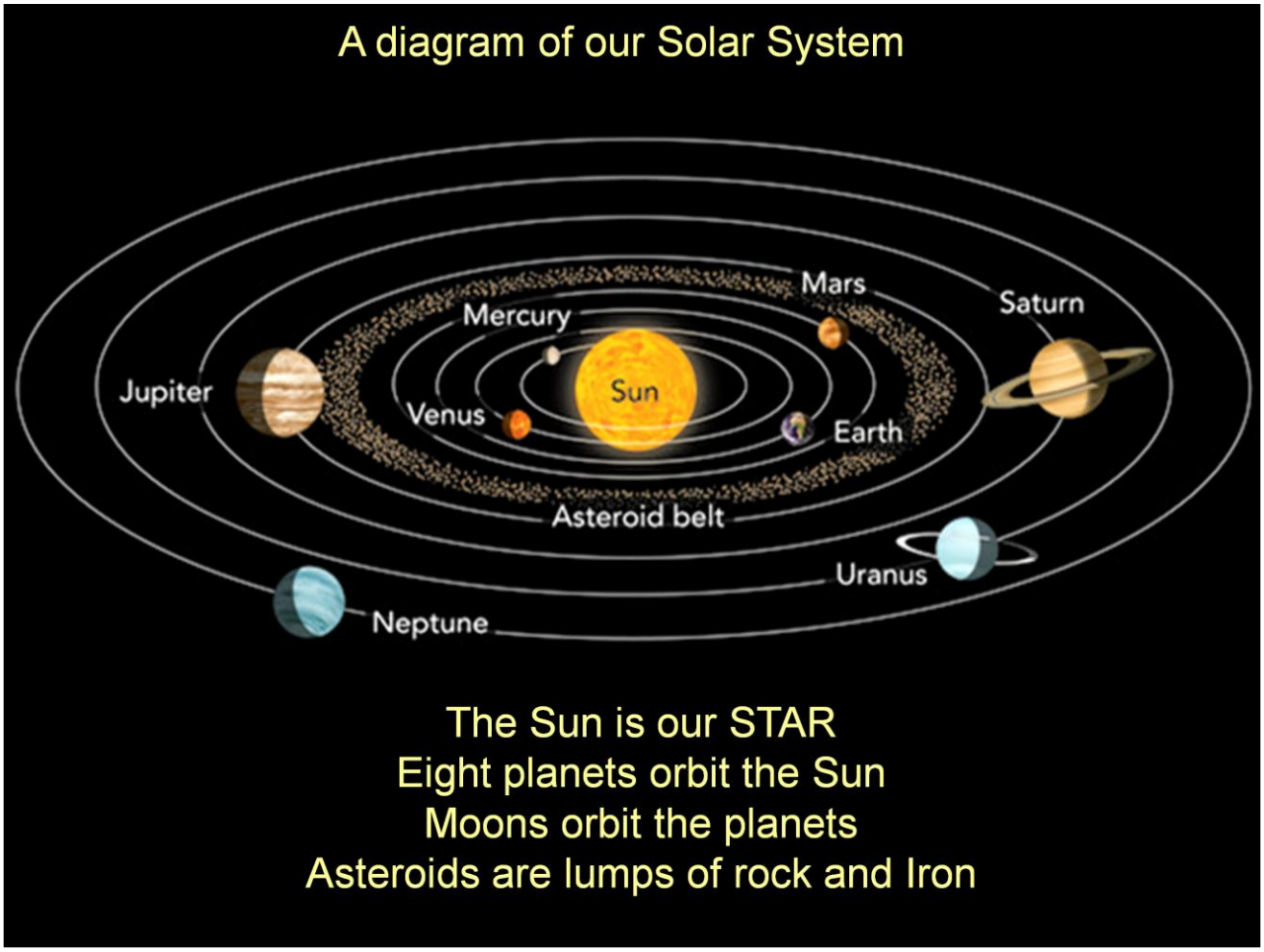
Observing our Solar System

Beginners 21st September 2022

Steve Harris



The chart above shows the Sun, main planets and minor planets that make up our Solar System.

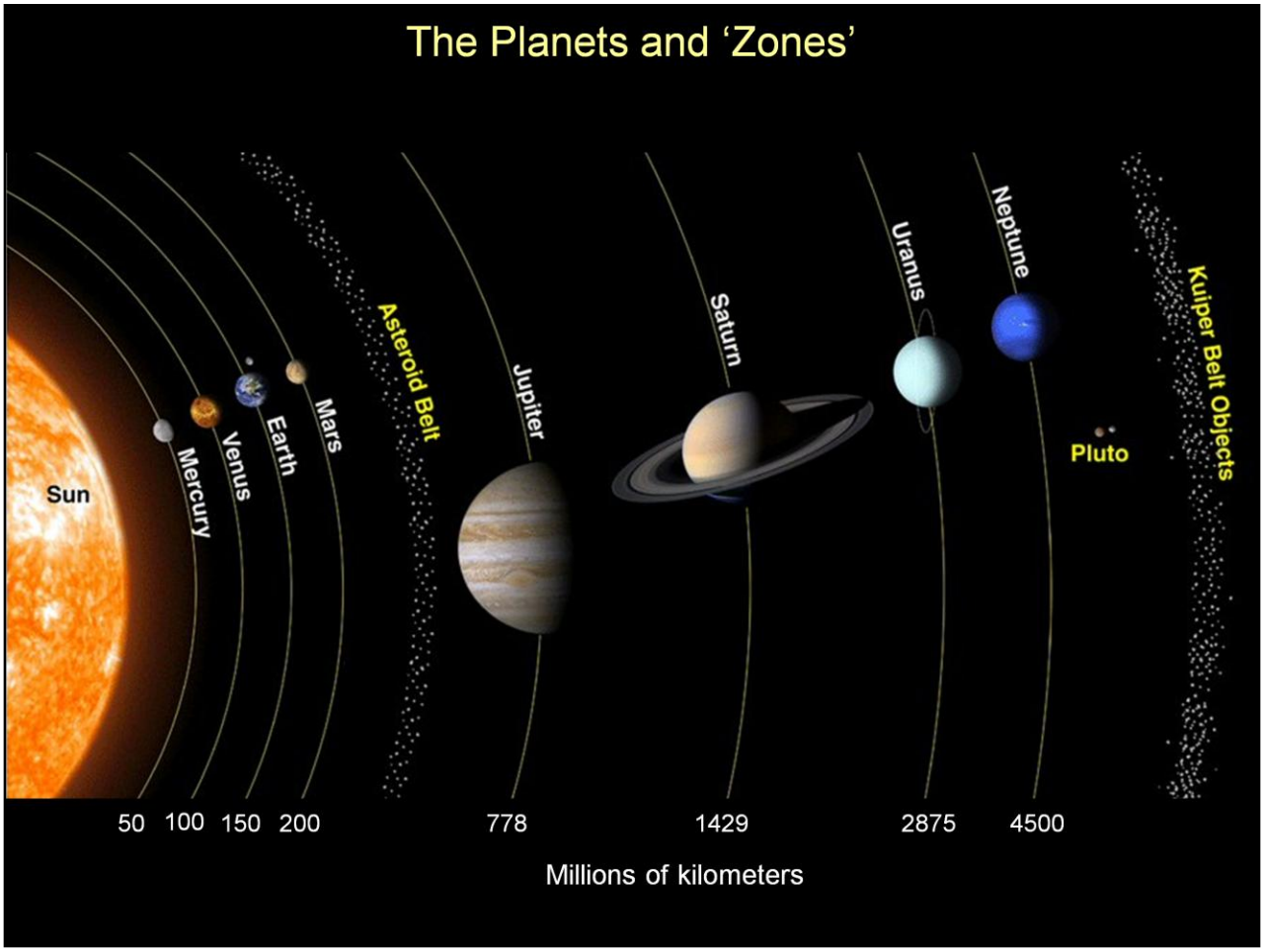
Let us first clarify the terms we use. Our Sun is a star and is in many ways a very ordinary star.

A star is a vast cloud of mainly Hydrogen with about 11% Helium.

This cloud has been compressed by gravity into its most compact shape which is a sphere. The enormous force of gravity produces Nuclear Fusion that powers the star and causes it to shine.

Planets are objects that orbit a star and have cleared paths from the original disc of material that formed around the developing star. Our Solar System has eight main planets that in order out from the Sun are called: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune. See the diagram above.

There are also small objects orbiting the Sun that we have called Dwarf Planets or Minor Planets.



Planets are objects that orbit a star and have cleared paths from the original disc of material that formed around the developing star.

Our Solar System has eight main planets that in order out from the Sun are called: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune.

There are also smaller objects orbiting the Sun that we have called Dwarf Planets or Minor Planets.

