Edexcel Physics IGCSE

Topic 8: Astrophysics

Summary Notes

(Content in **bold** is for physics only)

Motion in the universe

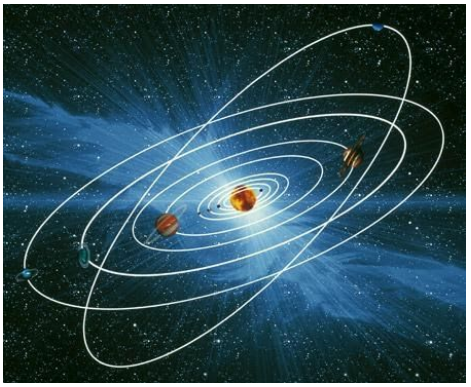
- The **universe** is a large collection of billions of galaxies.
- A **galaxy** is a large collection of billions of stars.
- A **solar system** is a collection of planets orbiting a common star. Our **solar system** is in the **Milky Way** galaxy.

The **gravitational field strength** is the force per unit mass on a body in a gravitational field and is measured in **Newtons per kilogram (N/kg).** It varies with the **mass** and **size** of the body and is therefore different on other planets and the moon compared to the Earth.

- $weight = mass \times gravitational\ field\ strength \qquad W = mg$

Gravitational force enables the various bodies to **orbit** around others. For example:

- Moons orbit planets
  - The orbits are **slightly elliptical** with **near constant orbital speed**
- Planets and comets orbit the Sun
  - The orbits of planets are **slightly elliptical** with **near constant orbital speed.** The orbits of comets are **highly elliptical.**
- Artificial satellites orbit the Earth



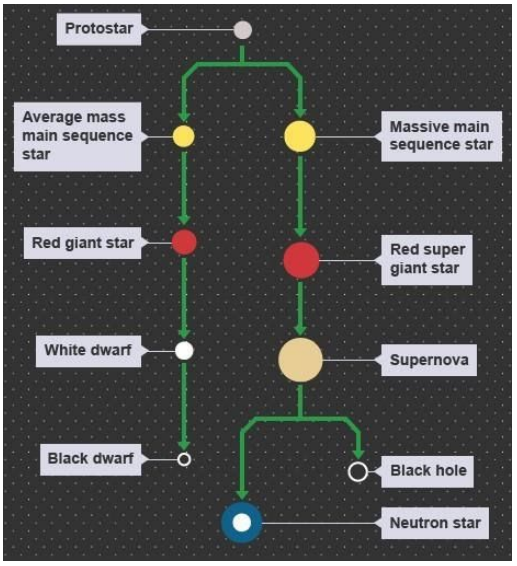
The greater the orbital radius or the smaller the time period, the greater the orbital speed:

- $orbital\ speed = \frac{2 \times \pi \times orbital\ radius}{time\ period} \qquad v = \frac{2\pi r}{T}$

Comets have a *greater* speed nearer to the star (when r is smaller) because the ice inside them melts as they get closer (& warmer) - causing their mass to decrease.

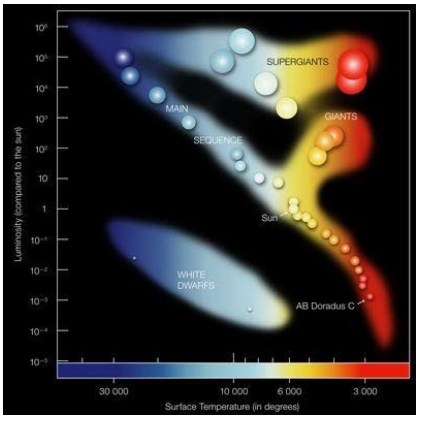
Stellar evolution

- A star begins as a cloud of dust & gas called a **nebula.** The particles experience a weak attraction towards each other due to gravity and begin to **clump** together.
- They continue to clump together until the **pressure** and **temperature** is great enough for **nuclear fusion** to occur.
  - **Hydrogen** nuclei fuse together to form helium nuclei which releases a large amount of energy and causes a great **outwards pressure.**
  - This outwards pressure **balances** with the **inwards pressure** due to gravity and the star is now stable and called a **main sequence star.**
- Eventually the hydrogen in the star is used up. There is no longer enough outward pressure from nuclear fusion and it **collapses** under its own gravitational attraction, becoming **unstable.**
  - If the star has a similar mass to the Sun, it expands massively and becomes a **red giant.** It then becomes a **white dwarf** (and finally cools into a black dwarf).



- If the star has a mass larger than the Sun, it expands and becomes a **red super giant,** before exploding in a **supernova.** What remains is either a **neutron star,** or if it was exceptionally massive, a **black hole.**

Stars can be **classified** according to their **colour.** The colour of a star is related to its **surface temperature,** with **hotter** stars being **bluer** and **cooler** stars being **redder.**



The brightness of a star depends upon where it is measured - at a standard distance it can be represented using absolute or apparent magnitude.

- **A star's absolute magnitude is defined to be equal to the apparent magnitude that the star would have if it were viewed from exactly 10 parsecs (32.6 light-years) away.**
- **The apparent magnitude is how bright it appears at a particular point in space.**

A Hertzsprung-Russell diagram (HR diagram) shows the relationship between a star's surface temperature and brightness. The main components are shown in the diagram on the right.

- **Supergiants (top right)**
- **Red giants (below supergiants)**
- **The Main Sequence (a diagonal strip from top left to bottom right)**
- **White dwarfs (bottom left)**

Other stages don't show on the HR diagram because a star is only in them for a very short period of time.

Cosmology

The Big Bang theory states that the universe expanded outwards from a single point. Evidence for this theory includes:

- **Red shift**
  - **The red shift of light from galaxies shows that they are all moving away from us and that those which are furthest away are moving the fastest, suggesting that the universe was formed from an explosion at a single point, evidence for the Big Bang. This is the principle of the Doppler effect.**
- **Cosmic microwave background radiation (CMBR)**
  - **Just after the Big Bang, lots of short wavelength radiation should have been released. This radiation, as the universe expanded over time, would have been stretched to become microwaves.**
  - **The fact that there is cosmic microwave background radiation present wherever you point a telescope in the sky provides evidence for the Big Bang.**

As the Big Bang theory is currently the only theory which accounts for all the experimental evidence, it is the most accepted model.

If a wave source is moving relative to an observer, there will be a change in the observed frequency and wavelength due to the Doppler effect. An example of this is when the siren of an ambulance is high-pitched as it approaches you, and low-pitched as it goes away.

- $\frac{\text{change in wavelength}}{\text{reference wavelength}} = \frac{\text{velocity of a galaxy}}{\text{speed of light}}$ $\qquad \frac{\lambda - \lambda_0}{\lambda_0} = \frac{\Delta\lambda}{\lambda_0} = \frac{v}{c}$

Doppler shift is responsible for the red-shift of light from galaxies which are moving away from Earth, which is when the wavelength of the light coming from them increases. The faster it is moving, the more its light is red-shifted.