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GCSE Physics

AQA Topic – Space physics

Overview
Space physics (physics only)

Solar system: stability of orbital motions; satellites (physics only)

- Our solar system
- The life cycle of a star
- Orbital motion, natural and artificial satellites

Red shift (physics only)

- Red shift
- Big bang theory

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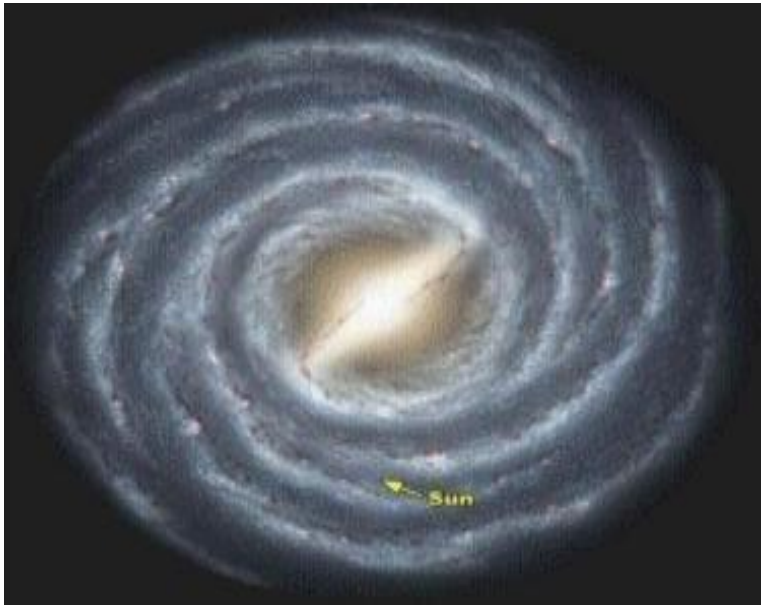
Solar system: stability of orbital motions; satellites (physics only)

- Our solar system
- The life cycle of a star
- Orbital motion, natural and artificial satellites

Space physics; orbital motions and satellites – Our solar system

Our **solar system** is a small part of a **galaxy** called the **Milky Way**.



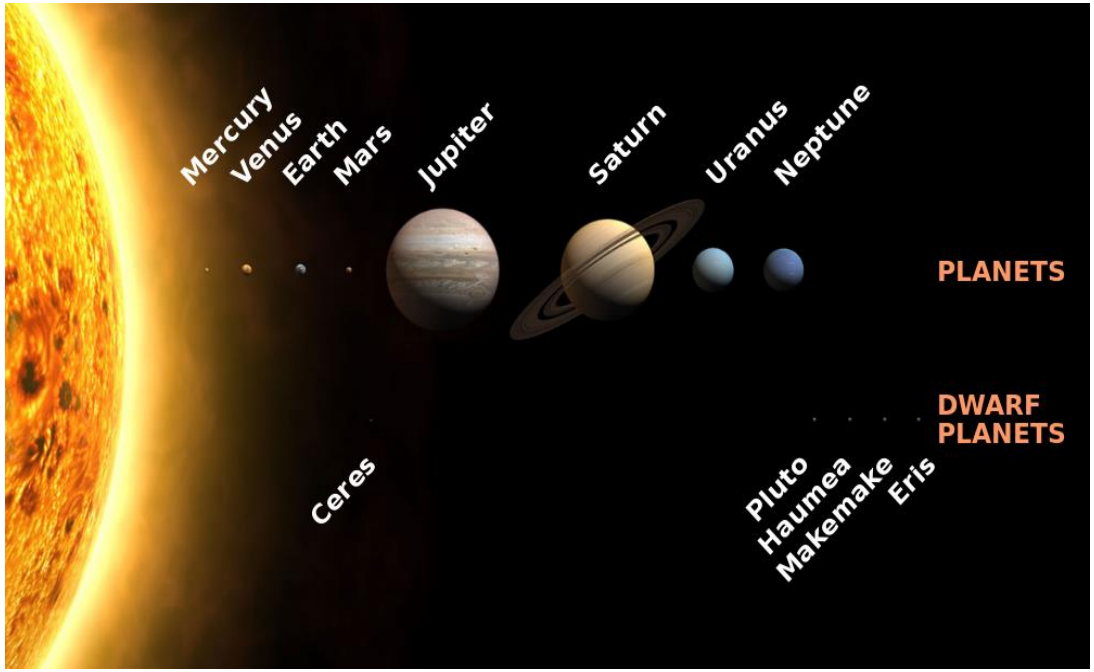
Our star (**The Sun**) is just one of approximately 300 000 000 000 stars in our galaxy. The whole **solar system** is too small to see on this picture of the Milky Way.

There is thought to be a massive **black hole** at the centre of the Milky Way.

The **Universe** is thought to have formed about **13.7 billion years** ago.
The **solar system** formed around **4.6 billion years** ago.

Space physics; orbital motions and satellites – Our solar system

The **solar system** is any object that is bound by **gravity** to a **Sun**. All objects in the solar system **orbit The Sun**.