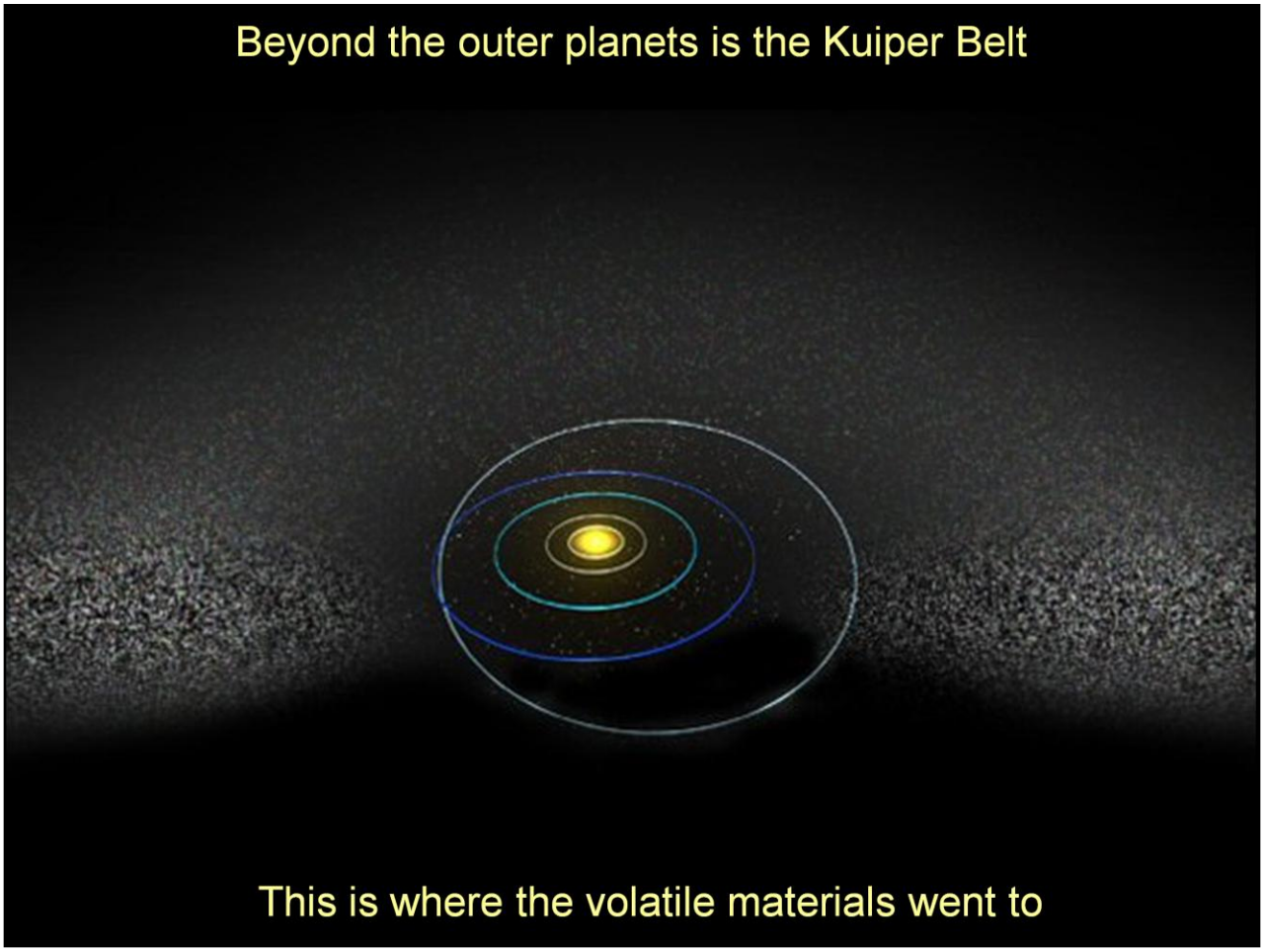
These objects mainly orbit in specific zones around the Sun.

ASTEROIDS are mostly found between the orbits of Mars and Jupiter in what is known as the Asteroid Belt.

But there are some special groups of asteroids that orbit outside the zone.

These sizes of these objects are from a few metres to a few hundred kilometres.

They are mainly comprised of rock and Iron.



DWARF PLANETS are found beyond the orbit of the outermost main planet Neptune. These are composed mainly of water ice and frozen gases that were driven off the inner planets.

When the Solar System first formed the Sun was more powerful than it is now and produced powerful ultraviolet radiation.

Any volatile materials on the inner planets were vaporised by the radiation and blown away into the outer reaches of the developing Solar System.

Here these volatile materials cooled and froze into ice and accumulated into objects up to a few thousands of kilometres in size.

The object called Pluto was reclassified from being considered a main planet to being a Dwarf Planet.

This Dwarf Planet Zone beyond the orbit of Neptune is called the Kuiper Belt and may contain millions of icy objects with many around the size of Pluto.

This is why the decision was made to reclassify Pluto.

So far there have been over 4000 objects, like Pluto and around the size that have been found, identified and named.

The object shown above was visited by the NASA probe New Horizons after its close fly-by of Pluto.

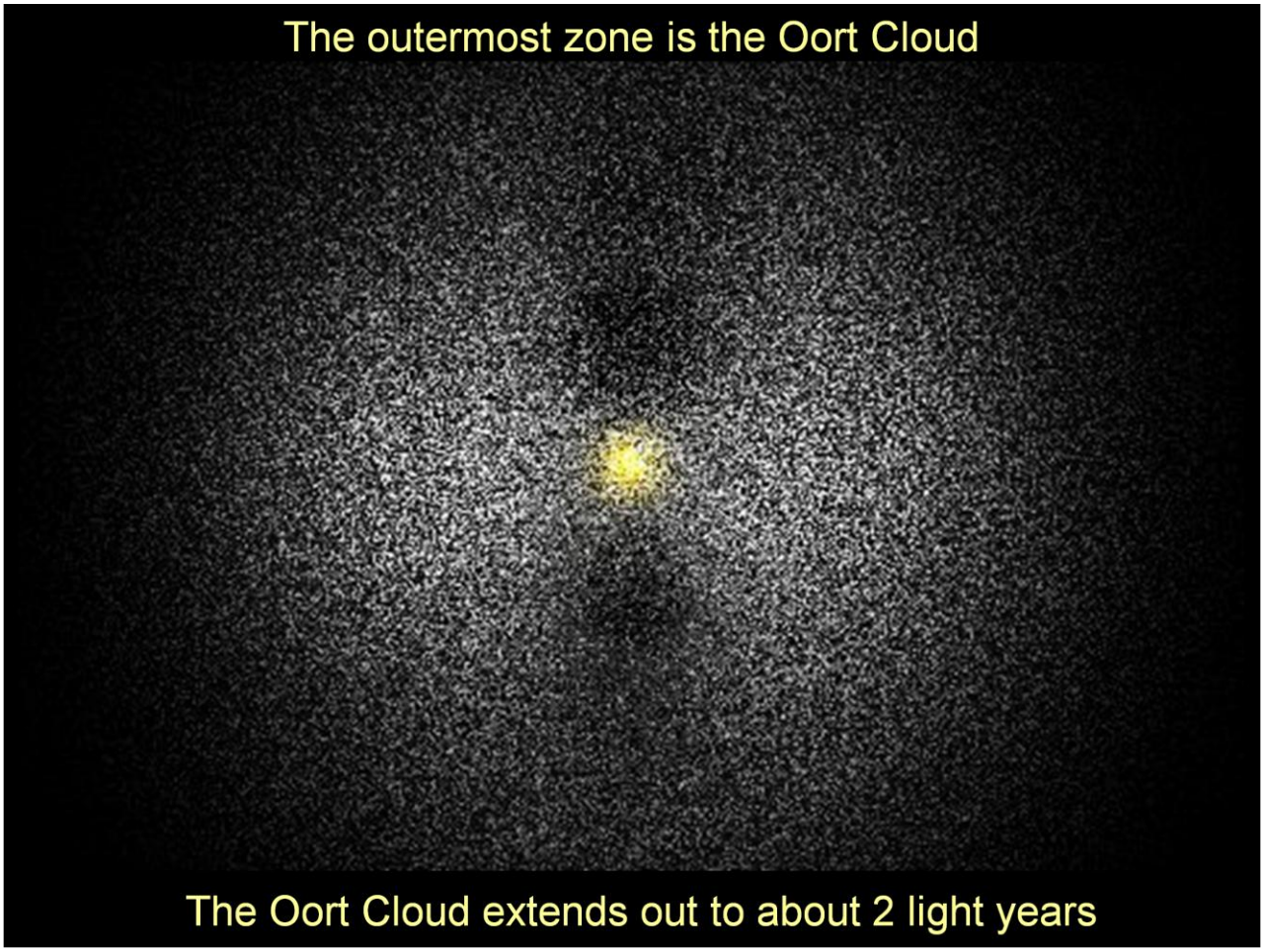
There are vast numbers of these Minor Planets orbiting the Sun beyond the orbit of the outermost main planet Neptune and Pluto is just the closest of these objects.

Ultima Thule (the furthest place) is thought to be two objects that are loosely pulled together by their very weak gravity.

‘Thule’ is the farthest north location mentioned in ancient Greek and Roman literature and cartography.

Modern interpretations have included Orkney, Shetland, the island of Saaremaa in Estonia and the Norwegian island of Smøla.

In classical and medieval literature, Ultima Thule acquired a metaphorical meaning of any distant place located beyond the "borders of the known world".



There is also thought to be a halo of icy objects beyond the Kuiper Belt and surrounding the Sun this is called the Oort Cloud but these objects are too far away to detect.

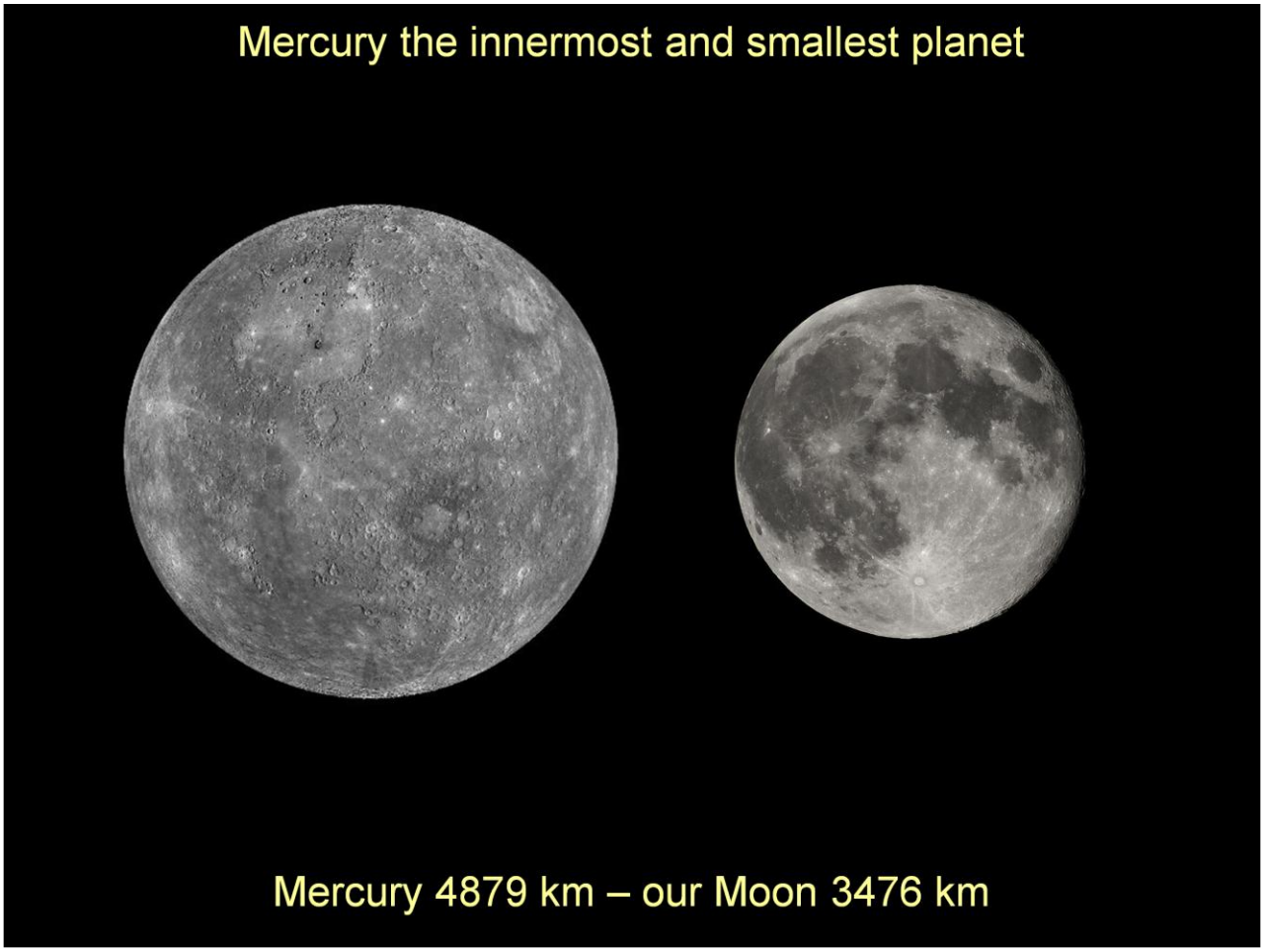
These mainly icy bodies surround the Sun in all directions and may extend out 1.5 billion (or more) from the Sun.

