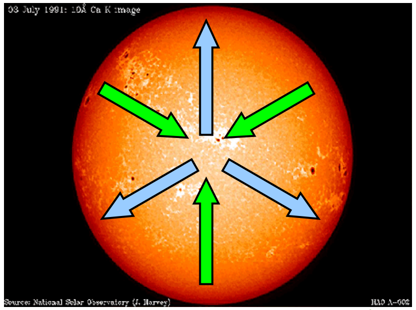
START

- The solar system was formed over very long periods from clouds of gases and dust in space, **about 5 thousand million years ago;**
- The distance to stars can be measured using the **relative brightness** of stars or **parallax.**
- All stars have a life cycle. fusion of hydrogen **nuclei is the source of the Sun's energy;**
- All chemical elements larger than helium were made in earlier stars;
- Therefore we were all created from stardust.

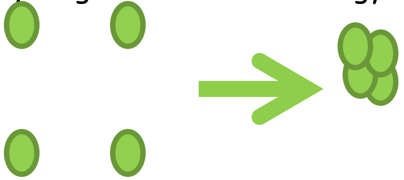
In a main sequence star the forces of attraction pulling the particles inwards (gravity) are BALANCED by forces acting outwards due to the huge temperatures inside the star.



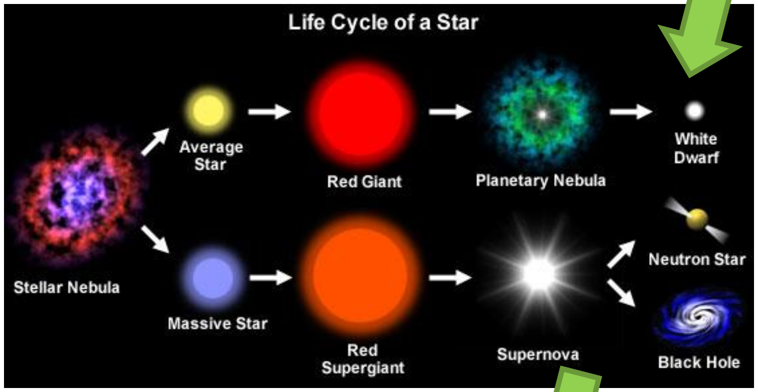
Stars are basically nuclear reactors that use hydrogen as a fuel. During its main sequence a star will release energy by converting hydrogen and helium (light elements) into heavier elements.

Key words:
Fusion: The joining of 2 nuclei, it releases a lot of energy.
Satellite: An object that orbits a planet.
Centripetal force: A force which acts on a body moving in a circular path and is directed towards the centre around which the body is moving.

Hydrogen → Helium + energy

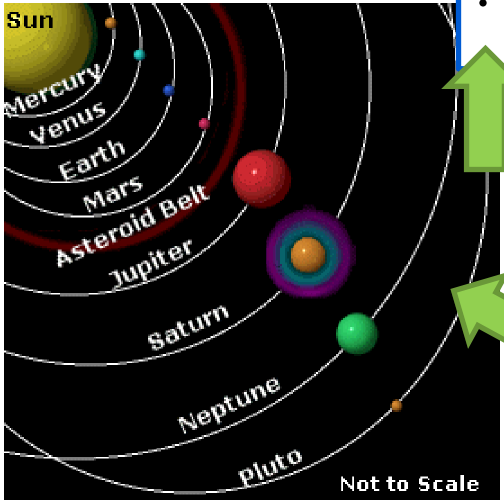


- In stars fusion continues to make bigger and bigger elements.
- When fusion stops big stars explode as supernovae
- Their debris, containing all 92 elements is scattered through space.
- When our solar system formed it gathered debris from dead stars.
- Except from hydrogen and helium, the chemical elements came from stars.



How did our solar system form?

- First there was lots of gas rocks and dust
- Due to gravitational forces causing dust particles to be pulled together
- This caused the particles to speed up, there were more collisions and temperatures increased
- Eventually the sun was formed at the centre of a spinning dust cloud thanks to gravity
- The suns heat evaporated ice and drove gas away from the inner solar system, leaving rocks behind
- The rocky planets formed near the sun and the gas giant planets formed further away from the sun
- The minor planet Pluto orbits the sun further beyond the giant planets
- They are all held in place orbiting the sun due to gravity