Our solar system there is:

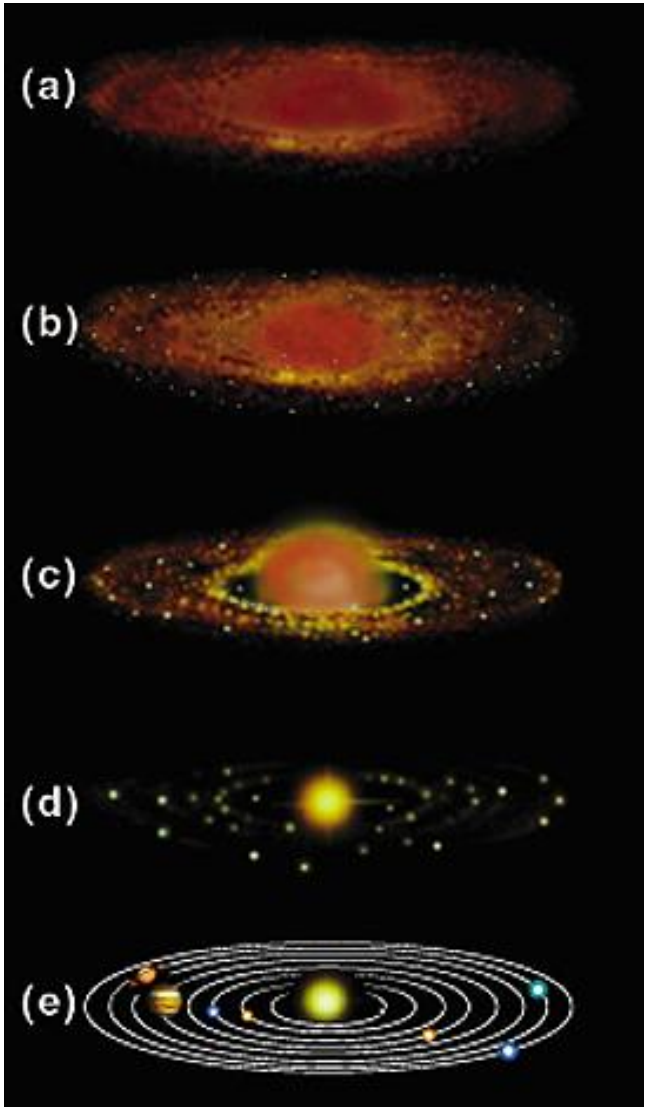
- **one star – the Sun**
- **eight planets**
- **dwarf planets**
- **natural satellites** called **moons** that orbit planets.

Other objects in
The solar system include:

- **Comets**
- **Asteroids**
- **Satellites**

Dust, ice and rocks make up the remaining mass.

Space physics; orbital motions and satellites – Formation of the sun and solar system



(a) The universe contains 'clumps' of **dust and gas** each called a **nebula**.

(b) Gravitational attraction pulls this dust and gas together.

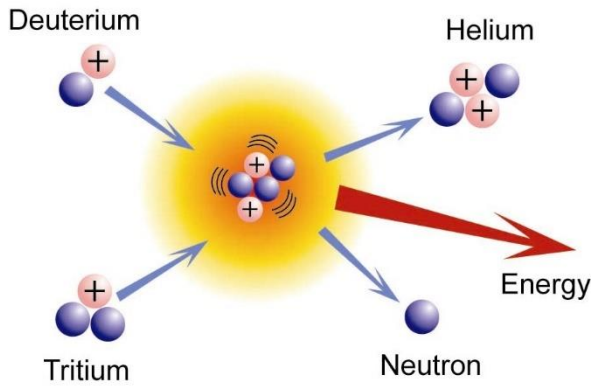
(c) Forming the Sun (a star).

(d) Fusion reactions lead to an **equilibrium** between the **gravitational collapse** of the star and the **expansion** of a star due to fusion energy.

(e) The remaining parts of the solar system form from the remaining dust and gas.

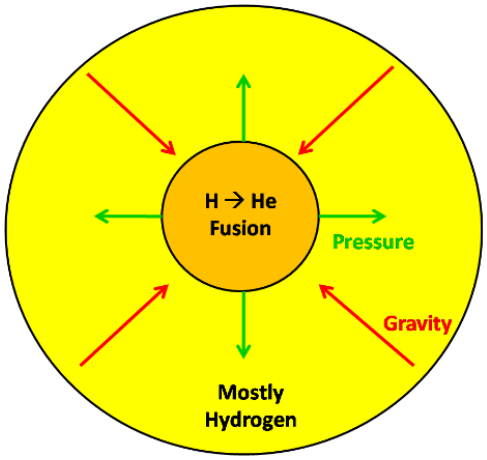
Space physics; orbital motions and satellites – Stability of the sun

The Sun, like all stars, releases energy through nuclear fusion reactions in the core.



Two isotopes of Hydrogen (Deuterium and Tritium) are forced together under **high temperature and pressure**. **Nuclear fusion occurs** to form Helium and a neutron.
A tiny amount of **mass is converted** into a large amount of **energy**, which is why stars emit a lot of energy.

The heat produced in the fusion process makes the star **expand** through **thermal pressure**.
Gravitational attraction is pulling the mass of the star **inwards**.
In a stable star, thermal expansion and gravitational attraction are **equal** so the star remains the same size.
This balance can change later in a star's life when a great increase in thermal pressure can cause it to **expand**.