This is about half the distance to our nearest neighbour star called Alpha Centauri C or Proxima.

These objects are thought to be where some Comets originate.

If the orbits of these distant objects are disturbed by the other bodies or even a star passing our solar system they may be redirected in towards the Sun or out of the Solar System.

Those redirected into a spiralling path towards the Sun can become comets as their ice begins to be melted by the warmth of the Sun.



We have looked at our Solar System as our star, the Sun, being the dominating central object of the system

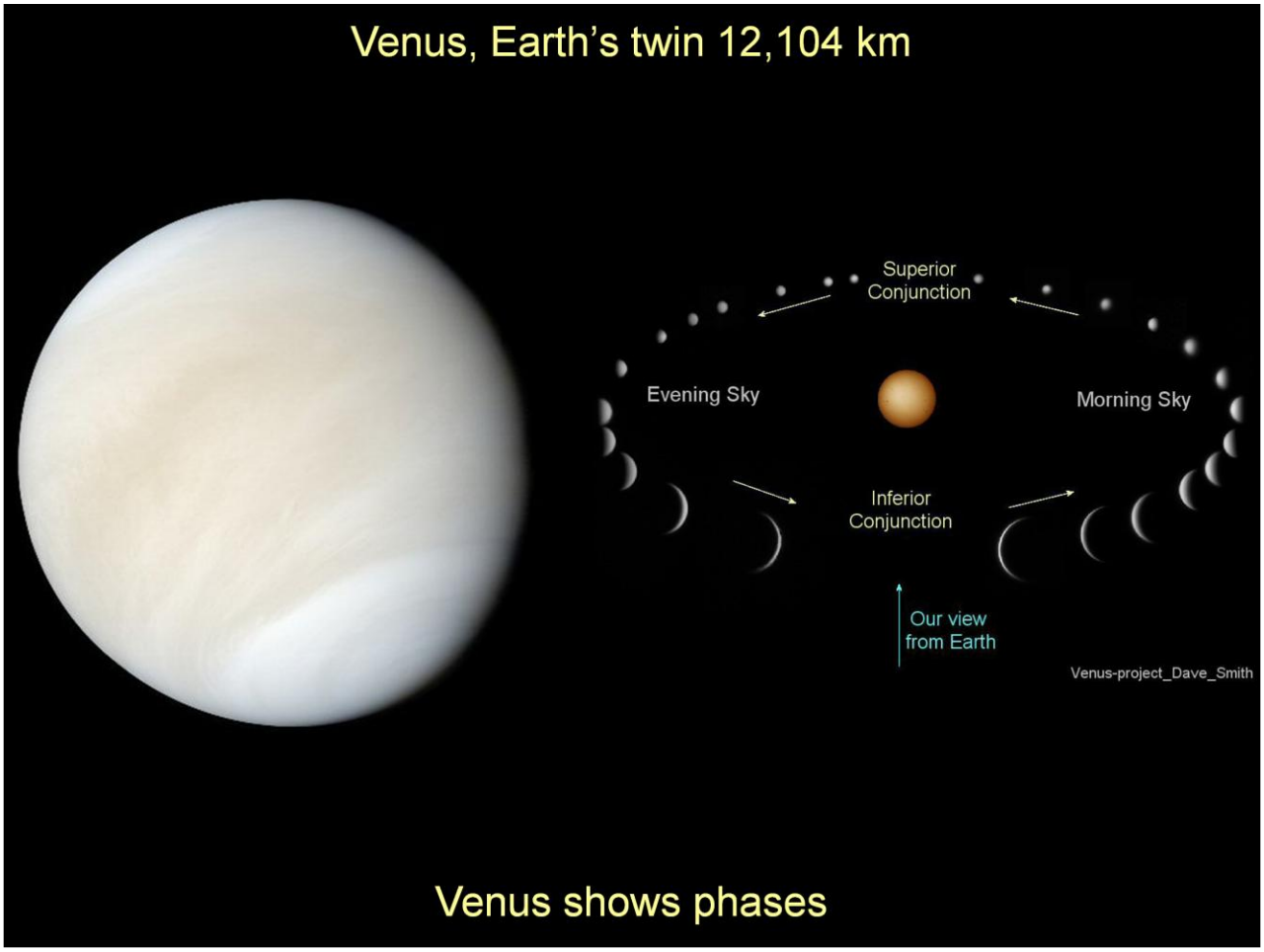
The Planets, Dwarf Planets, Asteroids and Comets having primary orbits around the Sun.

Now we can consider those objects that have secondary orbits within the Solar System.

We call these Moons that orbit around planets that in turn orbit the Sun.

The two inner planets do not have moons these are MERCURY and VENUS and they are closest to the Sun.

Mercury is the smallest of all the planets and is not a lot bigger than our Moon.



Venus is the second planet out from the Sun and is almost the same size as Earth and it does not have any moons.

Venus is 12,104 kilometres in diameter compared to the 12,756 kilometres of Earth.

Venus is completely covered in thick white clouds and appears featureless when viewed using a telescope.

However as it is an 'inferior' planet (orbiting inside Earth's orbit) we can see it has phases like our Moon.

As Venus orbits the Sun we see the planet illuminated from different directions as it passes in front and behind the Sun.

It also appears to change size as it moves closer and further away from us, as shown in the diagram on the right.

Our planet Earth has just one Moon but it is the biggest moon compared the size of its parent planet of all the planets and is sometimes said to be almost a double planet system.

It is almost certain that the early Earth was hit by another planet that we call Thea.

Thea was about the same size as Mars and is thought to have hit Earth off centre, crashed right through Earth knocking off a huge mass of rock and some of the Iron core.

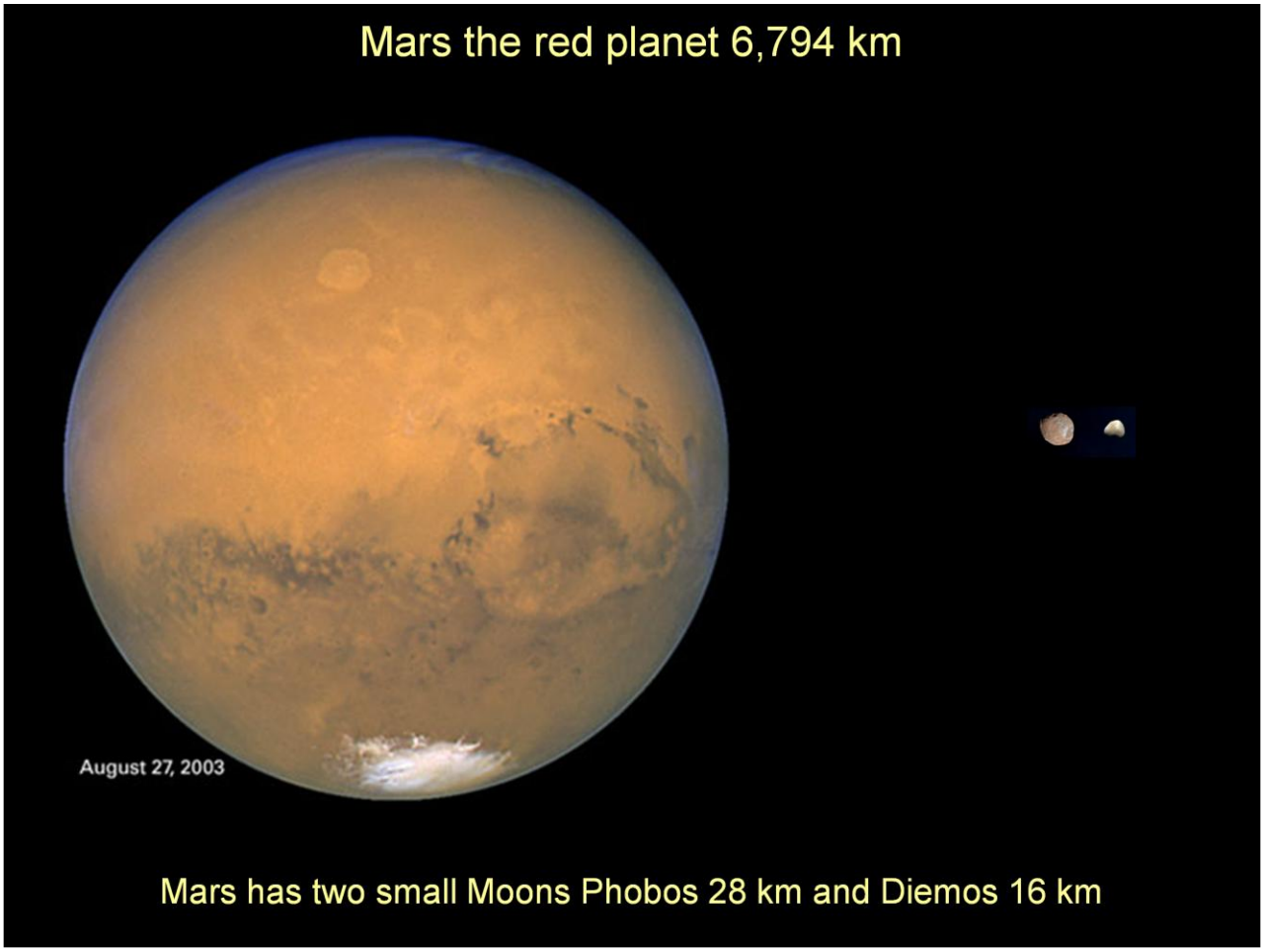
The debris was thrown into orbit around the molten remains of Earth.

