

The star in our planetary system is called The Sun (Sol).

The sun was formed from a NEBULA - this is a large cloud of gas and dust (mainly hydrogen).

Parts of the nebula are pulled together by GRAVITY. These areas become much MORE DENSE and their TEMPERATURE INCREASES.

We call these dense and hot regions PROTOSTARS. If they become hot enough and dense enough then HYDROGEN FUSION begins.

This marks the start of the life of a STAR.

In our planetary system we have:

One star (the Sun)

Eight planets (Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune)

(potentially) hundreds of dwarf planets (pluto, makemake, haumea)

Natural satellites (moons)

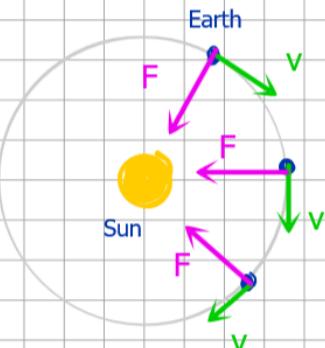
Artificial satellites (man made)

Other objects such as asteroids (a type of natural satellite)

## Orbital Motion

An orbit is a path one object takes around another.

All of the planets (and dwarf planets) orbit around the Sun (in our planetary system).



- The gravitational force of attraction acts towards the centre of the orbital path (it is CENTRIPETAL, or 'centre seeking').
- This changes the Earth's velocity by CHANGING ITS DIRECTION.
- The Earth is, therefore, accelerating. As acceleration is the rate of change of velocity.

As orbital radius increases, the velocity required to stay in a STABLE ORBIT decreases as the gravitational attraction to the Sun decreases.

## Initial formation

All stars form in large clouds of gas and dust (nebulae)

Gravity pulls particles in the nebulae together; becomes hot and dense

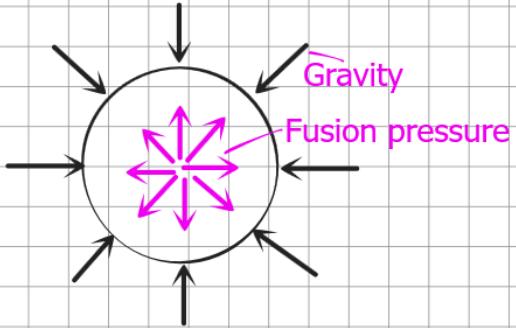
→ **PROTOSTAR**

Eventually (if temp. and density is high enough) then **HYDROGEN FUSION** begins

→ **MAIN SEQUENCE**

In this phase the inwards collapse due to **GRAVITY** is balanced by an outward force generated by the energy released by **FUSION** (fusion pressure).

The star is **STABLE**.



The following steps are for **sun-like stars** (a similar mass to the Sun)

When the star runs out of hydrogen (its fuel for fusion) it will **EXPAND**

→ **RED GIANT**

The outer layers of the star drift away (forming a planetary nebula)

The hot core of the star is left behind

→ **WHITE DWARF**

This hot core will eventually cool down

→ **BLACK DWARF**

The following steps are for stars that are much **MORE MASSIVE** than the Sun

Once a massive star runs out of Hydrogen it can continue to fuse and form heavier elements (up to **IRON**)

→ **RED SUPERGIANT**

Eventually these stars explode in a **SUPERNOVA**

Any element heavier than iron was formed in one of these explosions and scattered throughout the **galaxy**

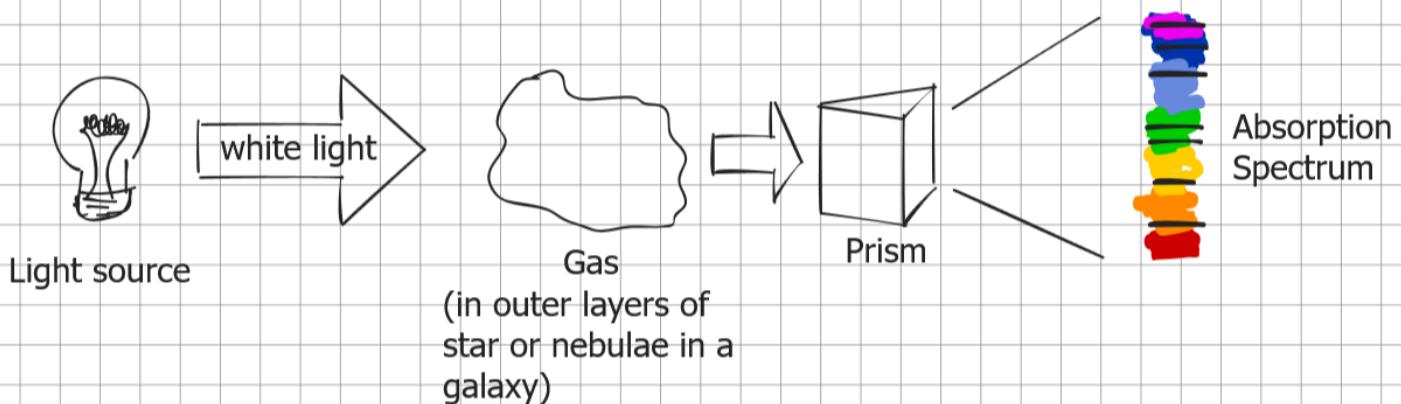
After a supernova the core can be left behind as a **NEUTRON STAR**.