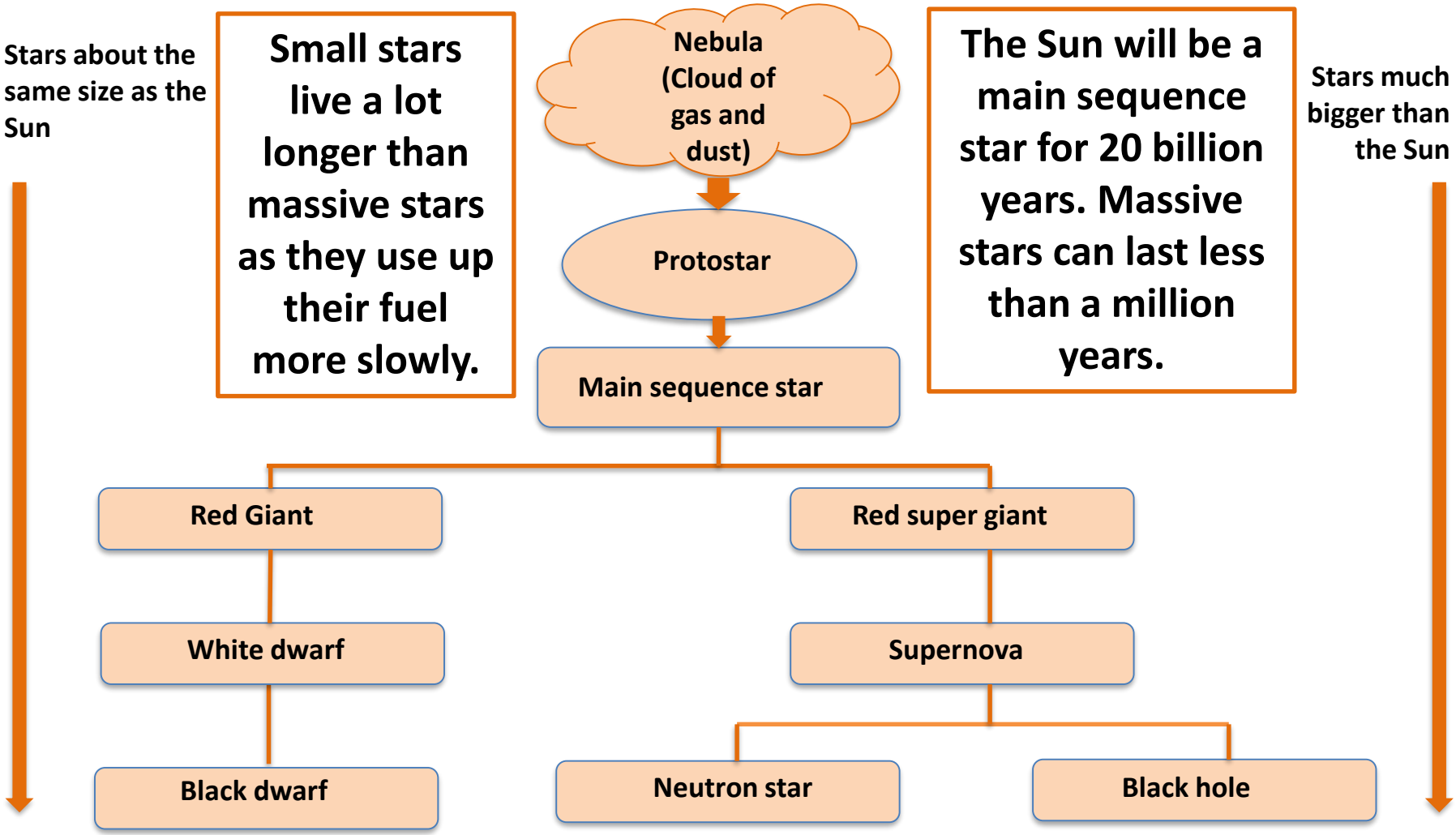


Space physics; orbital motions and satellites – Life cycle of a star

Stars go through a life cycle which is different for massive stars and smaller stars.

Stars about the same size as the Sun

Small stars live a lot longer than massive stars as they use up their fuel more slowly.



The Sun will be a main sequence star for 20 billion years. Massive stars can last less than a million years.

Stars much bigger than the Sun

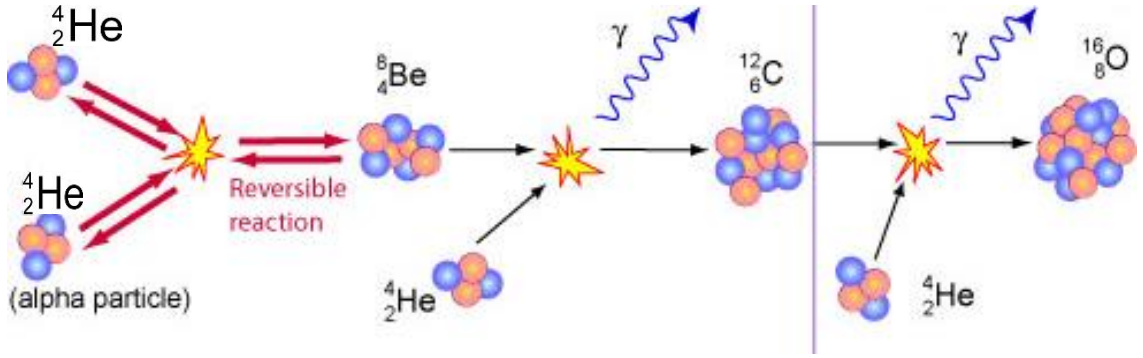
Space physics; orbital motions and satellites – Stars and the elements

- **Fusion processes** in stars produce **all** of the naturally occurring elements.
- **Elements heavier** than iron are produced in a **supernova**.
- The **explosion of a massive star** (supernova) distributes the elements throughout the **universe**.