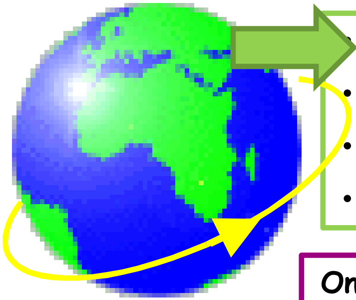


Life cycle of a little star

Part of the life cycle of a star	What happens? What is it?
1. Protostar	Dust clouds are pulled together by their own gravitational attraction so the particles speed up. The clouds merge together and become more and more concentrated to form a protostar. The particles collide more often creating more energy and the temperature increases.
2. Main sequence star	Fusion reactions of hydrogen take place to make helium and lots of energy is released as heat. The outward force of radiation from the fusion reaction and the inward force of gravity are balanced.
3. Red giant	The star now swells out, cool down and turns red. At this stage, helium and other light elements in the core fuse to form heavier elements.
4. White dwarf	There are no more light elements in the core, fusion stops, and no more radiation is released. Because of its own gravity the star collapses in on itself. As it collapses it heats up and turns from red to white. It becomes a hot, dense, white star much smaller in diameter than it was before .
5. Black dwarf	Once the white dwarf fades out it becomes cold

Life cycle of a big star

Part of the life cycle of a star	What happens? What is it?
1. Protostar	Dust clouds are pulled together by their own gravitational attraction so the particles speed up. The clouds merge together and become more and more concentrated to form a protostar. The particles collide more often creating more energy and the temperature increases.
2. Main sequence star	Fusion reactions of hydrogen take place to make helium and lots of energy is released as heat. The outward force of radiation from the fusion reaction and the inward force of gravity are balanced.
3. Red Super giant	Bigger stars swell out to become red super giants. They then collapse.
4, Supernova	As it collapses the matter around the star's core compresses. The compression suddenly reverses in a cataclysmic explosion called a supernova. This can outshine an entire galaxy for several weeks.
5. Neutron star	The core is compressed in to neutron star This is an extremely dense object that is only made up of neutrons
6. Black hole (if there is enough mass)	If the star is massive enough it becomes a black hole instead of a neutron star. The gravitational field of a black hole is so strong nothing can escape from it. Not even light or any other form of electromagnetic radiation



- GEOSTATIONARY SATELLITES :
- Stay above the same place on Earth.
- Speed of orbit matches the Earth's rotation.
- There is only room for 400!

One orbit takes 24 hours

Natural satellite such as the moon is something that orbits a planet

- Geostationary satellites remains in a fixed position above the earths surface and orbit the earth once every 24 hours around the equator. That is why when we turn our home satellite dish on to receive the TV signal from a particular geostationary satellite, we don't have to keep jumping up to adjust its position.
- ***A Geostationary satellite has a long orbit time because it is a large distance above the Earths surface…..36000Km.***
- All Geostationary satellites must be in the same orbital path. This causes a problem of overcrowding and the satellites cannot be to close together as their signals overlap due to diffraction

LOW POLAR ORBIT
Close to earths gravitational attraction = large centripetal accelerations. Speed is high!
Distance travelled in one orbit = 2 πr
The radius of the orbit is only slightly greater than the radius of the earth.

Time = $\frac{\text{distance}}{\text{speed}}$

This means the orbit time is small.

The opposite is true for geostationary satellites. Which are much higher above the earth

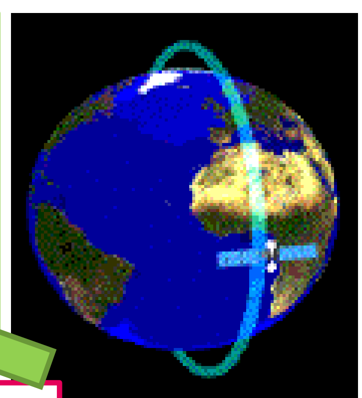
The further away a mass is then the smaller the gravitational force F will be. When a mass is twice as far away, F quarters. It obeys an inverse square law. When d is the distance away:-

F proportional $1/d^2$

Artificial satellites in low orbit travel faster because the gravitational force is stronger. This means they orbit the earth in a short period of time

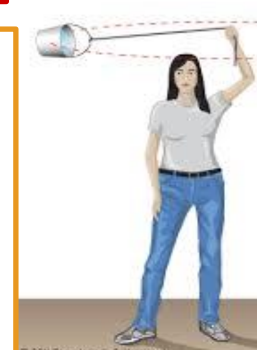
Uses of satellites:
Communications; TV; Mobile; GPS; Intelligence; Local weather forecasting