The heavy Iron including the core of Thea soon crashed back on to the remains of Earth causing another massive impact.

Much of the remaining mass comprised of lighter rock remained in orbit and formed into our Moon.

The impact of Thea knocked Earth off its axis and caused the 23.4º tilt of Earth's axis that we see today.

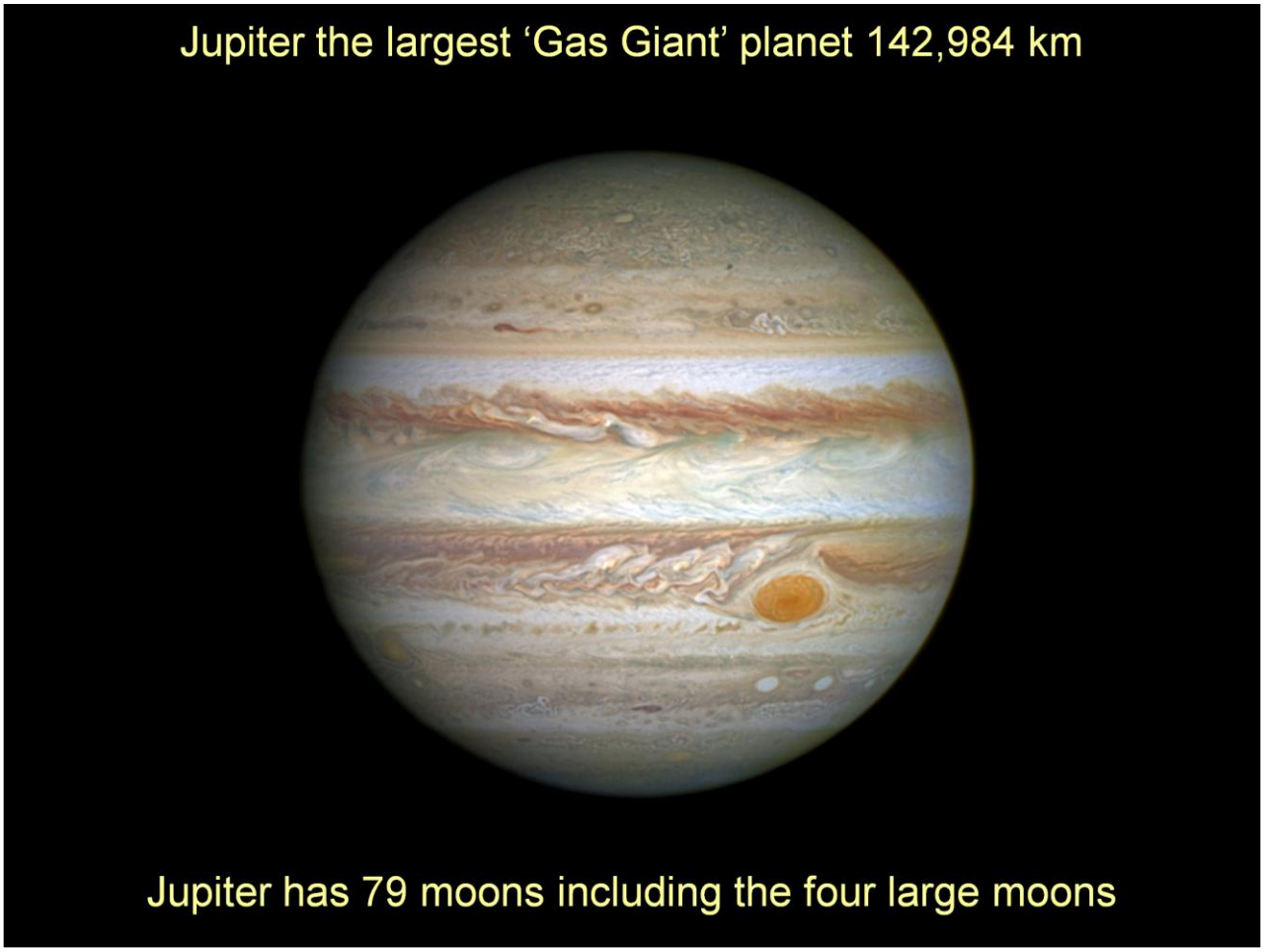
Thea was completely destroyed and became part of Earth as our planet cooled and became the planet we live on today.



MARS has two moons but they are very small and are thought to be asteroids that have been captured by the gravity of Mars and are now in orbit around the planet. Phobos is 22.2 km wide and Deimos is 12.6 km wide. The moons have been enlarged in the picture above, they are really much smaller when compared to Mars. The two small moons look just like lumps of rock.

Mars is the 4th Planet out from the Sun, the next out from Earth and the second smallest planet in our Solar System after Mercury. It is approximately half the diameter of Earth at 6780 km (Earth 12,600 km). Earth orbits the Sun at an average distance of 146.6 million km and Mars orbits at an average distance of 229.9 million km. Due to the eccentricity of their orbits the distance between Earth and Mars can vary, at their closest approach (Opposition), from about 55 million km to about 100 million km.

A telescope is required to see Mars as a disc. A small telescope even with an aperture of just 75mm will do because Mars is so bright. It will however require a magnification of at least 100 times. This means a telescope with a focal length of 1000mm will require a 10mm eyepiece to be used (1000 ÷ 10 = 100x).



JUPITER is the largest planet and is a Gas Giant. It has about 79 moons but only four are large and about the same size as our Moon. They are called Io, Europa, Ganymede and Callisto.

These four largest moons are known as the Galilean moons and were discovered in 1610 by Galileo Galilei.

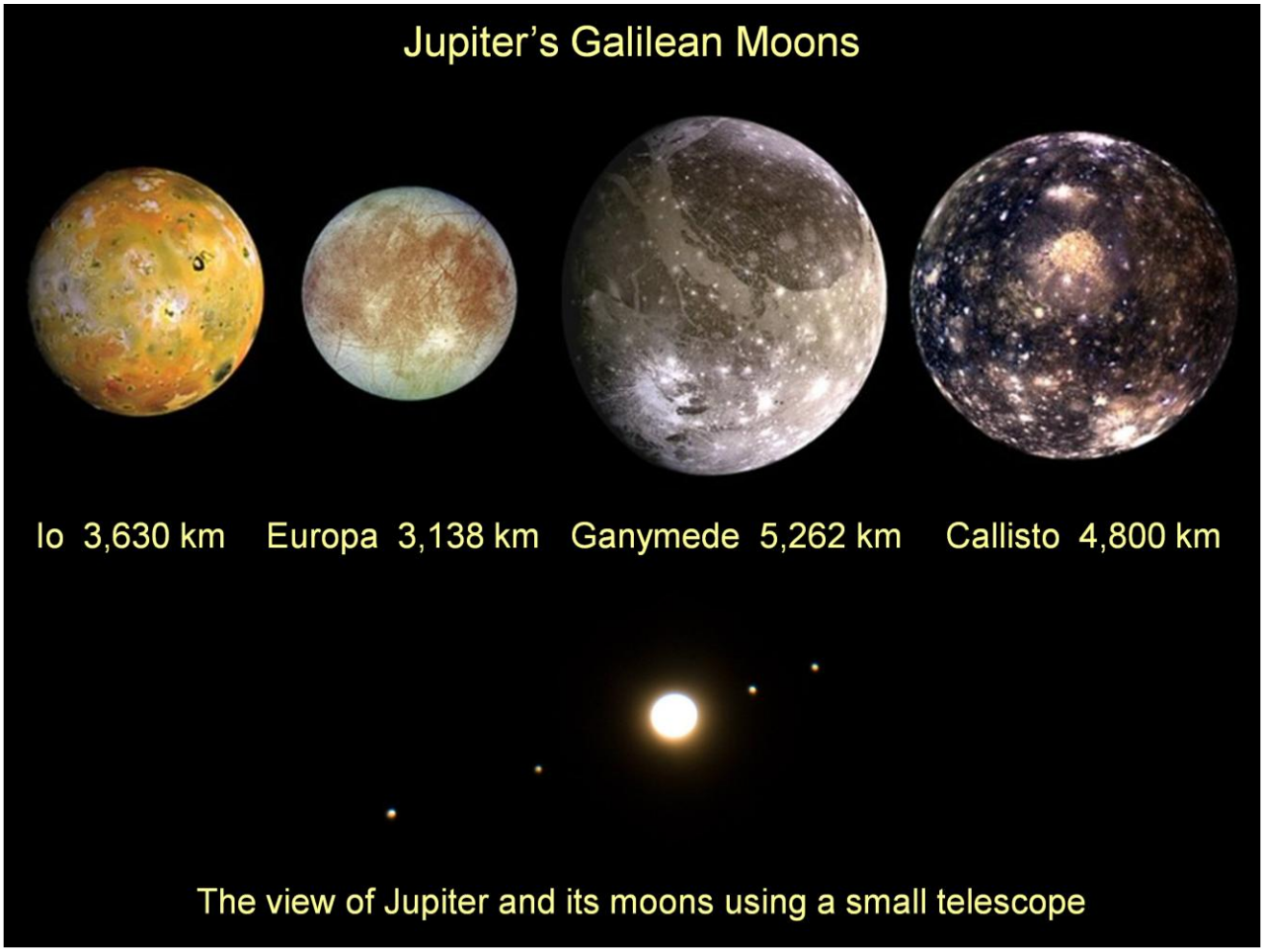
Jupiter’s Galilean moons are very different to each other in size and appearance.

