Topic 8: Space physics

AQA GCSE Physics 8463 · spec 4.8 · sheets 8.1–8.3

Space physics: stars, orbits and the expanding universe

- describe the solar system and how the Sun formed;
- describe the life cycles of stars, and explain where the chemical elements come from;
- explain how gravity keeps planets and satellites in orbit;
- explain how red-shift provides evidence for the Big Bang.

The solar system

- Our solar system has one star, the Sun, with eight planets and the dwarf planets that orbit it, and the natural satellites, called moons, that orbit the planets.
- The solar system is a very small part of the Milky Way galaxy, which contains hundreds of billions of stars.
- **How the Sun formed.** The Sun formed from a **nebula** , a cloud of dust and gas.
- Gravity pulled the dust and gas together.

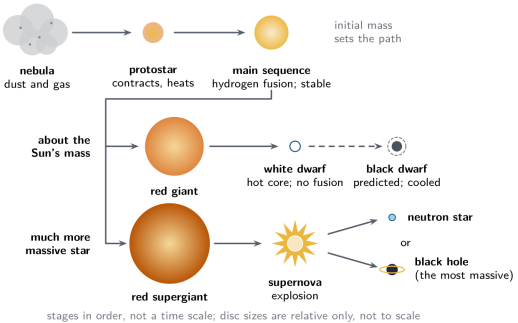
The life cycle of a star

- **A star about the size of the Sun**: **nebula** → protostar → main sequence star → red giant → white dwarf → black dwarf. When the hydrogen in its core runs low, the star swells into a red giant and fuses helium into heavier elements. Its outer layers drift away, leaving a hot, small core: a white dwarf. Fusion has stopped, so the white dwarf slowly cools and fades; after a very long time, it would become a cold black dwarf.
- **A star much more massive than the Sun**: nebula → protostar → main sequence star → red supergiant → **supernova** → neutron star or black hole. The red supergiant fuses heavier and heavier elements until its core is iron, then collapses and explodes as a **supernova**. The core that remains becomes a very dense neutron star or, for the most massive stars, a black hole, from which not even light can escape.

$$t = \frac{s}{v} = \frac{3.6 \times 10^{17}}{3.0 \times 10^{8}} = 1.2 \times 10^{9}\ \text{s}$$

exercises.lol exercises.com.cn

Figure: The life cycle of a star

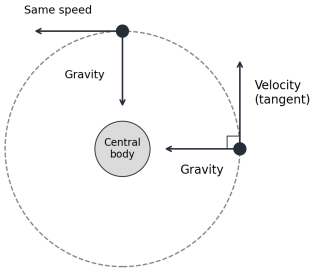


- The life cycles of a star like the Sun and of a much more massive star.
- Match each part of the diagram to the text.

Orbital motion and satellites

- Gravity keeps planets in orbit around the Sun, and keeps moons and artificial satellites in orbit around planets.
- Moons are natural satellites; artificial satellites are made by people, for communications, weather forecasting and navigation.
- **(HT) Changing velocity at constant speed.** An object moving in a circle at a constant speed has a changing velocity, because velocity is a vector and the direction keeps changing.
- The force of gravity acts towards the centre of the circle, at right angles to the motion.

Figure: Orbital motion and satellites



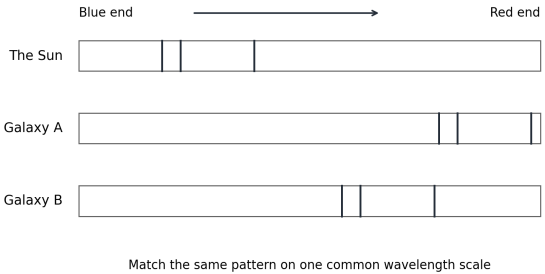
HT: velocity direction changes; speed stays constant

- A circular orbit with gravity as the centripetal force and velocity at a tangent.
- Match each part of the diagram to the text.

Red-shift and the Big Bang

- Light from most distant galaxies is red-shifted, so they are moving away from us.
- The further away a galaxy is, the bigger its red-shift, so the faster it is moving away.

Figure: Red-shift and the Big Bang



Schematic redrawing of AQA June2024 8463/2H Q03.4

- The galaxy's spectral lines are shifted to longer wavelengths (AQA GCSE Physics Paper 2H, June 2024, question 3, redrawn).
- Read the axes and units first.

Sources for this lesson

- AQA, *GCSE Physics (8463) specification*, section 4.8 Space physics.
- E. Hubble, "A relation between distance and radial velocity among extra-galactic nebulae", *Proceedings of the National Academy of Sciences*, 15 (1929); V. M. Slipher, "Nebulae", *Proceedings of the American Philosophical Society*, 56 (1917).
- AQA, *GCSE Physics* Paper 2 Higher, June 2024, question 3 (Betelgeuse, Arcturus and spectral lines, adapted).

Common errors

- Saying stars burn fuel; they release energy by nuclear fusion.
- Giving the Sun a **supernova**; it will become a white dwarf.
- Saying elements heavier than iron are made in main sequence stars; they are made in supernovae.

Common errors (2)

- Saying red-shift means a galaxy looks red; it means its spectral lines have longer wavelengths.
- Saying a satellite moving at constant speed has no acceleration.
- Saying a smaller orbit is slower; a smaller orbit needs a higher speed.

Key terms

- **Nebula**: a cloud of dust and gas from which stars form.
- **Main sequence**: the stable stage of a star's life, when fusion balances gravity.
- **Supernova**: the explosion of a very massive star.

Key terms (2)

- **Satellite**: an object that orbits a larger object; it can be natural or artificial.
- **Red-shift**: the increase in wavelength of light from a source moving away.
- **Big Bang theory**: the theory that the universe began from a very small, extremely hot and dense region and has been expanding since.

Check yourself

- 1.
- What is the Milky Way? 2.
- Explain why a main sequence star stays the same size. 3.
- Give the life cycle of a star much more massive than the Sun. 4.