

Red-shift

4.8.2 · Space physics · revision notes

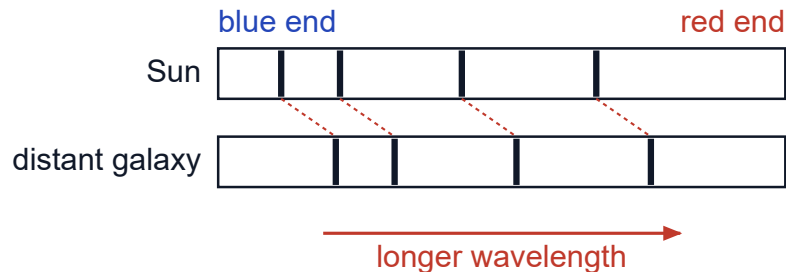
Red-shift is the observed increase in the wavelength of light from most distant galaxies. You need to explain what it shows about how galaxies are moving, why it is evidence for an expanding universe and the Big Bang theory, and what is still not understood, such as dark mass and dark energy. GCSE Physics only, not in Combined Science.

Key facts

- Red-shift: an observed increase in the wavelength of light from most distant galaxies
- Further away → moving away faster → bigger red-shift
- Big Bang theory: the universe began from a very small region that was extremely hot and dense
- Since 1998: supernova observations suggest distant galaxies are receding ever faster
- Red-shift → the galaxy is moving away from us
- Red-shift is evidence that space itself (the universe) is expanding
- Red-shift supports the Big Bang theory
- Not yet understood: dark mass and dark energy

What red-shift is

- Light from most distant galaxies is observed to have longer wavelengths than expected. This observed increase in wavelength is called **red-shift**.
- In the spectrum of a galaxy, the pattern of dark lines is the same as in the Sun's spectrum, but every line is shifted towards the red (longer wavelength) end.



Same pattern of lines, shifted towards the red end: red-shift.

- Red-shift happens because the galaxy is moving away from us: the light waves are stretched out, so the wavelength increases and the frequency decreases.
- The further away a galaxy is, the faster it is moving away and the bigger its red-shift.



Further away → moving away faster → bigger red-shift.

Evidence for an expanding universe and the Big Bang

- Distant galaxies in every direction are moving away from us, and the most distant ones are moving fastest. This is evidence that space itself (the universe) is expanding.
- If the universe is expanding, it must have been smaller in the past. Tracing the expansion back suggests the universe began from a very small region that was extremely hot and dense.
- This is the **Big Bang theory**. The observed red-shift supports it.
- Scientists arrived at this theory from observations: they measured red-shifts, proposed an explanation that fits them, and checked it against more data. Theories can change if new evidence does not fit.

What is still not understood

- Since 1998, observations of supernovae suggest that distant galaxies are moving away **ever faster**: the expansion of the universe is speeding up.
- Scientists do not know what causes this. The unknown cause is called **dark energy**.
- Galaxies also seem to contain much more mass than we can see. This unseen mass is called **dark mass** (dark matter). It is detected only by the effect of its gravity.
- So there is still much about the universe that is not understood.

How to answer each type of question

State what red-shift is and what it shows

1 to 2 marks

Grade 4

1. Define it: an observed increase in the wavelength of the light from a distant galaxy.
2. Say what it shows: the galaxy is moving away from us.

Example. The light from a distant galaxy shows red-shift.

Describe what is meant by red-shift and what it tells you about the galaxy.

Model answer. The wavelength of the light we observe from the galaxy is increased (shifted towards the red end of the spectrum) (1). This shows that the galaxy is moving away from us (1).

Compare the red-shifts of two galaxies

2 marks

Grade 5

1. Check the line pattern: the same pattern moved to longer wavelengths means red-shift.
2. The galaxy with the bigger shift is moving away faster.
3. It is also further away.

Example. Astronomers compare the spectra of two galaxies, X and Y, with the spectrum of the Sun. Both galaxies show the same pattern of dark lines as the Sun. The lines for galaxy Y are shifted further towards the red end of the spectrum than the lines for galaxy X.



What can you conclude about galaxy Y compared with galaxy X?

Model answer. Galaxy Y is moving away from us faster (1).

Galaxy Y is further away (1).

Don't lose marks

- ✗ Saying the galaxy or its light turns red. Red-shift means the wavelength increases, so the lines in the spectrum move towards the red end.
- ✗ Saying the frequency increases. When the wavelength increases, the frequency decreases.
- ✗ Describing the Big Bang as an explosion of matter into empty space from one point. The theory says the universe began from a very small, extremely hot and dense region, and space itself is expanding.
- ✗ Thinking that because distant galaxies in every direction are moving away from us, we must be at the centre. Every galaxy would see the others moving away.
- ✗ Mixing up dark mass and dark energy: dark mass is unseen mass; dark energy is the unknown cause of the expansion speeding up.

More tips

Memory tricks

- Red light has the longest wavelength of visible light, so 'red-shift' means 'shifted to a longer wavelength'.
- Further, faster, more red: all three go together.
- Picture dots drawn on a balloon as it is blown up: every dot moves away from every other dot, dots that are further apart separate faster, and no dot is the centre.
- Spectrum check: same pattern of lines, all moved towards the red end, means the galaxy is moving away.

Exam technique

- Use the phrase 'observed increase in wavelength' when you define red-shift.
- For Big Bang evidence, build a chain with 'so': red-shift → moving away → further away means faster → space is expanding → the universe began very small, hot and dense.
- When describing data, say whether the relationship is directly proportional, not just 'as one goes up, the other goes up'.
- For 'not understood' questions, name dark mass and dark energy and say that scientists do not yet know what they are.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 4

Describe what red-shift is

Red-shift is an observed increase in the wavelength of light from most distant galaxies.

Grade 5

Explain what red-shift shows about galaxies

A red-shifted galaxy is moving away from us, and a bigger red-shift means it is further away and moving faster.

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