Space Notes

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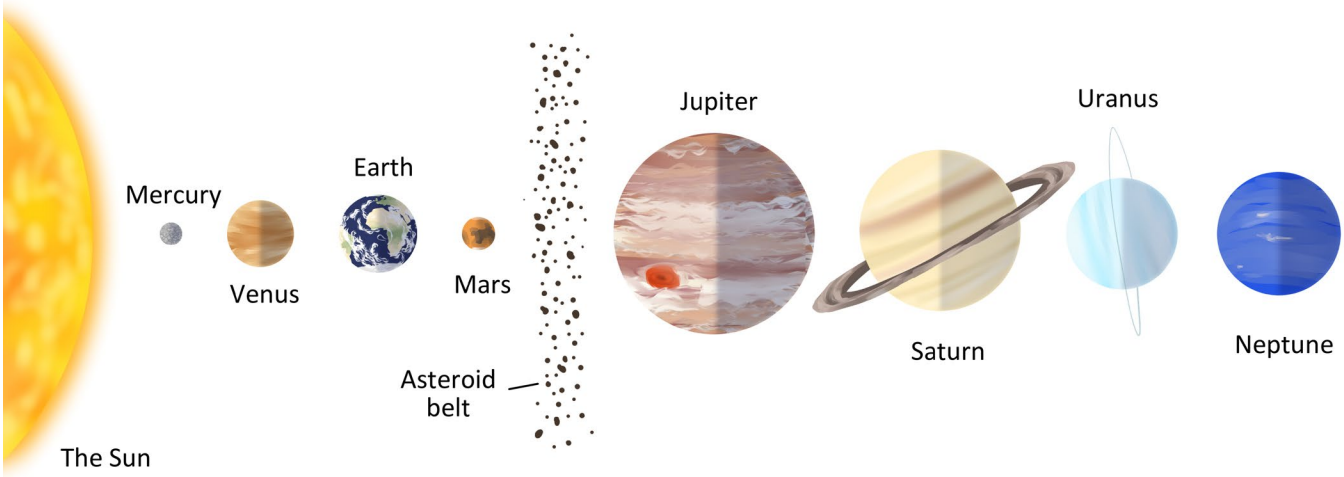
Space has fascinated us as a species for as long as we have been around. All civilizations had their own connection and stories about space, or what they thought space was. Even we today with our Star Wars and Star Trek, Buzz Lightyear and the much overlooked gem of Stargate SG1. We are always looking to space 😊
So, what do we need to know? Let's start with our solar system.

Our Solar System

Our solar system: is made up of the Sun and all objects that are affected by its gravitational field this includes planets, moons, asteroids, comets, and dwarf planets.

The figure below shows our solar system. We need to make sure that we know the order of the planets.



Let's look at each of the components of the solar system.

The Sun	The sun is the main sequence star at the centre of our solar system. It is made mostly of hydrogen. The sun does nuclear fusion in its core.
Mercury	Is the closest planet to the sun. It is mostly made of rock. Mercury is the smallest planet in the solar system. **Orbit**: Mercury orbits the sun once every 88 earth days.
Venus	Is the second planet from the sun. It is mostly made of rock and it is a similar size to earth. It has a very thick atmosphere mostly made of carbon dioxide. **Orbit**: Venus orbits the sun once every 225 earth days.
Earth	Is the third planet from the sun. It is mostly made of rock. It is the only planet we know of that has liquid water on its surface and that is capable of supporting life. **Orbit**: Earth orbits the sun every 365.25 earth days.
Mars	Is the fourth planet from the sun. It is also known as the red planet, this is because its surface has a lot of iron oxide (rust) in it. It is mostly made of rock. **Orbit**: Mars orbits the sun once every 687 Earth days.
Asteroid belt	Is a region of the solar system between Mars and Jupiter. It has a huge number of rocky objects.
Jupiter	Is a gas giant. This means that it is made up mostly of hydrogen and helium. It is also the largest planet in our solar system. **Orbit**: Jupiter orbits the sun once every 11.86 earth years.
Saturn	Is another gas giant. It is the planet that has the beautiful ring system. **Orbit**: Saturn orbits the sun once every 29.46 earth years.
Uranus	Is an ice giant planet. This means it is made up mainly of frozen water, methane, and ammonia. It has a small rocky core. It does not have a solid surface. **Orbit**: Uranus orbits the sun once every 84 earth years.
Neptune	Is another ice giant and the furthest planet from the sun. **Orbit**: Neptune orbits the sun once every 164.8 earth years.

The Sun

The Sun is the star of our solar system. It is a main sequence star which means that it is in the stage of its life where it is doing nuclear fusion to convert hydrogen into helium. The sun has the greatest mass and gravity in our solar system.

Why does the sun stay the same size? The Sun stays the same size because of a balance between its two opposing forces, gravitational force (pulling it inwards) and the energy from nuclear fusion (which is not a force but feel free to think of it as a force). If these were unbalanced then the sun could change size.

Why do stars get bigger later in their lives? As stars age they burn their fuel so they have less mass. When they have less mass their gravity is less but the nuclear forces acting on the star are the same. This causes the sun to get bigger.