Io is the inner moon and is covered in active volcanoes.

Europa is the smallest and mainly water ice.

Ganymede is the largest moon in oure Solar System.

Callisto has the oldest surface in the Solar System.



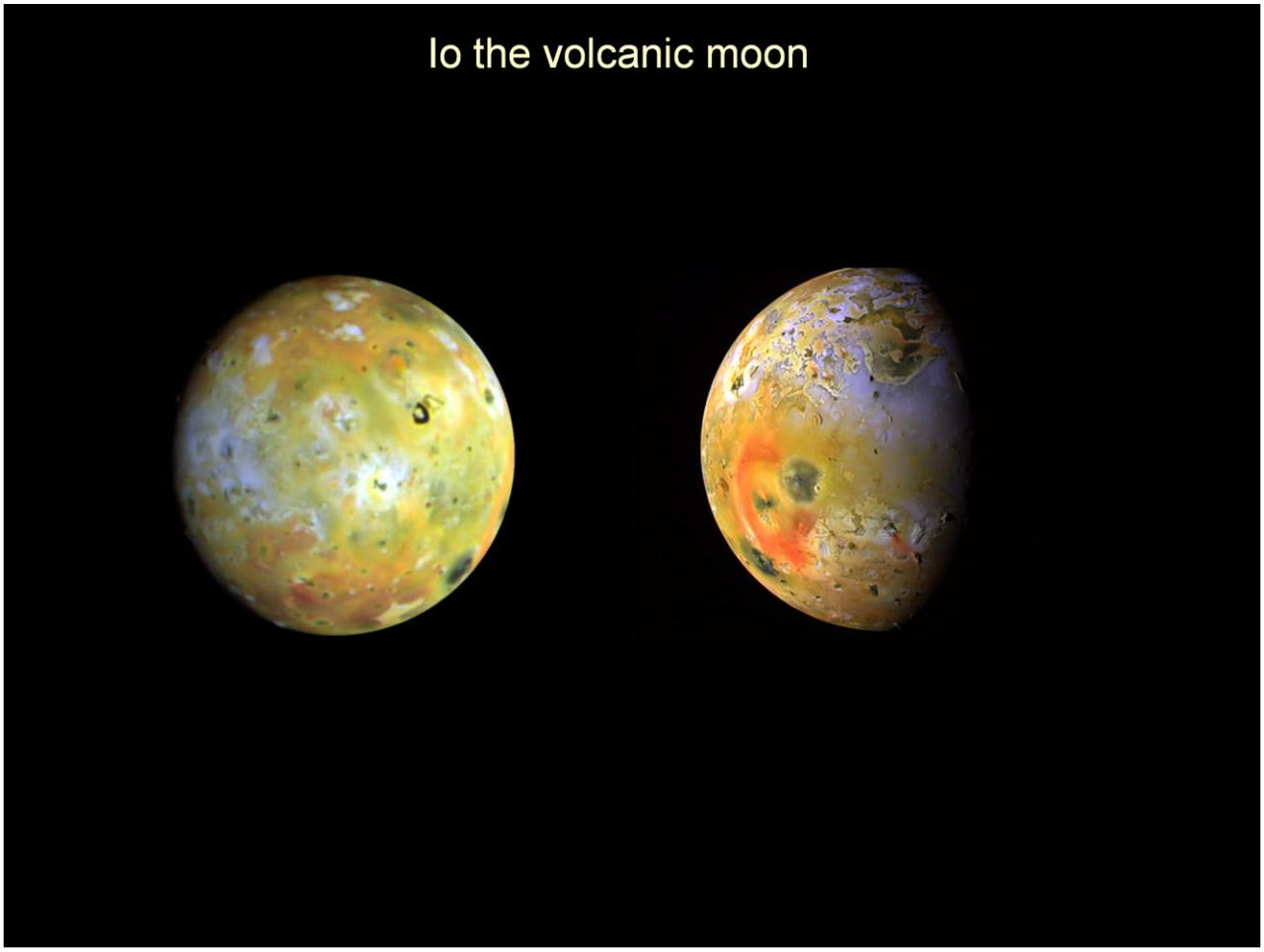
Io is the innermost and smallest of the four Galilean moons in an orbit that takes just 1,77 (Earth) days to complete and because it is just 421,600 km from Jupiter it is possibly the weirdest of them all. During the first 'fly-by' space mission strange plumes were seen on the edge of Io. The plumes were found to be active volcanoes, this was a great surprise. Later probes showed that the volcano eruptions were of liquid rock like the volcanoes on Earth.

Europa is the second moon out from Jupiter and the smallest of the four Galilean moons its orbit takes 3.55 (Earth) days. It is also quite close to Jupiter with an orbit 670,900km from the centre of Jupiter.

Europa is also affected by Jupiter's enormous gravity but its effect is manifested in a very different way

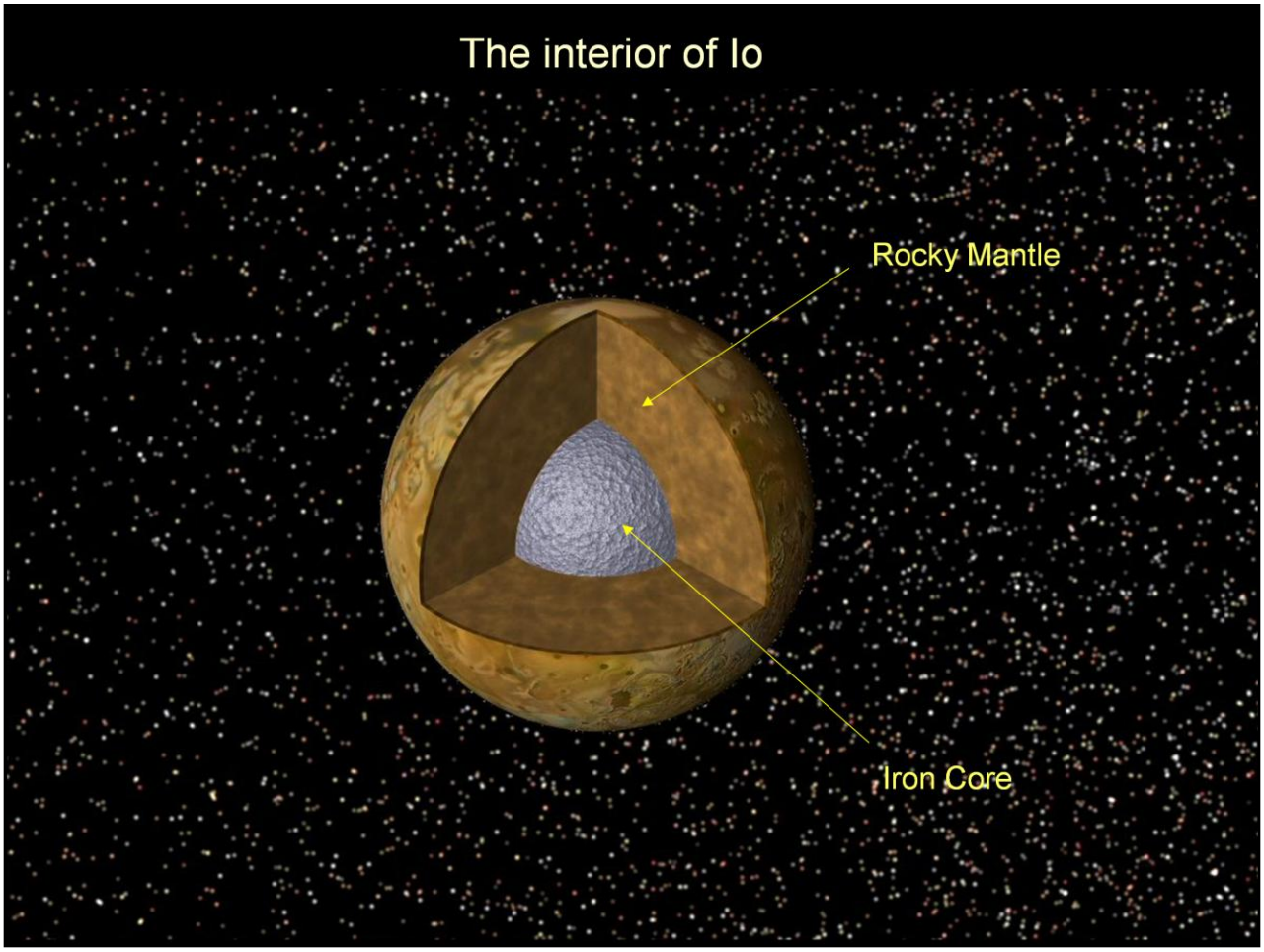
Ganymede is the largest moon in the solar system (5,263km in diameter). It orbits Jupiter in about 7.16 (Earth) days at just over 1 million km from Jupiter.

Callisto, unlike the other three Galilean moons, appears not to have had any noticeable internal activity or source of heat. Consequently the surface is old and has one of the most heavily cratered surfaces in the Solar System. It is a large moon with a diameter of 4,800km orbiting Jupiter at 1.8 million km and takes just 16.69 (Earth) days to complete each orbit.