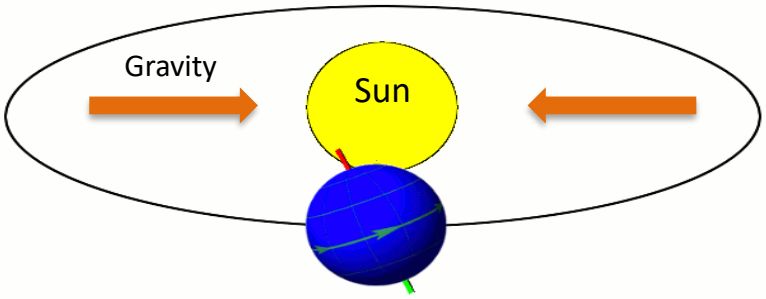
How fusion processes lead to to the formation of new elements:

Stars begin with **hydrogen** as their "fuel". Hydrogen nuclei join to becomes **helium** during the **fusion** process. Further fusion processes continue to create larger elements (as big as **iron** on the periodic table).

Elements bigger than iron are produced in a **supernova**. The supernovae distribute elements throughout the Universe.

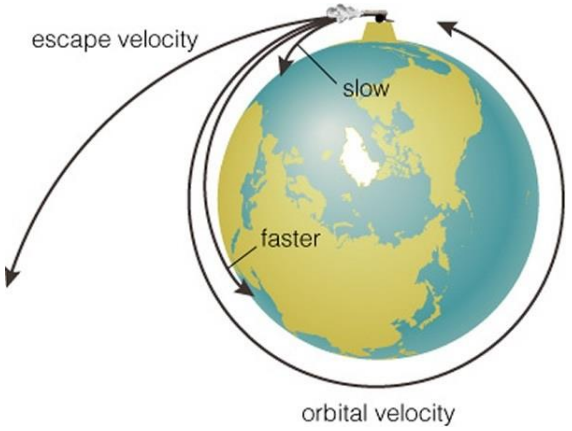


Space physics; orbital motions and satellites – Orbits and speed



Gravity pulls the Earth (and other planets) towards the sun. The planet is effectively "falling" towards the sun but is travelling fast enough so that it constantly misses falling into the sun.

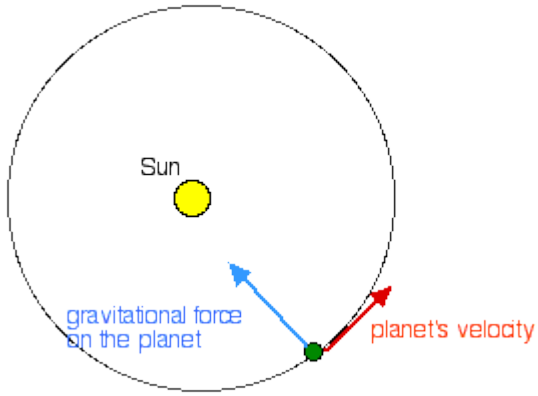
This is like a cannon firing a cannonball at just the right speed so it does not escape into space or fall down to Earth.
This is how planets, moons and artificial satellites remain in orbit around larger objects in space.



The force of **gravity increases** the **closer an object** orbits. To avoid being pulled into the sun, a planet must be travelling faster, the closer it is to the sun.
This is why **Mercury's** orbit of the sun takes **3 Earth months** whereas it takes **Neptune 165 Earth years** to orbit the sun.

Space physics; orbital motions and satellites – Orbits and speed (HT)

In a perfectly circular orbit, a body will travel at **constant speed** to maintain its orbital distance.
However, gravity is constantly **changing** the **direction** of the body. As velocity depends on speed and direction, the **velocity** is constantly **changing** even though **speed** remains the **same**.
This applies to planets, moons and satellites.



Planets velocity is in a straight line. Gravity causes body to change direction so velocity must be changing

QuestionIT!

Solar system: stability of orbital motions; satellites (physics only)

- Our solar system
- The life cycle of a star
- Orbital motion, natural and artificial satellites

Solar system: stability of orbital motions; satellites (physics only) – QuestionIT

1. Name the star in our solar system.
2. How many planets in our solar system?
3. What is the difference between a moon and a dwarf planet?
4. What do we call the natural satellites in the solar system?
5. Name the galaxy our solar system is part of.
6. How was the sun formed, and what caused this to happen?

Solar system: stability of orbital motions; satellites (physics only) – QuestionIT

7. List the major bodies found in the solar system.

8. What is a nebula?

9. What determines the life cycle a star will take?

10. Describe the lifecycle of a star the size of the sun.

11. Describe the lifecycle of a star more massive than the sun.

Solar system: stability of orbital motions; satellites (physics only) – QuestionIT

12. What processes produce all of the naturally occurring elements?

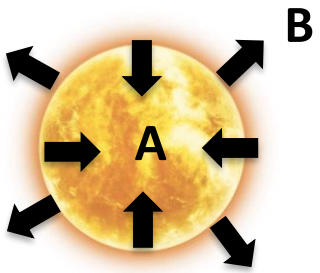
13. Where are elements heavier than iron produced?