How did the sun form? The Sun began forming about 4.6 billion years ago from a **giant nebula** which is an enormous cloud of gas and dust. We are not sure what started it off but the nebula started to collapse in on itself. This created a central region with more mass, like a giant dog pile or pile on. More and more matter kept piling on and this matter increased the heat and pressure at the centre of the object. When this happened it started to give out heat and light. It wasn't a star yet. At this point we would have called this **a proto star**.

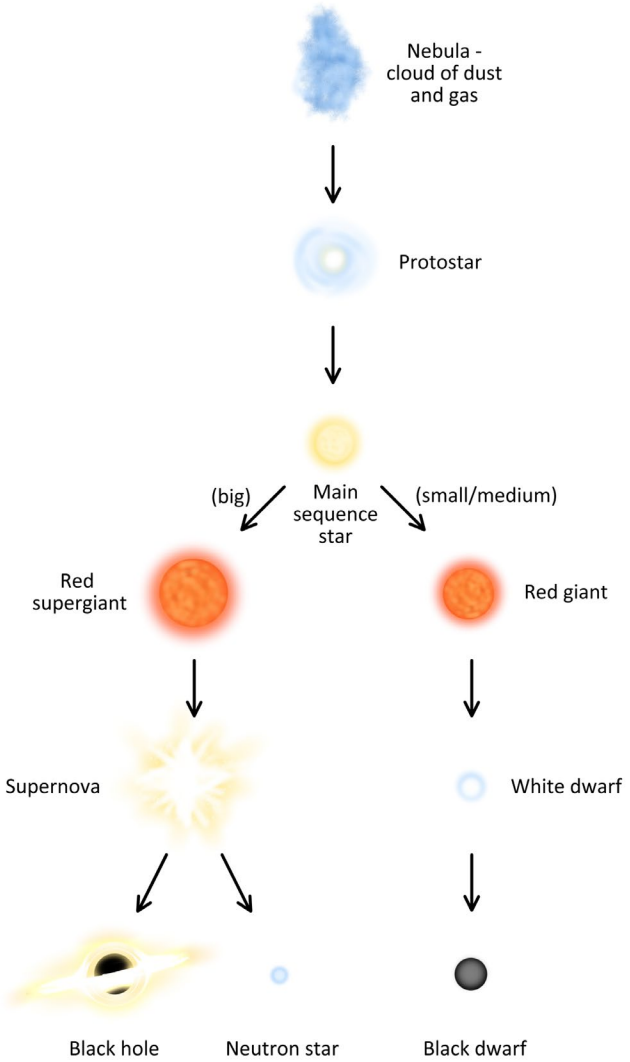
All the time more and more matter was piling on… until… The temperature and pressure at the centre of the proto star were high enough to do nuclear fusion. In that moment when the first two atoms of hydrogen fused to make one atom of helium our star was born. The sun has been in the **main sequence stage** of its life cycle ever since.

Exam note: stars can usually only fuse elements up to and including iron, meaning all elements heavier than iron are created exclusively in the extreme heat of a **supernova**, which then scatters them across the universe!

Remember, every single atom that goes into making all of us was forged in a star!

The Life Cycle of Stars

The easiest way of covering this is with the diagram below 😊 Please learn off the diagram and you'll be fully set for any question on the life cycle of stars.



Orbits

When it comes to orbits we need to know what they are and what a natural and an artificial satellite are.

An orbit: the curved path an object follows as it moves around a larger object due to gravity.

A natural satellite: a naturally occurring object that orbits a planet or other object in space.
The following are examples of natural satellites:

1. Any planet orbiting the sun.
2. The Moon orbiting Earth.
3. Any moon orbiting Mars etc.

An artificial satellite: any man made object in space that orbits either earth or another object.
The following are examples of artificial satellites:

1. **The international space station.**
2. **Starlink satellites.**
3. **Any man made satellite.**

Orbits and Velocity

The word technically is going to get a lot of use in this section 😊

We know that a satellite orbits an object… Satellites are usually moving at a constant speed. But all satellites, including the earth are technically accelerating around their object. How? If the they are moving at a constant speed?

Velocity is speed in a given direction 😊 As a satellite is constantly changing direction then it is technically constantly changing its velocity even though it's moving at a constant speed.

Acceleration is the change in velocity of the object divided by the time taken for the change. As the satellite is technically changing its velocity, the object is technically accelerating 😊

What happens if a satellite changes its speed? First, remember that an orbit ideally needs to be stable. As in the satellite keeps having the exact same orbit each time it orbits its object.

If a satellite speeds up or slows down that can change the forces that the satellite is experiencing, that could change the orbit. Let's look at what can happen when the satellite speeds up and slows down 😊. Let's use Earth as an example when we talk about this.

Speeds up – if a satellite speeds up, it could fly off into space unless the force of gravity pulling it in gets stronger.
To get a stronger gravitational pull, it must move to an orbit that is closer to the Earth meaning it has a smaller radius.

