

Red shift and the expanding universe

AQA GCSE Separate Physics 8463 only | Foundation and Higher | Paper 2

20 parts | 40 marks | Estimated/untrialled 35–40 min independent +15–20 review

Specification points covered

4.8.2: increased wavelength, recession and the distance trend; evidence that space is expanding
4.8.2: evidence for the Big Bang model; an initially very small, extremely hot and dense universe
4.8.2: later supernova evidence, accelerating recession and remaining unknowns; evaluating theories

An observatory is preparing a public exhibit from its archive. Check model spectral fingerprints, compare a survey of distant galaxies and help the team separate observations from conclusions.

Use matching spectral features, not brightness, to compare wavelength changes. Figure 1 is qualitative; use the exact values in the tables for calculations. No red-shift equation or numerical galaxy speed is needed. Answer all sections.

1 Checking the exhibit vocabulary

The team uses red-shift measurements and the Big Bang model in its exhibit. Start by checking the meaning of the terms.

1(a) State what red-shift means in terms of the observed wavelength of light. **[1 mark]**

1(b) The Big Bang model begins with a very small region. State the two other physical conditions of this early universe. **[1 mark]**

1(c) A laboratory lamp is made fainter, but all its spectral lines stay at their original wavelengths. A trainee calls this red-shift. Explain why the claim is wrong. **[2 marks]**



2 Comparing spectral fingerprints

Figure 1 shows selected absorption features of the same model source in the laboratory and two distant galaxies. The marks show wavelength positions, not physical colours. Compare corresponding lines from left to right; this is not a scale for numerical readings.

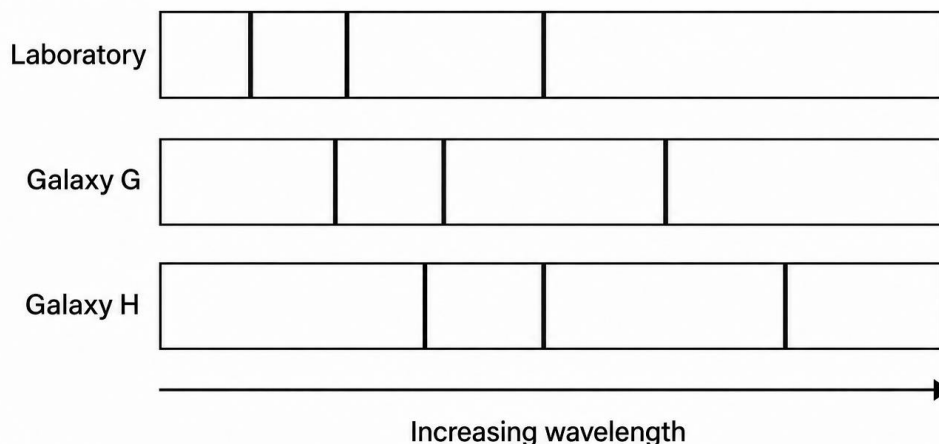


Figure 1

2(a) Compare the wavelengths of the features in galaxy G with the corresponding laboratory features. **[1 mark]**

2(b) Compare the recession speeds of G and H. Explain your answer using the spectral features. **[3 marks]**

2(c) Only one dark feature is detected in a faint third galaxy. Explain why the team should seek several matching features before making a confident comparison with the laboratory pattern. **[2 marks]**



3 Auditing the wavelength data

Table 1 gives exact values for the three corresponding features P, Q and R in the model. All values are wavelengths in nm. Use these data, not measurements from the diagram.

Table 1

Feature	Laboratory / nm	G / nm	H / nm
P	450	495	540
Q	500	550	600
R	600	660	720

3(a) For feature Q, calculate the wavelength increase for G and for H relative to the laboratory value. **[2 marks]**

3(b) Calculate the wavelength increase of feature R for H. Compare it with the 100 nm increase of feature Q for H. **[2 marks]**

3(c) A technician redraws H by adding 90 nm to EVERY laboratory wavelength. Use features P and R to explain why this does not match Table 1. **[2 marks]**



4 Testing a distance trend

Table 2 is a simplified survey of distant galaxies. Every row uses the SAME feature, measured at 500 nm in the laboratory. Distances were estimated independently. A light-year is a unit of distance. Use the trend, without calculating a galaxy speed.

Table 2

Galaxy	Distance / million light-years	Observed wavelength / nm
R	120	505
S	240	510
T	360	515
U	480	520

4(a) Use Table 2 to put R, S and T in order of increasing recession speed, starting with the slowest. **[1 mark]**

4(b) Describe how the wavelength shift and inferred recession speed change as distance increases in this survey. **[2 marks]**

4(c) Another distant galaxy W has this same feature at 530 nm. Using the survey trend, compare its expected recession speed and distance with U. **[2 marks]**

4(d) A writer says Table 2 proves that each individual galaxy is speeding up with time. Explain why the table alone cannot establish this. **[2 marks]**



5 Checking what the evidence means

The exhibit writer must describe expansion accurately and show how the team checks its conclusions. Use the spectral evidence and the survey when answering.

5(a) The draft says expanding space means every galaxy must itself be growing in size. Correct this interpretation of the survey. **[2 marks]**

5(b) Explain why tracing the expansion backwards supports a smaller earlier universe. State why these wavelength data alone do not measure its initial temperature. **[2 marks]**

5(c) Describe one check the team could use before accepting its wavelength results, and explain how the check increases confidence in the conclusion. **[2 marks]**

6 Reviewing later observations

A separate review of supernova observations from 1998 onwards suggests that distant galaxies are receding ever faster. The review lists dark mass and dark energy as aspects of the universe that are not yet fully understood.

6(a) Explain what the supernova review means by “receding ever faster”. **[1 mark]**

6(b) A previous model predicted constant recession speeds. Explain how scientists should respond if repeated new observations instead favour accelerating recession. **[2 marks]**

6(c) A visitor says naming dark mass and dark energy means scientists have explained everything about the universe. Evaluate this claim using the review. **[2 marks]**

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