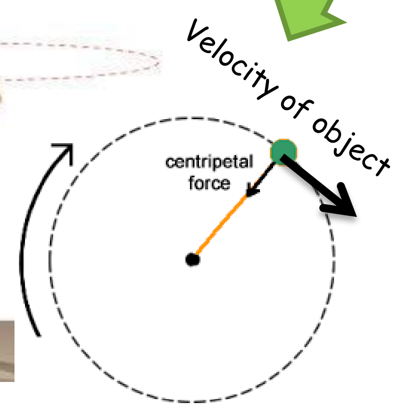
LOW POLAR ORBIT SATELLITES :
- Low orbit around the Earth passing over North and South poles.
- Earth rotates underneath them as they orbit.
- Closer to earth so gravity is stronger so it orbits much quicker



One orbit could take around 90 minutes

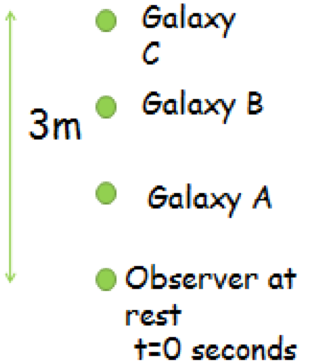
Centripetal force
The force of gravity pulls the object inwards while the direction of the velocity is perpendicular, this causes the object to move around it in a circular motion.

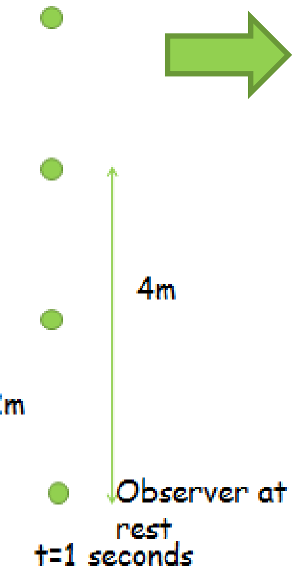




Expanding Universe

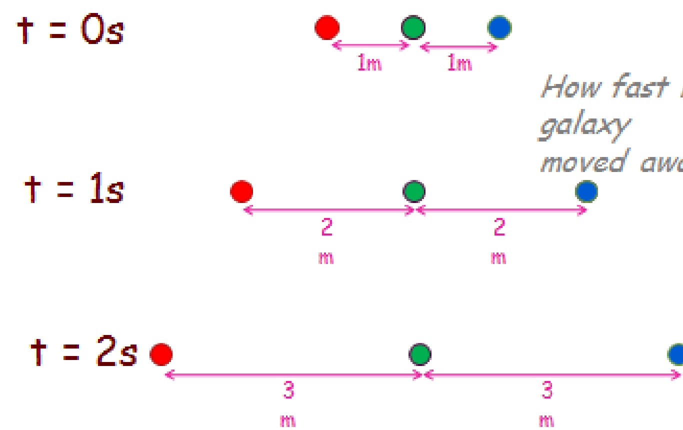
Galaxy A appears to be 1m away from Earth at t=0
After t=1 second the galaxy has expanded to twice its original size





Consider three dots in an expanding universe....

Now lets imagine that the earth is the blue dot, the green dot is a galaxy close to us and the red dot is a distant galaxy....



How fast has each galaxy moved away from us?

The galaxies which are further apart are moving away faster

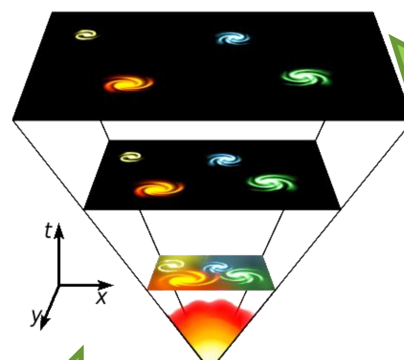
The whole of space is expanding, like the surface of the balloon.

Hubble's Law

The further away a galaxy is from us, the faster it moves away.

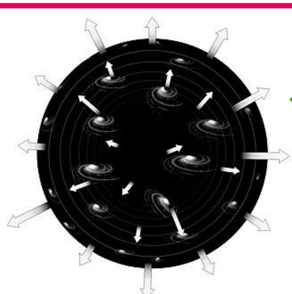
The motions of galaxies suggests that they are not just flying apart – **Space is expanding**

Bad Science Alert: The big bang caused an expansion of space, not an explosion!