Slows down – if a satellite slows down, the gravity will pull it towards Earth! To stay in orbit with a weaker gravitational pull, it must move to an orbit that is further away from the Earth meaning a larger radius.

The Big Bang Theory

The Big Bang Theory: is one theory on the origin of the universe. It puts forward that the universe began from a single point and has been expanding and cooling ever since. This point is called the singularity. We don't know much about it as no one was around to study it.

What is the evidence for the Big Bang Theory?

1. Redshift of galaxies, this shows the expansion of the universe over time. Redshift is covered in the next section 😊
2. Cosmic Microwave Background Radiation.

What is cosmic microwave background radiation? CMBR is low energy radiation that fills the entire universe.

How was CMBR formed? The universe has been expanding since the moment of the big bang. CMBR started out as light when the universe was very hot and dense. Over time as the universe has expanded the wavelength of this light has increased. This changed the wave from light to infrared radiation and over more time from infrared to microwaves.

Note: when we say the universe is expanding we mean all of it is at all times. The distance between the atoms that make up everything is increasing right now. The change is insanely small but over time it all adds up.

Red Shift

Red shift: the increase in the wavelength of light that is given out by a source that is moving away from the observer.

Red shifted: the term given to light that has undergone red shift and whose wavelength has moved towards the red part of the light spectrum.

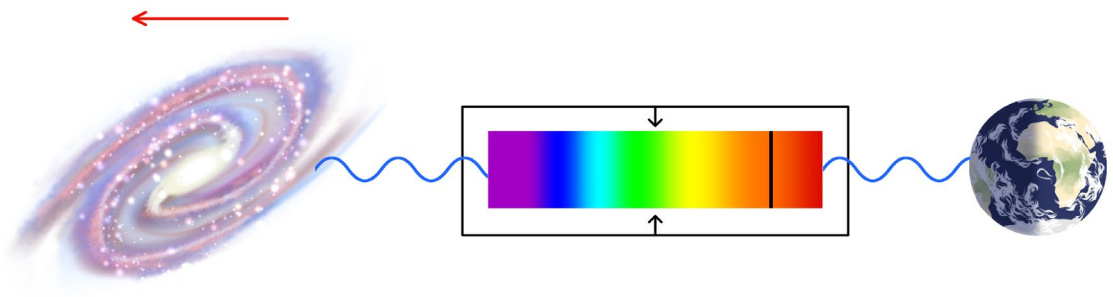
What does this mean? Let's use an example to explain this. An astrophysicist uses a telescope to observe light from a galaxy that is 100 million light years away from Earth. The light is analysed by a computer and tells the astrophysicist that the light from the galaxy is red shifted. Why is the light not just white light? Why is it red shifted?

The light that the astrophysicist was studying was sent out by the galaxy 100 million years ago. It took that long for the light to reach us here on earth. As the light travelled through the universe the universe itself expanded. This caused the wavelength of the light to increase moving it towards the red part of the light spectrum.

What does this tell the astrophysicist? This tells them that the galaxy they observed is moving away from earth.

Note: the more red shifted light appears when it is detected tells us that the source is moving away from us faster than something that is only a little red shifted. Red shift provides one avenue of evidence for the Big Bang Theory.

The figure below demonstrates red shift occurring.

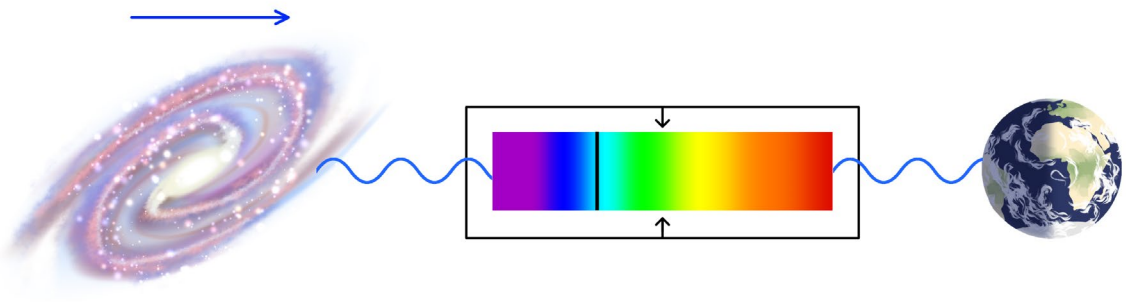


We can see in the figure above that the black absorption line indicates that the light has shifted towards the red part of the spectrum. It doesn't have to go fully red to be red shifted. Any move away from the centre towards the red part of the spectrum tells us the light is red shifted.

Blue Shift

Blue shift: the decrease in the wavelength of light that is given out by a source that is moving towards the observer.

Blue shifted: the term given to light that has undergone blue shift and whose wavelength has moved towards the blue part of the light spectrum.

Blue shift is the opposite of red shift 😊 If an object, let's use the example of a galaxy again, is blue shifted it means that galaxy is moving towards us. The Andromeda galaxy is moving towards our Milky Way galaxy and the two will eventually collide. This isn't calculated to happen for quite a sometime yet (4.5 billion years).

The figure below shows light that has been blue shifted from its source to the observer.