14. How are these elements distributed throughout the universe?

15. What force enables planets and satellites to maintain their circular orbits?

Solar system: stability of orbital motions; satellites (physics only) – QuestionIT

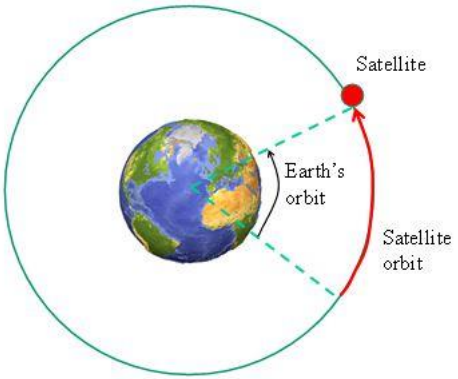
16. Main sequence stars are stable despite opposing forces acting on the star. Describe forces A and B.



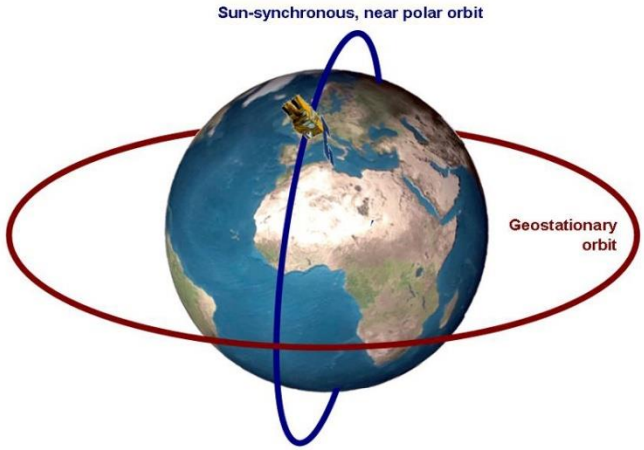
17. The international space station takes 92 mins to orbit the Earth. The Moon takes 27.3 days to orbit the Earth. Explain why these orbital times are different.

Solar system: stability of orbital motions; satellites physics only) (HT) – QuestionIT

18. The diagram shows a satellite orbiting the Earth.
    Explain how the Earth's gravity can result in the satellites velocity changing but not its speed.



19. Explain why satellites in a polar orbit must travel at much higher speeds than a satellite in a geostationary orbit.



AnswerIT!

Changes of state and the particle model

- Density of materials
- Changes of state

Solar system: stability of orbital motions; satellites (physics only) – QuestionIT

1. Name the star in our solar system.
   The Sun.
2. How many planets in our solar system?
   8
3. What is the difference between a moon and a dwarf planet?
   Dwarf planets orbit the sun; moons orbit planets.
4. What do we call the natural satellites in the solar system?
   Moons.
5. Name the galaxy our solar system is part of.
   The Milky Way.
6. How was the sun formed, and what caused this to happen?
   From a cloud of dust and gas (nebula); pulled together by gravitational attraction; causing fusion reactions.

Solar system: stability of orbital motions; satellites (physics only) – QuestionIT

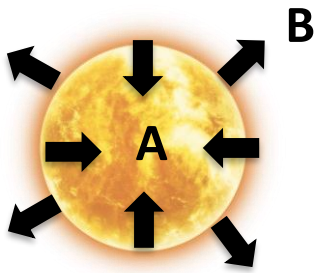
7. List the major bodies found in the solar system.
   Star, planets, dwarf planets, moons, asteroids, comets.
8. What is a nebula?
   Could of dust and gas.
9. What determines the life cycle a star will take?
   The size of the star.
10. Describe the lifecycle of a star the size of the sun.
    Cloud of gas and dust, protostar, main sequence star, red giant, white dwarf, black dwarf.
11. Describe the lifecycle of a star more massive than the sun.
    Cloud of gas and dust, protostar, main sequence star, red super giant, supernova, neutron star or black hole.

Solar system: stability of orbital motions; satellites (physics only) – QuestionIT

12. What processes produce all of the naturally occurring elements?
    Fusion.
13. Where are elements heavier than iron produced?
    Supernova.
14. How are these elements distributed throughout the universe?
    Explosion of massive star (supernova).
15. What force enables planets and satellites to maintain their circular orbits?
    Gravity.

Solar system: stability of orbital motions; satellites (physics only) – QuestionIT

16. Main sequence stars are stable despite opposing forces acting on the star. Describe forces A and B.



A – gravitational attraction

B – thermal expansion

16. The international space station takes 92 mins to orbit the Earth. The Moon takes 27.3 days to orbit the Earth. Explain why these orbital times are different.

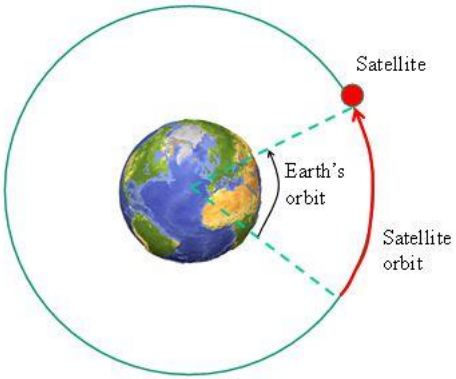
Moon orbits at a much greater distance than the ISS; it is much further away from the Earth.

The further from the Earth the lower the gravitational attraction

So The Moon travels slower and it takes much longer to orbit the Earth.

