The H–R diagram: temperature and brightness

Student activity • observation and reasoning

YEAR 11 / LESSON 109 / PHYSICS ONLY

The question

How can a cool star be intrinsically bright while a hot star is faint?

Plot original schematic star data using correctly oriented H–R axes and classify broad regions.

Equipment

- Booklet, graph paper, ruler and model-star table

Desk-based graphing. No lamps, lasers or brightness tests directed at people are used.

Course coverage: Physics only: 8.11P–8.12P. Absolute magnitude and main regions of the H–R diagram.

Plan, model or apparatus sketch

Draw clearly labelled astronomical axes, spectra or orbital/pathway diagrams as appropriate.

Method and reasoning

Read the whole sequence before starting

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1. Define absolute magnitude as the apparent magnitude a star would have at the standard distance of 10 parsecs. Explain that a lower numerical magnitude means brighter in the specified band.

2. Draw an H–R diagram with surface temperature decreasing left to right from 30000 K to 3000 K. Put absolute magnitude on the vertical axis with −6 at the top and +12 at the bottom.

3. Plot model stars A (20000 K, −3), B (6000 K, +5), C (3500 K, +10), D (3500 K, −2), E (12000 K, +11) and F (4500 K, −6). These are schematic examples, not a real catalogue.

4. Use A, B and C to sketch a main-sequence band. Locate D in the cool luminous giant region, E in the hot faint white-dwarf region and F in the supergiant region.

5. Explain why surface temperature alone does not set total luminosity: emitting area also matters. Do not infer an exact radius from the schematic magnitudes.

6. Compare absolute and apparent magnitude. State that the H–R diagram is a population plot, not a physical map of where the stars are in space or a single path every star follows.

Cleanup

- Retain labelled plots and collect rulers.

Record your evidence

Blank spaces are for your own work

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Reference and task data

The plotting values are invented for classification. All magnitudes refer to one consistent band. Use temperature labels to make the reversed horizontal direction explicit; a logarithmic scale is conventional, but any schematic classroom scale must be clearly labelled.

Star	Temperature / K	Absolute magnitude	Region
A	20000	-3	
B	6000	5	
C	3500	10	
D	3500	-2	
E	12000	11	
F	4500	-6	

Show your calculations, labelled model or correction here.

Explain and evaluate

Use evidence and show calculation steps where relevant

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1. What is the standard distance for absolute magnitude?

2. Which way does temperature increase on this diagram?

3. Which is brighter: magnitude −2 or +5?

4. Which example represents a white dwarf?

5. Why can a cool giant be luminous?

6. Is the H–R diagram a map of spatial positions?