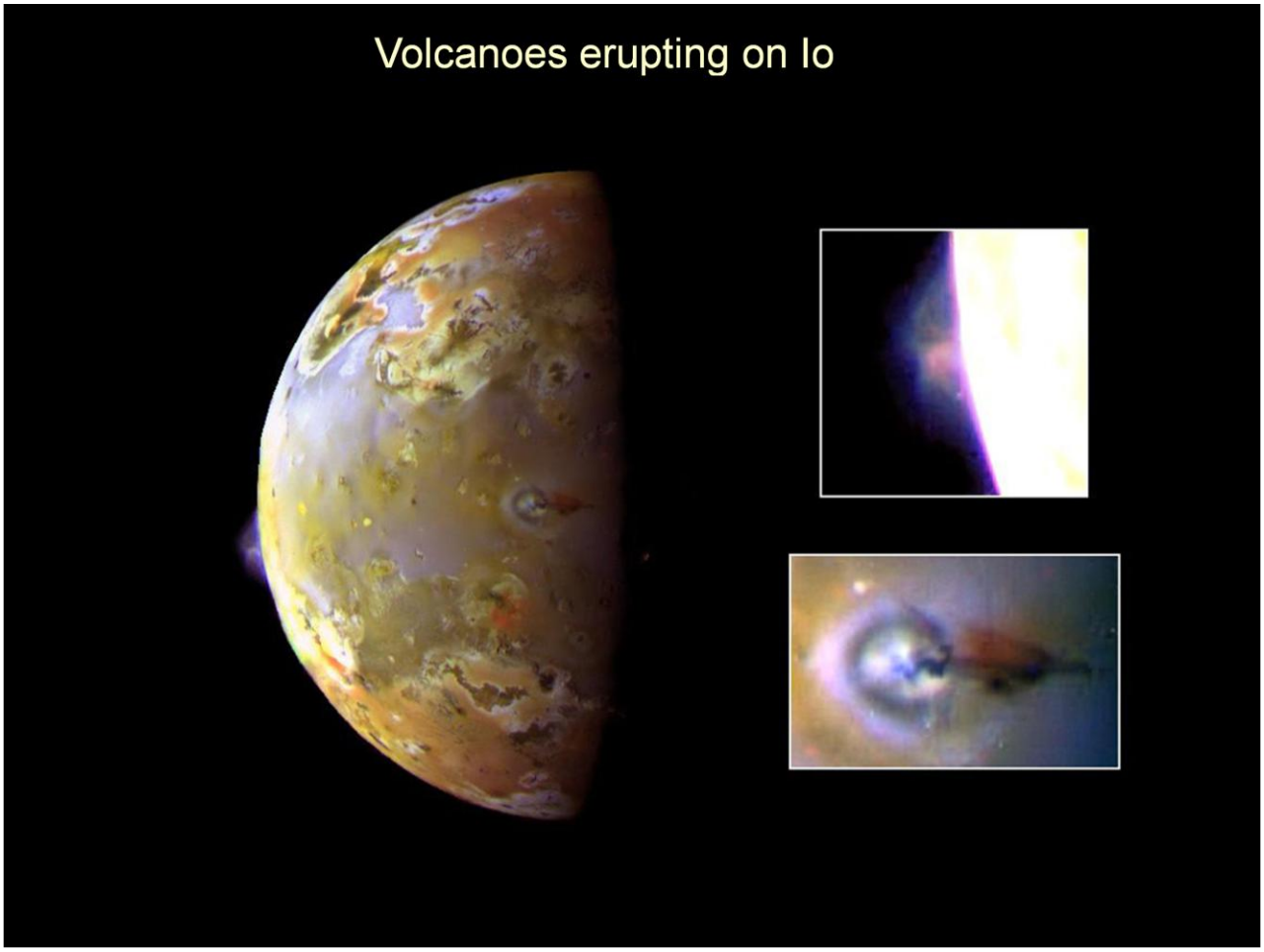


Io is the innermost and smallest of the four Galilean moons in an orbit that takes just 1,77 (Earth) days.

This is because it is just 421,600 km from Jupiter it is possibly the weirdest of all Jupiter's moons.



Io has no water to speak of, unlike the other, colder Galilean moons. Data from the Galileo spacecraft indicates that an iron core may form Io's centre, thus giving Io its own magnetic field.

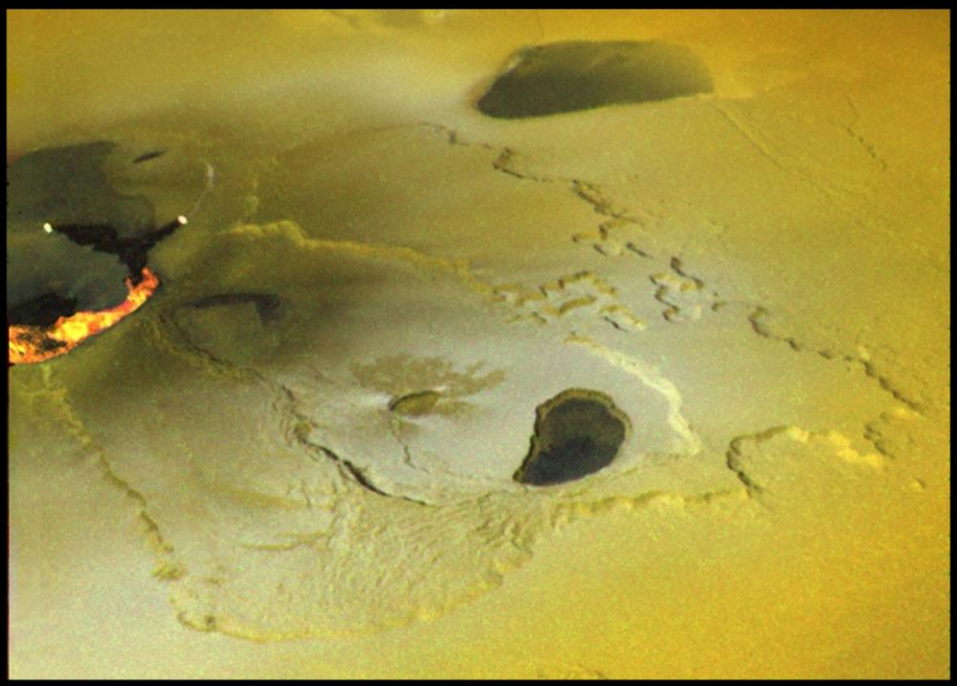


During the first ‘fly-by’ space mission strange plumes were seen on the edge of Io.

The plumes were found to be active volcanoes, this was a great surprise.

Later probes showed that the volcano eruptions were of liquid rock like the volcanoes on Earth.

Lava flow on Io



This tidal pumping generates a tremendous amount of heat within Io.

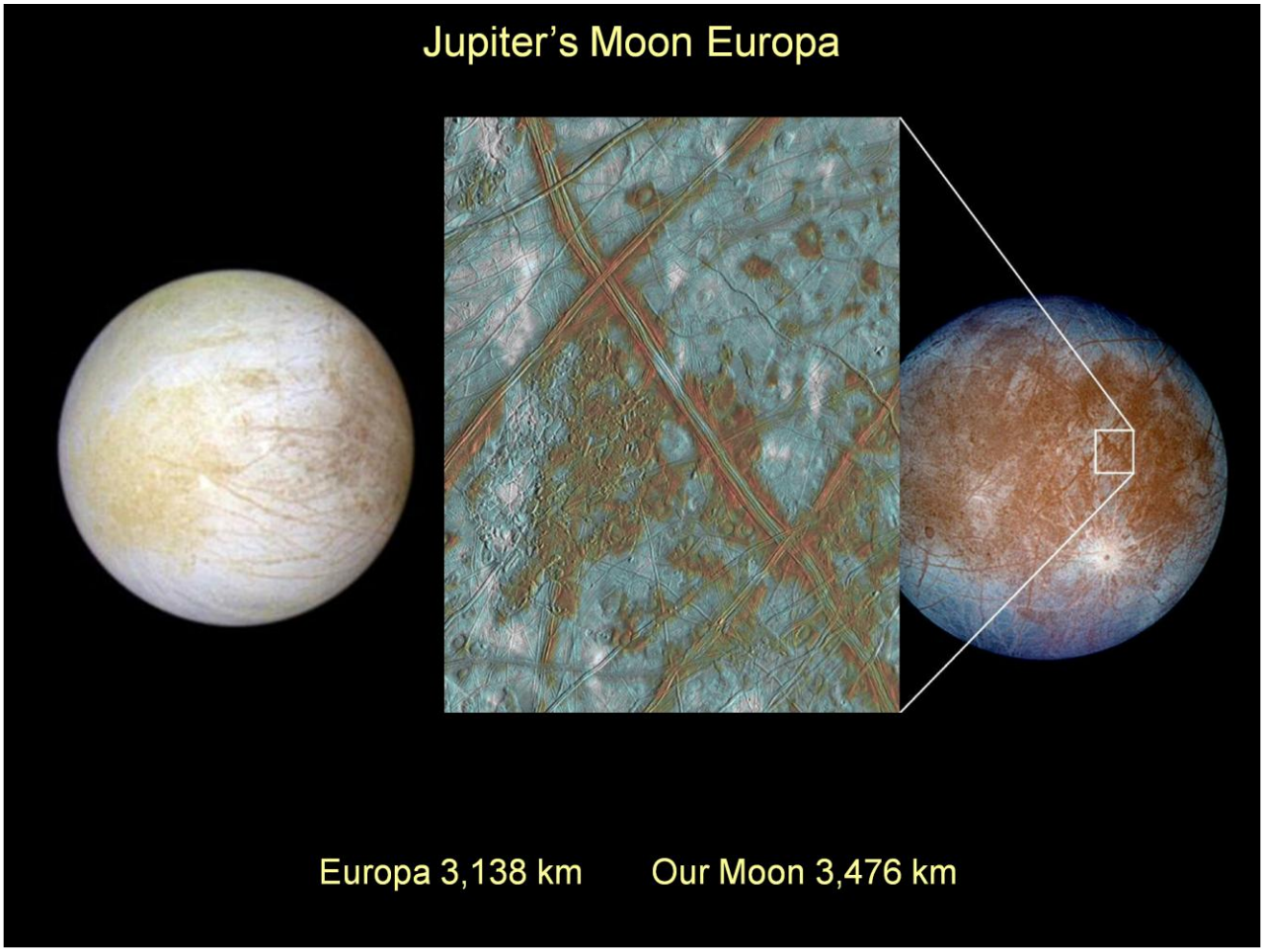
Much of its subsurface crust is in liquid form seeking any available escape route to the surface to relieve the pressure.

The surface of Io is constantly renewing itself, filling in any impact craters with molten lava lakes and spreading smooth new floodplains of liquid rock.