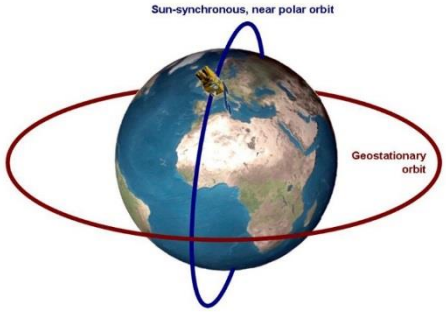
Solar system: stability of orbital motions; satellites physics only) (HT) – QuestionIT

18. The diagram shows a satellite orbiting the Earth.
Explain how the Earth's gravity can result in the satellites velocity changing but not its speed.



In a circular orbit the speed of the satellite remains constant. Velocity is a vector so has size AND direction.
As the direction is changing, the velocity must be changing.

19. Explain why satellites in a polar orbit must travel at much higher speeds than a satellite in a geostationary orbit.



Polar satellite are in a much lower orbit than geostationary satellites.
In a lower orbit, gravity has a much stronger influence so the polar satellite must travel much faster to avoid being pulled down to Earth.

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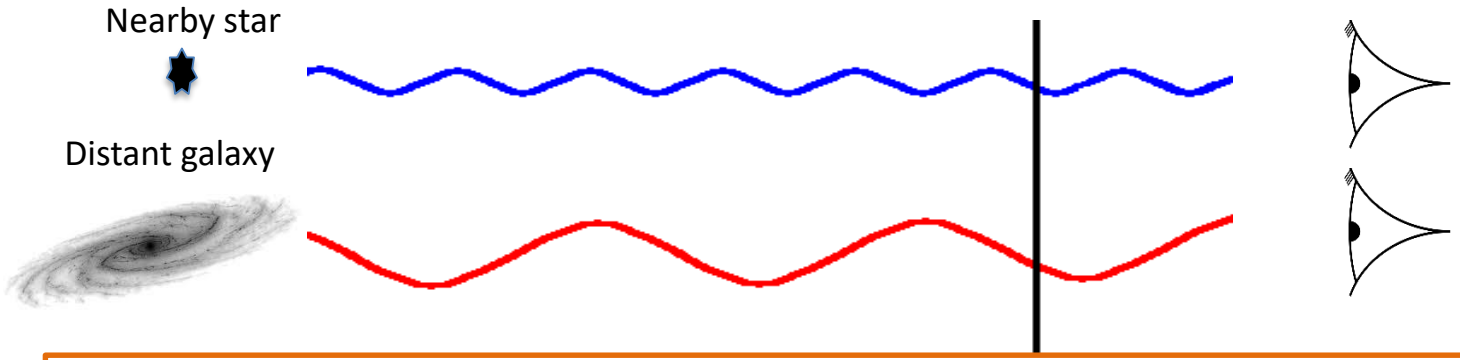
Red shift (physics only)

- Red shift
- Big bang theory

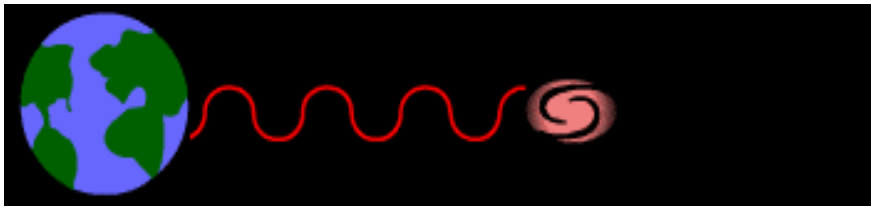
Red shift

There are billions of galaxies in the Universe. We can see them because the stars within them give off light which travels to Earth.



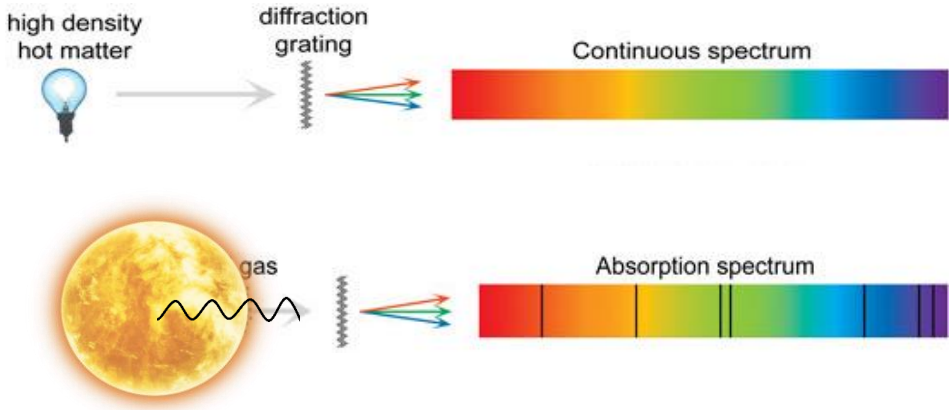
Light from a **nearby star** appears **white** as the wavelength of light emitted covers the **whole visible spectrum**.
The light we receive from a **distant galaxy** has had its **wavelength increased**.
As longer wavelengths of light are the red end of the spectrum, the light appears redder than from the nearby star – this is called **RED SHIFT**.

Red shift happens because the galaxy is **moving away** from us at high speed, causing the wavelengths of light to be **stretched**.



