# Fusion and stars

International Baccalaureate · IB Diploma · Physics · HL

## Scope and prerequisites

This handout covers selected HL topics for the course first assessed in 2025; it is not the whole syllabus.

Prerequisites: read the stated quantities and units, and use arithmetic and the model conditions below.

The examples are original and fictional: they are not real measurements or real student investigations.

## Stars, radiation and stars

### What would explain this observation?

- Two stars can have the same apparent brightness while having different luminosities. Distance changes the **flux** reaching an observer.

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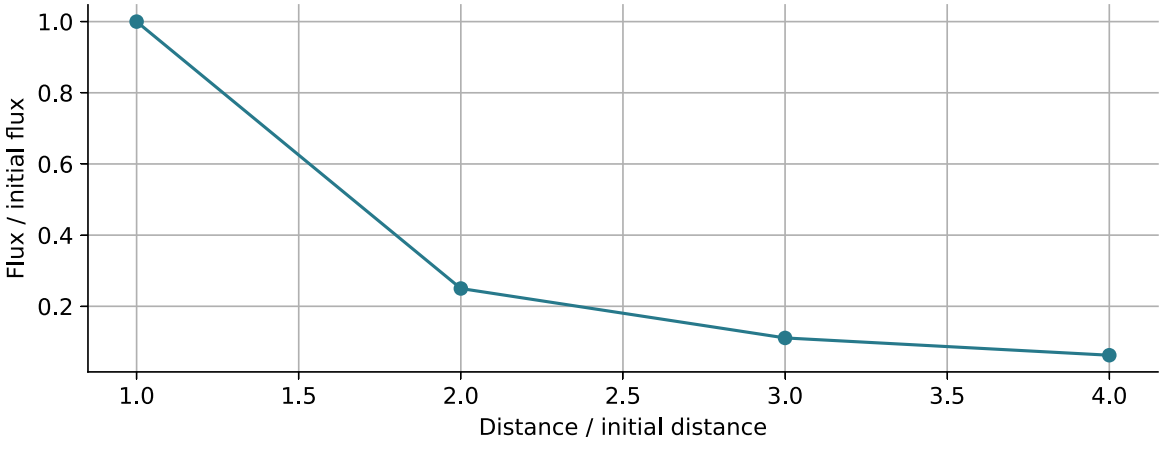
### Build the model

- **Luminosity** is total power emitted; flux is power received per area.
- A stellar spectrum carries information about surface temperature and composition.
- Fusion transfers energy as light nuclei combine.
- luminosity: Total emitted power.
- flux: Power received per unit area.




*Inverse square: the same power spread over $4\pi d^2$, so twice as far gives a quarter of the flux*

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### Choose evidence that can test it

- For isotropic emission without absorption, flux follows an inverse-square relationship with distance.
- Observed brightness alone therefore cannot establish luminosity.

**In the lab:** Keep distance units consistent, identify which quantities are intrinsic to the star, and distinguish observational evidence from a model of stellar evolution. Do not confuse a red giant stage with every possible final remnant.

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### Work from known quantities

- Known: distance doubles while luminosity remains fixed.
- Use F proportional to $1/d^2$.
- Flux ratio = $1/2^2 = 1/4$.
- A flux of 12 units becomes 3 units.
- This assumes no change in absorption or source output.

**Your turn:** A source gives flux 18 units. Find flux at three times the distance.

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### Check the conclusion and its limits

- The Sun is not expected to become a supernova.
- Redshift can support cosmological expansion; it does not mean every nearby object must move away from every observer.

**Not true:** Apparent brightness alone always determines a star luminosity. Apparent brightness depends on distance as well as luminosity (F = L/4 pi d^2). A dim-looking star may be very luminous but far away, so brightness alone cannot fix luminosity without a distance.

**Key:**

- Luminosity is total power emitted; flux is power received per area.
- For isotropic emission without absorption, flux follows an inverse-square relationship with distance.
- Watch for: the Sun is not expected to become a supernova.

### Write from a flux of 5 units

- A source gives flux 45 units.
- Find the flux at three times the distance. Apparent brightness alone does not give luminosity.

### Write from a distance tripled

- A source gives flux 45 units at distance d.
- At 3d: $45 \div 9 = 5$ units – the inverse-square law, one more time.

### Write from an apparent-brightness trap

- Sirius outshines Betelgeuse in our sky, yet Betelgeuse emits far more light.
- Apparent brightness folds in distance ($F = L \div 4\pi d^2$) – "brightest in the sky" is a claim about d as much as L.

### Write from a luminosity comparison

- Star A delivers twice the Sun's power at twice the Sun's distance.
- Its flux here $= 2 \div 2^2 =$ half the Sun's – luminosity is emission; flux is what ARRIVES, divided by $4\pi d^2$.