stated low-speed model. Do not apply this approximation without checking the regime or treating a cosmological redshift as a simple exact velocity.

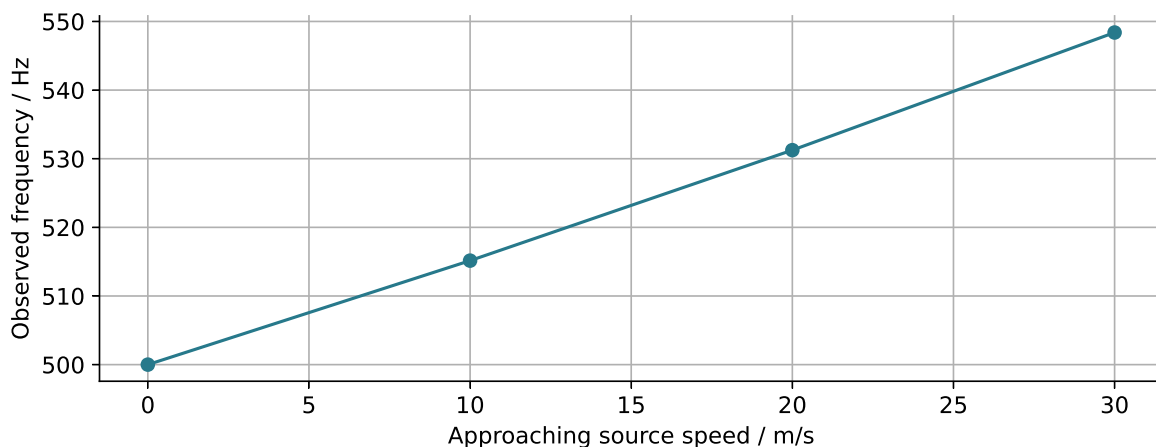
Doppler effect: separate source motion from wave speed

■ What would explain this observation?

- An approaching sound source is heard at a higher pitch even when the source produces a constant frequency.
 - Start with a prediction. State the quantities or features you would compare, then decide what evidence could distinguish two explanations.
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■ Build the model

- **Doppler shift** arises from relative source-observer motion. A moving source compresses **wavefront** spacing ahead and increases it behind. For sound in a stationary medium, the wave speed relative to that medium need not change.
- Doppler shift: Change of observed frequency due to relative motion; wavefront: A surface joining points with the same wave phase.



■ Choose evidence that can test it

- For a source approaching a stationary observer along the line of sight, $f_{\text{observed}} = f_{\text{source}} \times v / (v - v_{\text{source}})$. Recession uses $v + v_{\text{source}}$ in the denominator. These are sound-wave models; light requires its appropriate relation.
 - Use a simulation or recorded data with stated source and observer directions. Draw wavefronts before choosing signs. Avoid demonstrations near moving traffic or unsafe high-volume sources.
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■ Work from known quantities

- State the known values and their units. Choose the relation because its assumptions fit this case, then rearrange before substitution.
- Known: source frequency 500 Hz, sound speed 340 m/s, source approaches at 20 m/s. Observed frequency = $500 \times 340 / (340 - 20) = 531.25$ Hz. The increase is 31.25 Hz; it is not the source frequency changing.

Example:

A 600 Hz source approaches a stationary observer at 20 m/s. Use $v = 340$ m/s. Find observed frequency. Use the same sequence: known quantities $\rightarrow$ model $\rightarrow$ relation $\rightarrow$ substitution $\rightarrow$ unit and interpretation.

■ Check the conclusion and its limits

- A stationary source and moving observer require the observer-motion relation. Do not use the same denominator formula for every arrangement or import a sound formula into relativity.
- Return to the original observation. Explain what the result supports, which conditions it assumes, and one way to test a competing explanation.

Warn:

The Doppler effect always means the wave speed in the medium changed. This claim is false: A stationary source and moving observer require the observer-motion relation. Do not use the same denominator formula for every arrangement or import a sound formula into relativity.

Key:

Doppler effect: separate source motion from wave speed: For a source approaching a stationary observer along the line of sight, $f_{\text{observed}} = f_{\text{source}} \times v / (v - v_{\text{source}})$. Recession uses $v + v_{\text{source}}$ in the denominator. These are sound-wave models; light requires its appropriate relation.