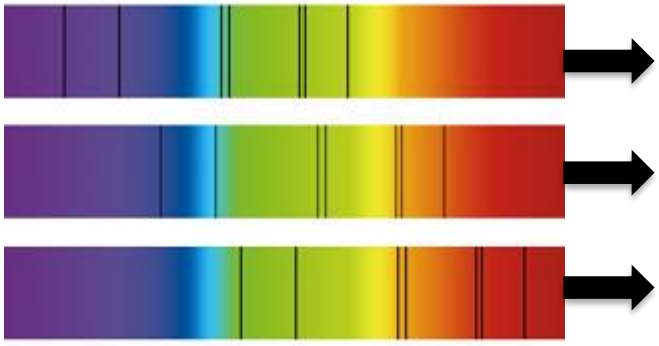
Red shift

Light emitted by a hot object produces a continuous spectrum. When light is emitted by a star, the light has to travel through the gases which make up the star. These gases absorb specific wavelengths of light, leaving black lines in the spectrum.



Absorption spectra from stars in every galaxy would look the same if all the galaxies were a fixed distance from the Earth. Galaxies have different amounts of red shift which means they are moving away from us at different speeds.

The faster a galaxy is moving, the further away it is.



Spectrum from a star in our galaxy – no red shift

Spectrum from a star in another galaxy – some red shift

Spectrum from a distant galaxy – a lot of red shift

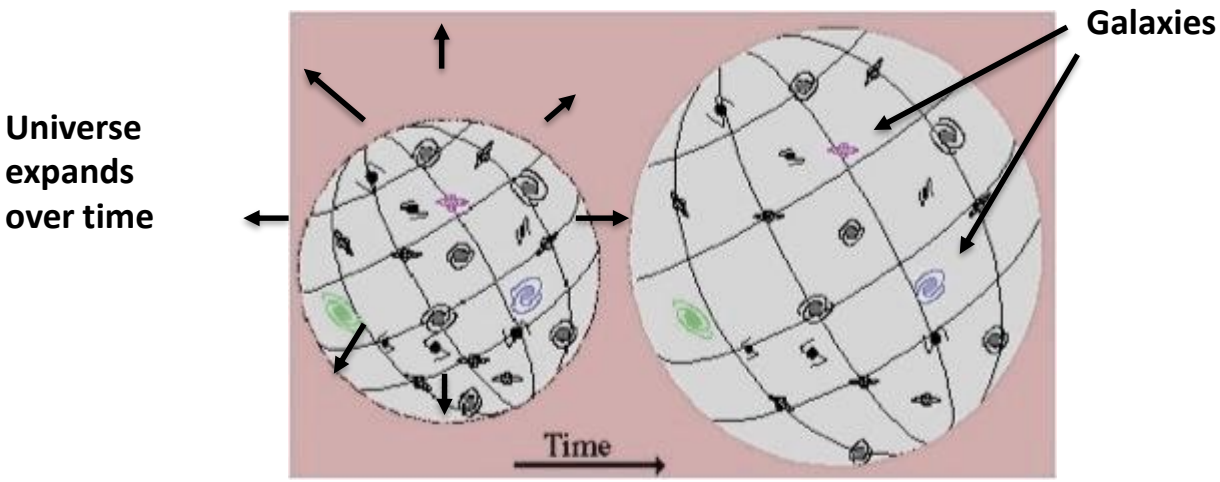
Red shift

Summary

- Red light has a **longer wavelength** than blue light.
- Most **distant galaxies** show an **increase in wavelength** of light.
- The **further away** the galaxies the **faster** they are moving and the **bigger the increase in wavelength**.
- This effect is called the **RED-SHIFT**.
- The observed red-shift provides **evidence** that the **universe is expanding** and supports the **Big Bang theory**.

Big Bang theory

Like a balloon expanding, all **galaxies** are **moving away from each other** and from a point of origin. Only the fastest moving galaxies would be on the surface of this model. Slower moving galaxies would be on the inside but still moving away from the centre. These observations have provided evidence of an **expanding Universe**.



Red shift measurements of many galaxies have given evidence that all galaxies are **moving away** from a **single point** of origin at **different speeds**. This has led to the **Big Bang theory** that the Universe expanded from a single point of matter around 13.7 billion years ago.

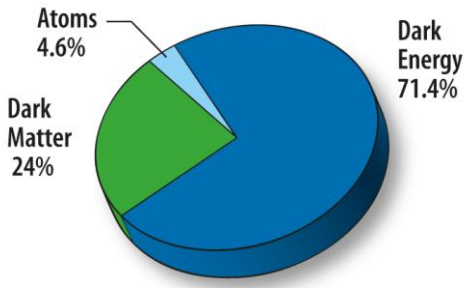
Understanding the Universe

Over the last century, much has been discovered about our Universe:

- The age of the Universe.
- The Universe is more than just our galaxy.
- The size of the Universe.
- There are probably billions of other planets beyond our Solar System.
- The Universe is expanding.
- Cosmic microwave background radiation supporting the Big Bang theory.

However, there is still much we do not yet understand about the Universe.

- **Dark matter** and **dark energy** – continued expansion and acceleration of the Universe suggests there must be a lot more matter and energy than we can see. This is described as dark matter/energy that we have yet to find.
- **Fate of the Universe**. Is the Universe going to continue forever or collapse back to a point and start again?
- Is our Universe just one of a series of **multiverses**?
- Does **life** exist anywhere else in the Universe?



QuestionIT!