The composition of this material is not yet entirely clear, but theories suggest that it is largely molten sulphur.

Mixing with other elements compounds produces the variegated colouring of the surface.

Sulphur dioxide is the primary constituent of a very thin atmosphere on Io.



Europa is also affected by Jupiter's enormous gravity but its effect is manifested in a very different way.

This small moon is primarily composed of water ice and Carbon Di-oxide ice.

The very strong gravitational force from Jupiter produces powerful tidal forces and heat in a similar way to those on Io.

Heat produced from the friction causes the ice to melt and it seems to have produced a liquid ocean.

The ocean is thought to be salty water, similar to the seas on Earth, beneath a ~50km thick crust of ice.

The frozen surface is thought to crack because of the stresses caused by Jupiter's strong gravity.

Water then appears to gush from these cracks and leave a reddish brown stain as the water re-freezes around the cracks.

Jupiter's Moon Europa

Geysers may have been detected on Europa

The icy surface also makes Europa one of the most reflective objects in the solar system.

Researchers using the Hubble Space Telescope spotted a possible water plume jetting from Europa's South Polar Region in 2012.

The plumes have not yet been fully confirmed but they do provide a suggestion that there is water in Europa's ocean jetting to the surface.

This has given the scientists a possible way to test the ocean water for possible signs of life.

NASA is excited about its Juno spacecraft as it is set to fly by Europa, Jupiter's moon, on 29th September.

This will be the closest views of the icy world in over 22 years.

Juno will get as close as about 350 kilometres above Europa's surface.

NASA's Galileo probe also skimmed over the Moon from 351 kilometres back in January 2000.

However it was not programmed to look for these plumes on that approach.

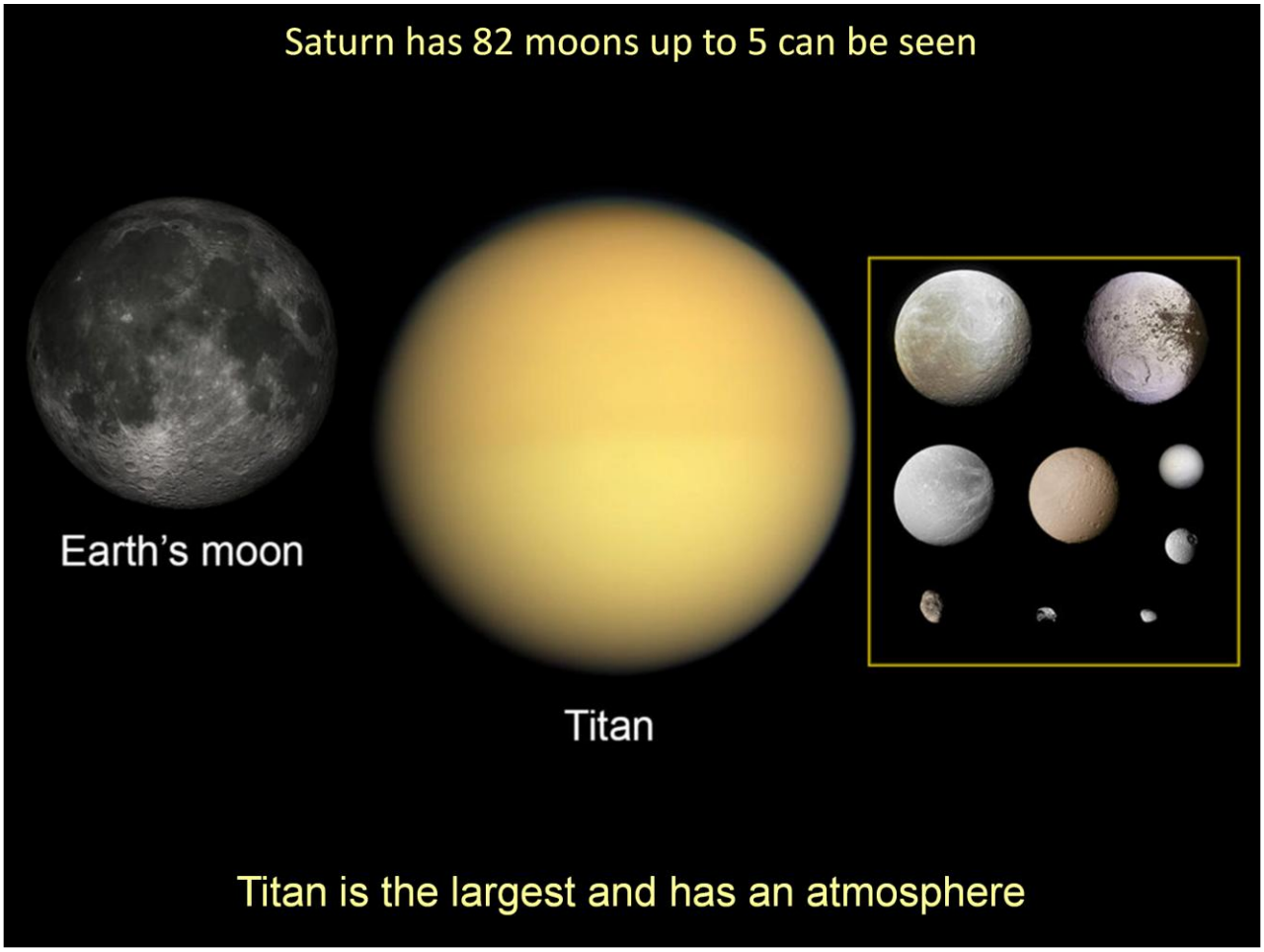
It may be possible to fly a probe through a plume to take a sample of the water and analyse it and send back its findings.

Unfortunately Juno will not be able to search for signs of life in any samples that it collects but it can have a good look.

Saturn, with its magnificent ring system, is surely the easiest planet to recognise. Any poster or cartoon depicting a space scene will almost certainly have a planet with a ring system looking somewhat like Saturn. All the large outer planets also have ring systems but those are all feeble compared to Saturn's.

Saturn is the second largest planet in our Solar System after Jupiter. The planet itself is 120,000 km in diameter at the equator but is flattened to 108,000 km at the poles due to its rapid rotation. Although Saturn is 10 times the diameter of Earth it rotates on its axis (1 day) in only 10 hours 14 minutes. The rings are 275,000 km (170,000 miles) across but may be less than a hundred metres thick. To put this in perspective, the ring diameter is almost the same as the distance from Earth to the Moon.

A 100mm telescope will show the ring system but a larger telescope is required to see the detail. On a really good clear night it is possible to see the Cassini Division in the ring. This is shown as the dark division in the rings in the image above. A smaller telescope will probably be able to show the division to the right and left of the planet but the portion to the front of the planet may be difficult to see.

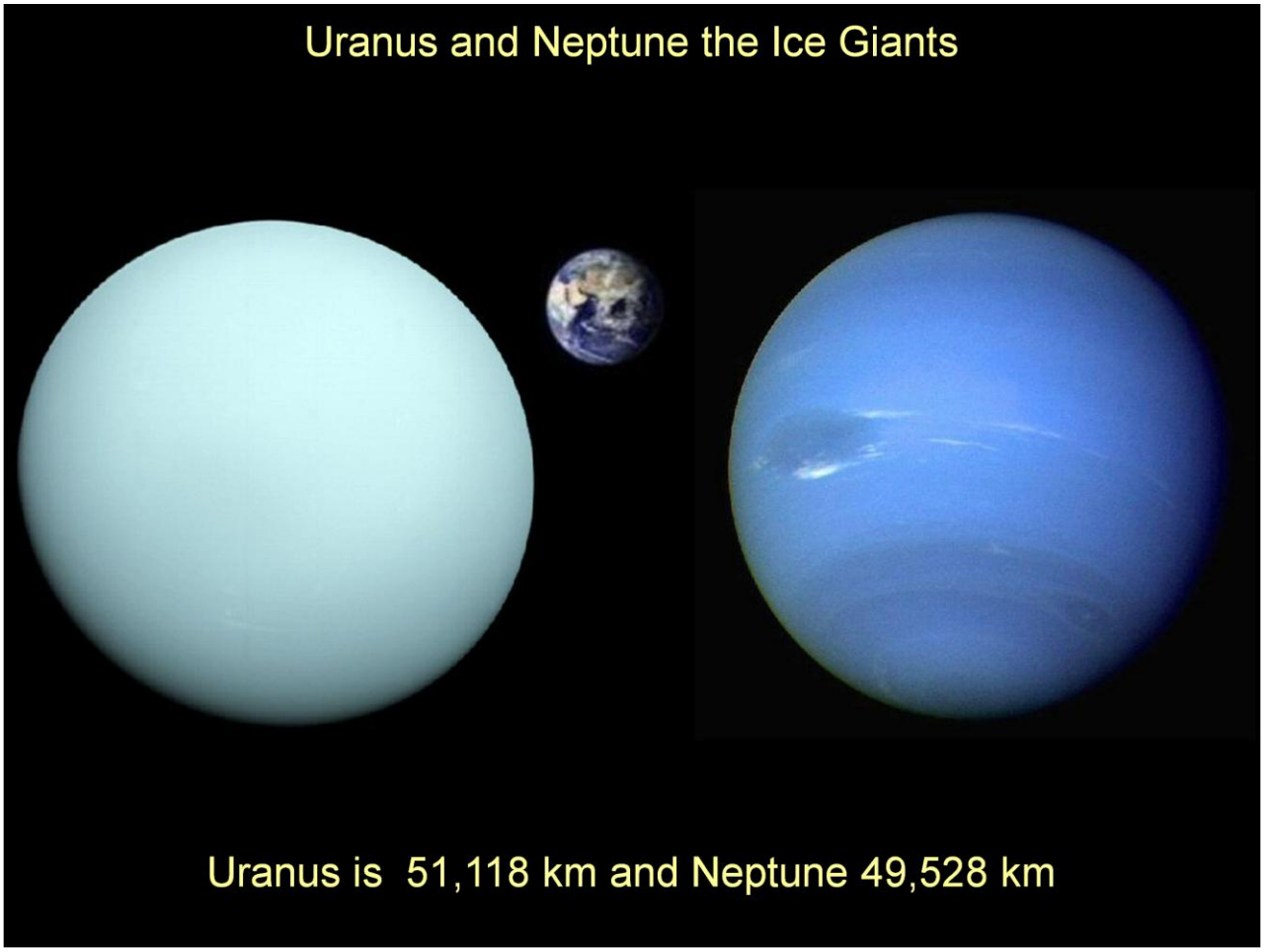


Saturn's largest moon is called Titan and is the second largest moon in the Solar System (5,105 km) after Jupiter's Ganymede (5,262 km). Titan has a thick atmosphere .