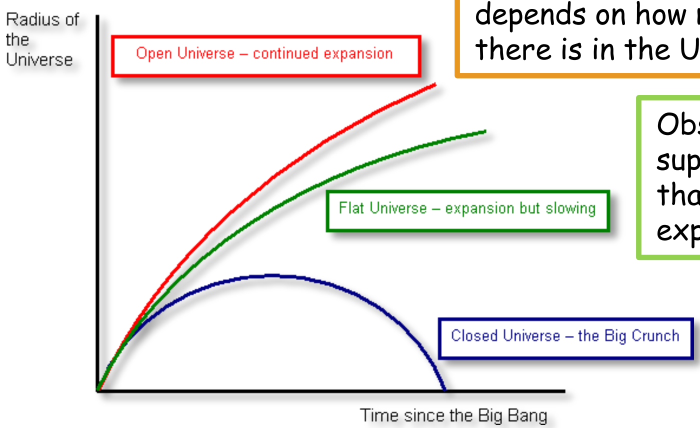
Scientists believe that the universe began with a 'big bang' about **14,000 million years ago**

Hot, tiny and dense big bang



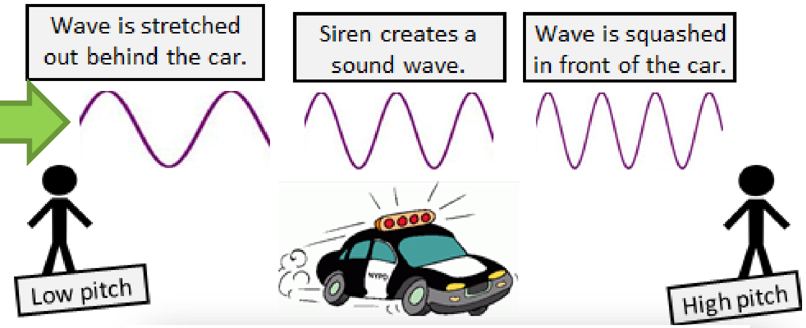
Galaxies are moving apart due to space itself expanding. They are not being blasted apart like particles in an explosion.

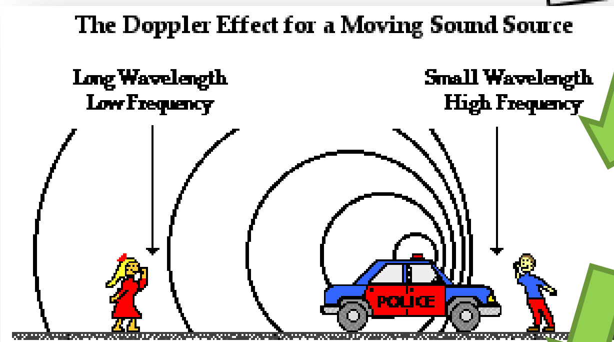
Fate of the Universe



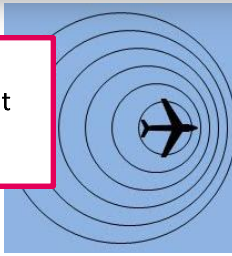
Which one of these is right depends on how much matter (mass) there is in the Universe

Observations of supernovae seem to show that the rate of expansion is increasing...

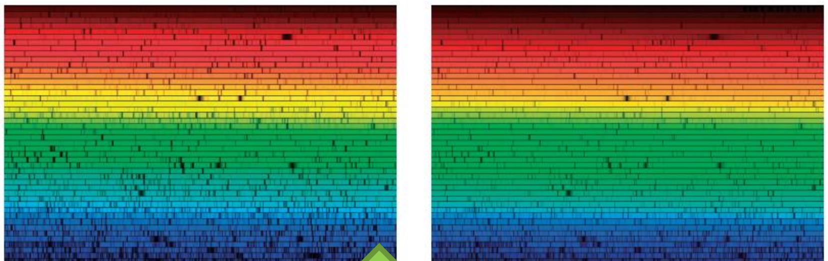




Wave is stretched out behind the plane.



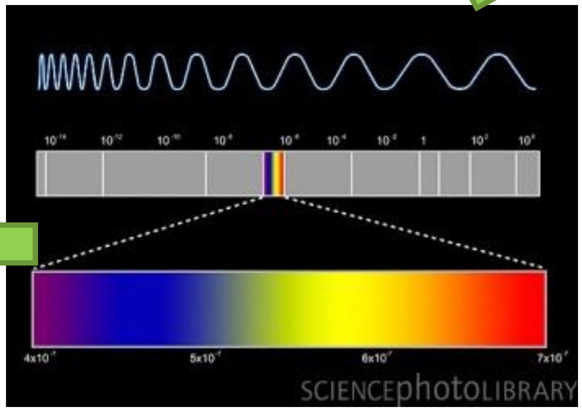
Wave is squashed in front of the plane.