If the star is very massive its core will become a **BLACK HOLE**.

### Red Shift

3rd April

When we observe light that has arrived from distant stars and galaxies we can analyse the **SPECTRUM** of this light, and determine the object's chemical composition.



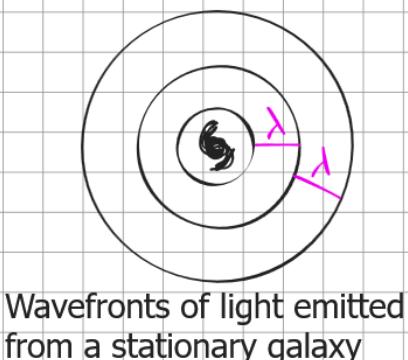
The **DARK LINES** in the spectrum show where certain wavelengths of light have been **ABSORBED** by the **ELECTRONS** orbiting the atoms in the gas.

Each type of atom has a unique set of dark lines.

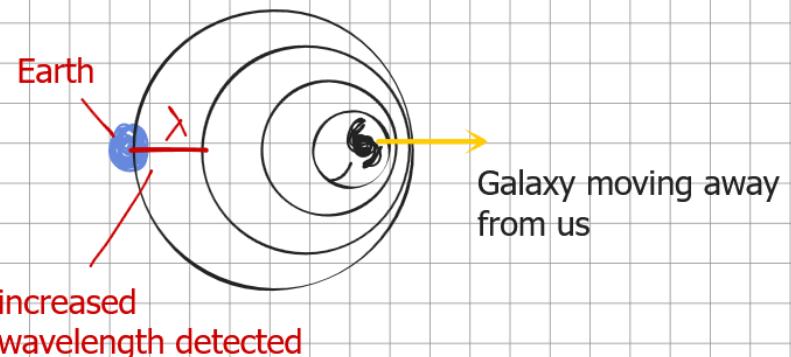
When observing the spectrum of light from very distant objects we noticed that these dark lines had been '**RED SHIFTED**' (shifted to a slightly longer wavelength).

We also saw that the **FURTHER AWAY** the object was the **GREATER** the **RED SHIFT**.

Red shift happens when the source of a wave (i.e. a distant galaxy) is moving AWAY from the observer (i.e. a scientist on Earth). The wavelength of the detected wave is increased due to the relative motion.



Wavefronts of light emitted from a stationary galaxy



increased wavelength detected

Galaxy moving away from us

The fact that we observe GREATER REDSHIFT for MORE DISTANT OBJECTS is evidence that the UNIVERSE is EXPANDING.

The space itself between distant objects is INCREASING.

## The History of the Universe

23rd April

There were two main theories that explain the origin and structure of the universe.

Steady State: as the universe expands new matter is constantly created. The universe has always existed and has a constant density.

Big Bang: universe was initially very small, hot and dense. It then rapidly expanded. As it expanded, it cooled.

The observation that the universe was expanding (everything is moving away from everything else.. as shown by more distant objects having greater redshift & moving away faster) implies that the universe began at some point in time and was very small.

Shortly after the big bang energy and matter separated and released light.

The wavelength of this light has been stretched (red shifted) as the universe has expanded and is now in the microwave region of the EM Spectrum.

We call this light COSMIC MICROWAVE BACKGROUND RADIATION. Only the big bang theory explains its existence.

Its discovery provided EVIDENCE that supported the Big Bang Theory.

There are a few aspects of the universe we do not yet understand:

- There is more mass in the universe than we can see. This 'invisible mass' is called Dark Matter
- The rate of expansion of the universe is increasing. We attribute this to an unknown effect we call Dark Energy.