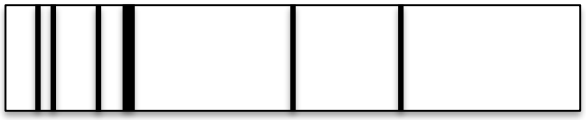
Red shift (physics only)

- Red shift
- Big bang theory

Red shift and Big Bang theory – QuestionIT

1. Which colour of light has the longest wavelength?

2. The diagram shows the spectrum of light from a star in our galaxy.

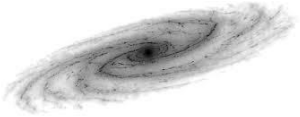


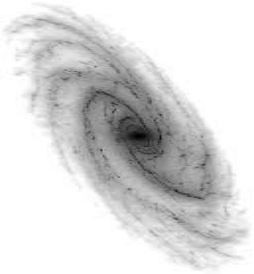
Copy the second box by adding the spectra you would expect from a star in a distant galaxy.

3. The light reaching Earth from distant galaxies exhibits red shift.
Explain why red shift occurs.

Red shift and Big Bang theory – QuestionIT

4.

Galaxy A 

Galaxy B 

If galaxy A has a much bigger red shift than galaxy B, what does this tell you about galaxy A?

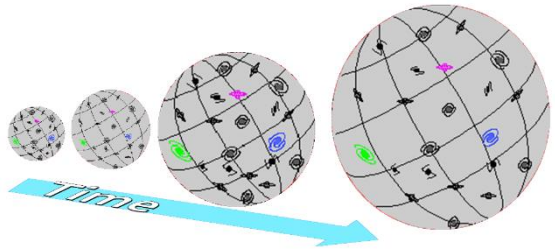
5. Which theory about the origin of the Universe does red shift of galaxies support?

6. Approximately how many years ago did the Universe begin? (Circle the correct answer)

14 million 14 billion 14 trillion

Red shift and Big Bang theory – QuestionIT

7. What does the diagram suggest is happening to the Universe over time?



8. Describe the current theory of how the Universe began.

9. Atoms are only thought to make up about 5% of the known Universe. What do scientists think the remaining 95% is made up of?

10. The most distant galaxies in the Universe are thought to be:
(tick the correct box)

The biggest galaxies	☐	Accelerating	☐
Slowing down	☐	The coldest	☐

AnswerIT!

Red shift (physics only)

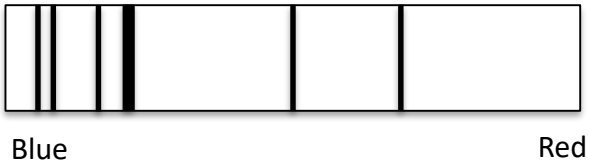
- Red shift
- Big bang theory

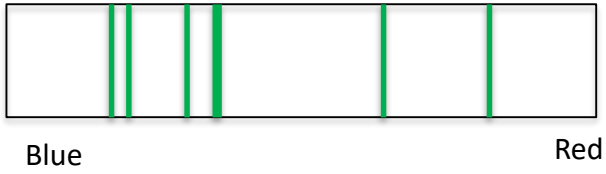
Red shift and Big Bang theory – AnswerIT

1. Which colour of light has the longest wavelength?

   Red

2. The diagram shows the spectrum of light from a star in our galaxy.





   Copy the second box by adding the spectra you would expect from a star in a distant galaxy.

3. The light reaching Earth from distant galaxies exhibits red shift.
   Explain why red shift occurs.

   Galaxy is moving away at high speed

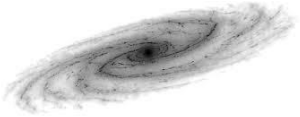
   Light waves from the galaxy are being stretched to longer wavelengths.

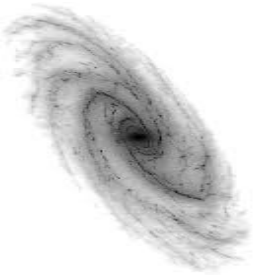
   Longer wavelengths of light are found at the red end of the spectrum.

   This shift of wavelength is called red shift.

Red shift and Big Bang theory – AnswerIT

4.

Galaxy A 

Galaxy B 

If galaxy A has a much bigger red shift than galaxy B, what does this tell you about galaxy A?

It is travelling away at a higher speed. It is further away.

5. Which theory about the origin of the Universe does red shift of galaxies support?

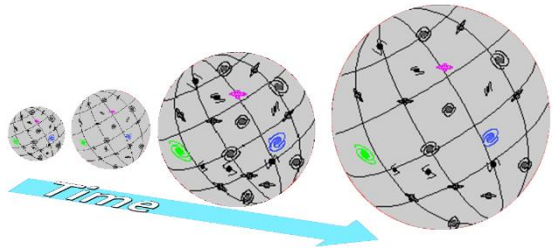
Big Bang theory.

6. Approximately how many years ago did the Universe begin? (Circle the correct answer)

14 million 14 billion 14 trillion

Red shift and Big Bang theory – QuestionIT

7. What does the diagram suggest is happening to the Universe over time?



It is expanding.

8. Describe the current theory of how the Universe began.

Started as a small region that was very hot and dense.
Big Bang caused it to rapidly expand.

9. Atoms are only thought to make up about 5% of the known Universe. What do scientists think the remaining 95% is made up of?

Dark matter and dark energy.

10. The most distant galaxies in the Universe are thought to be:
(tick the correct box)

The biggest galaxies	☐	Accelerating	✓
Slowing down	☐	The coldest	☐