All the distant galaxies show a red-shift. The further away a distant galaxy is from you, the greater the red-shift.

The spectra of the bright star Arcturus (left) and the Sun (right). The colours in its light show the sun is hotter.

The faster a distant galaxy is moving away from you the greater the red shift



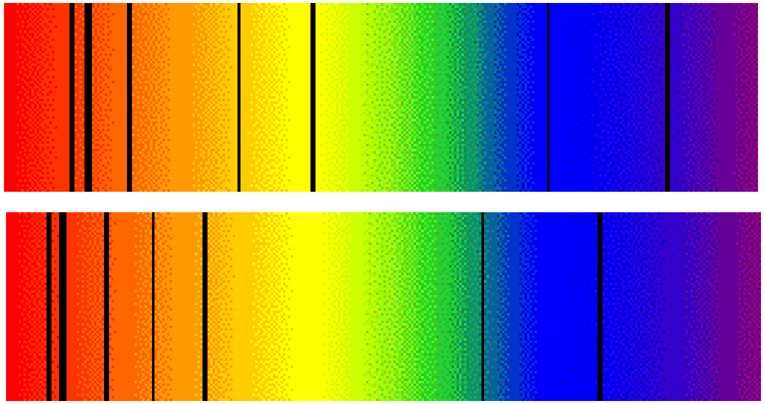
Short wavelength High frequency

Long wavelength (red colour) Low frequency

What is spectra?

- Different elements **absorb and emit** different frequencies of light.
- The absorption patterns are **unique to each element**
- These patterns are known as **spectra**
- The spectra of an element is like its fingerprint

Red shift is observed in the outer galaxies of the universe. This suggest a longer wave length of light and that the universe is moving further apart



Spectrum of the sun

Spectrum of a distant star

Evidence of the Big Bang

There are two key pieces of evidence for Big Bang theory.
These are **red shift** and the **Cosmic Microwave Background** radiation.

Red-shift

- When an object moves away from an observer, its light is affected by the Doppler effect.
- **Spectra from distant galaxies**
- Our Sun contains helium. We know this because there are black lines in the spectrum of the light from the Sun where helium has absorbed light. These lines form the absorption spectrum for helium.
- The positions of the lines have changed because of the Doppler effect. Their wavelengths have increased (and their frequencies have decreased).
- Astronomers have found that the further from us a star is, the more its light is red-shifted. This tells us that distant galaxies are moving away from us, and that the further away a galaxy is, the faster it's moving away.
- Since we cannot assume that we have a special place in the Universe, this is evidence for a generally expanding universe. It suggests that everything is moving away from everything else.

A summary of some of the evidence of the Big Bang and its interpretation

Evidence	Interpretation
The light from other galaxies is red-shifted.	The other galaxies are moving away from us.
The further away the galaxy, the more its light is red-shifted.	The most likely explanation is that the whole universe is expanding. This supports the theory that the start of the universe could have been from a single explosion.
Cosmic Microwave Background	The relatively uniform background radiation is the remains of energy created just after the Big Bang.

Cosmic Microwave Background radiation

- Scientists discovered that there are microwaves coming from every direction in space. Big Bang theory says this is energy created at the beginning of the universe, just after the Big Bang, and that has been travelling through space ever since.
- A satellite called COBE has mapped the background microwave radiation of the universe as we see it. Big Bang theorists are still working on the interpretation of this evidence.

1. Explain how a star is formed
2. Explain how planets are formed
3. Explain the different sequences in the life cycle of a little star
4. Explain the different sequences in the life cycle of a big star
5. Explain how elements are formed
6. Explain the process of fusion
7. Explain what centripetal force is
8. Explain what a satellite
9. Explain how the force on a satellite is effected by the distance away from the planet it is orbiting
10. Explain the difference between a geostationary and a low polar orbit satellite
11. Explain the Doppler effect
12. Explain the theory of the expanding universe
13. Explain red shift
14. Explain what cosmic microwave radiation shows
15. Explain the evidence that supports the big bang
16. Explain what spectra is

17. Complete the table

Expanding Universe

Galaxy	Distance from reference point at t=0 (m)	Distance from reference point at t=1 (m)	Distance moved (m)
A	1	2	1
B	2	4	2
C	3	6	3

Conclusion

Galaxy A appears to have moved ___m per second
Galaxy B appears to have moved ___m per second
Galaxy C appears to have moved ___m per second
The ________away galaxies are from us the ________ they are moving