Titan is primarily composed of ice and rocky material, which is likely differentiated into a rocky core surrounded by various layers of ice, including a crust of ice of and a subsurface layer of ammonia-rich liquid water.

The atmosphere of Titan is largely Nitrogen; minor components lead to the formation of Methane and Ethane clouds. The climate including wind and rain creates surface features similar to those of Earth, such as dunes, rivers, lakes, seas (probably of liquid methane and ethane) and deltas and is dominated by seasonal weather patterns as on Earth. With its liquids (both surface and subsurface) and robust nitrogen atmosphere, Titan's methane cycle bears a striking similarity to Earth's water cycle albeit at the much lower temperature of about −179.2º C (−290.5º F).

Titan is visible along side Saturn using 100mm plus telescopes and up to four of the other moons are visible using larger telescopes.



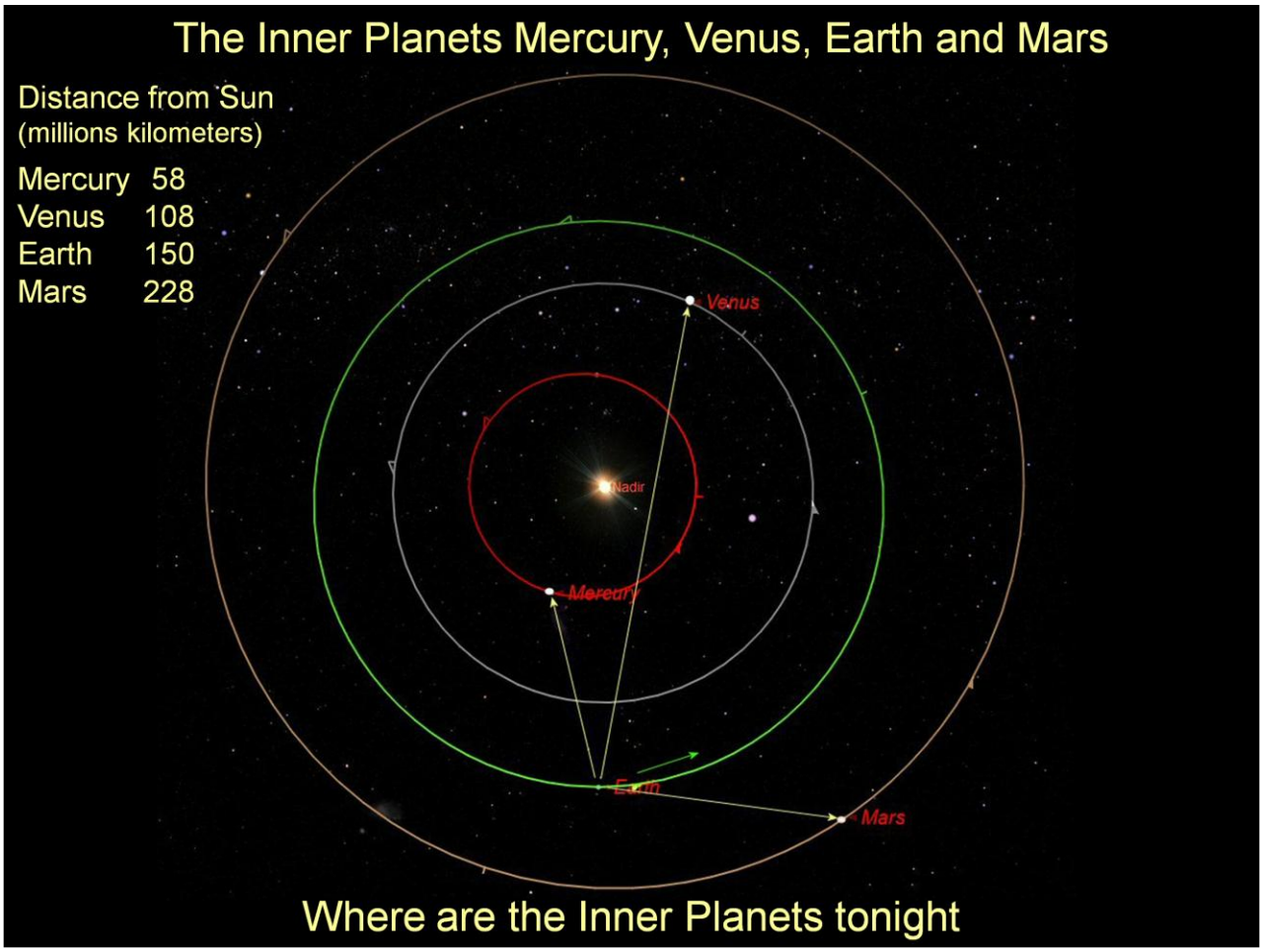
Beyond the Gas Giant Planets are the orbits of the outer icy frozen planets Uranus and Neptune that have their orbits much further apart. These planets are almost the same size and about four times the diameter of Earth. They are very far from the Sun and are therefore very cold.

Uranus is 51,118 kilometers in diameter and Neptune is slightly smaller at 49,528 km. This is about four times the diameter of Earth. The two most distant planets are very cold with most materials frozen. Strangely Neptune has a dynamic atmosphere and cloud system but the source that provide the power for this system is unknown.

Both planets are observable as small blue discs using most amateur telescopes but it is not possible to see an detail.

Uranus has 27 moons and Neptune has 13.

Observing the planets

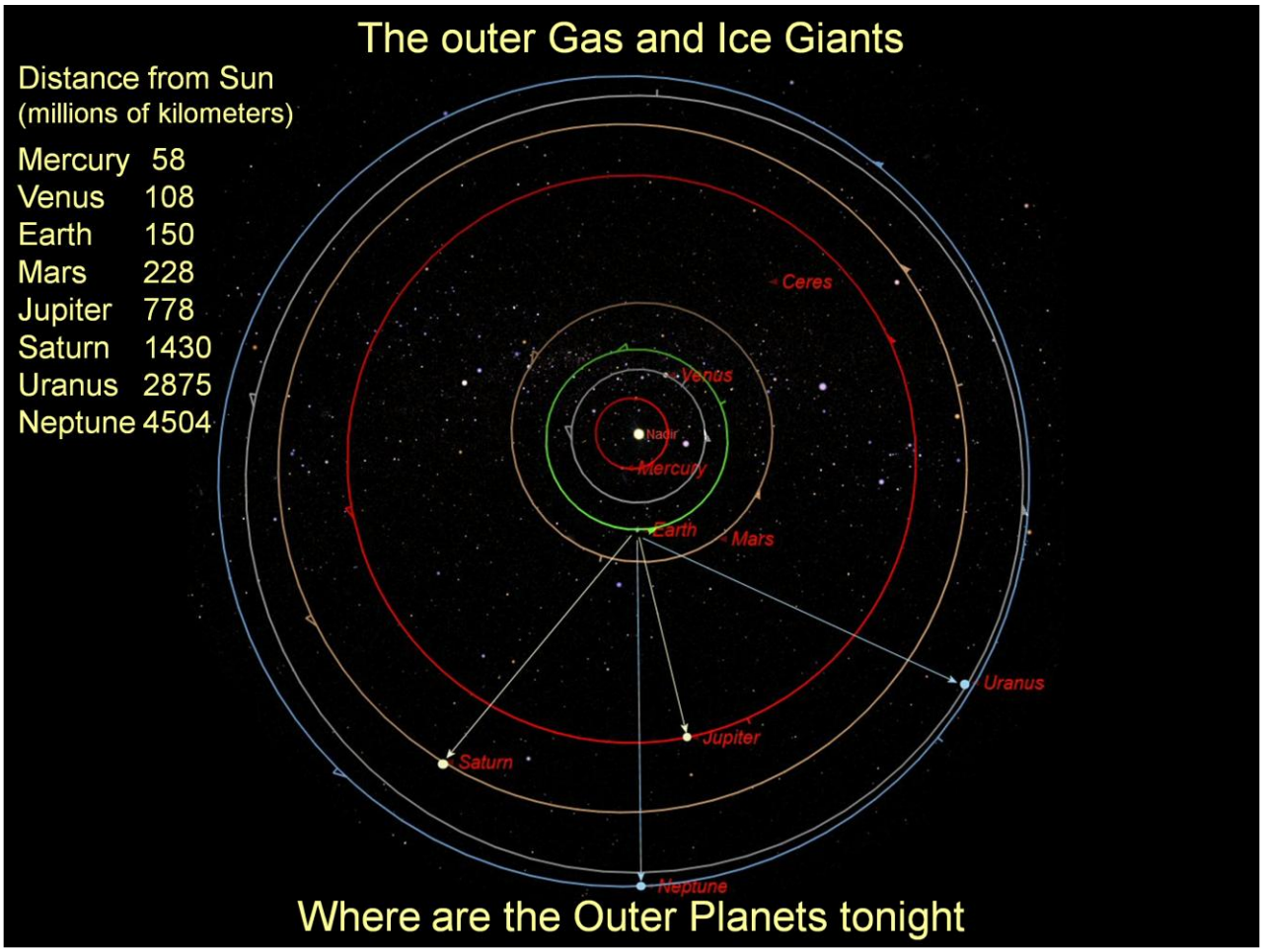


The chart above shows the inner four planets Mars, Earth, Venus and Mercury clustered around the Sun.

They are evenly space about 50million kilometers apart.

These inner planets are called the Terrestrial (or rocky) planets.

They are composed of rock and Iron and are kept warm by the heat from the Sun.



Beyond the realm of the inner planets we see the orbits of the Gas Giant planets Saturn and Jupiter.

These two planets are about ten times the diameter of Earth and their orbit are much further apart.

Jupiter 778.3 million kilometers and Saturn 1429.4 million kilometers from the Sun.

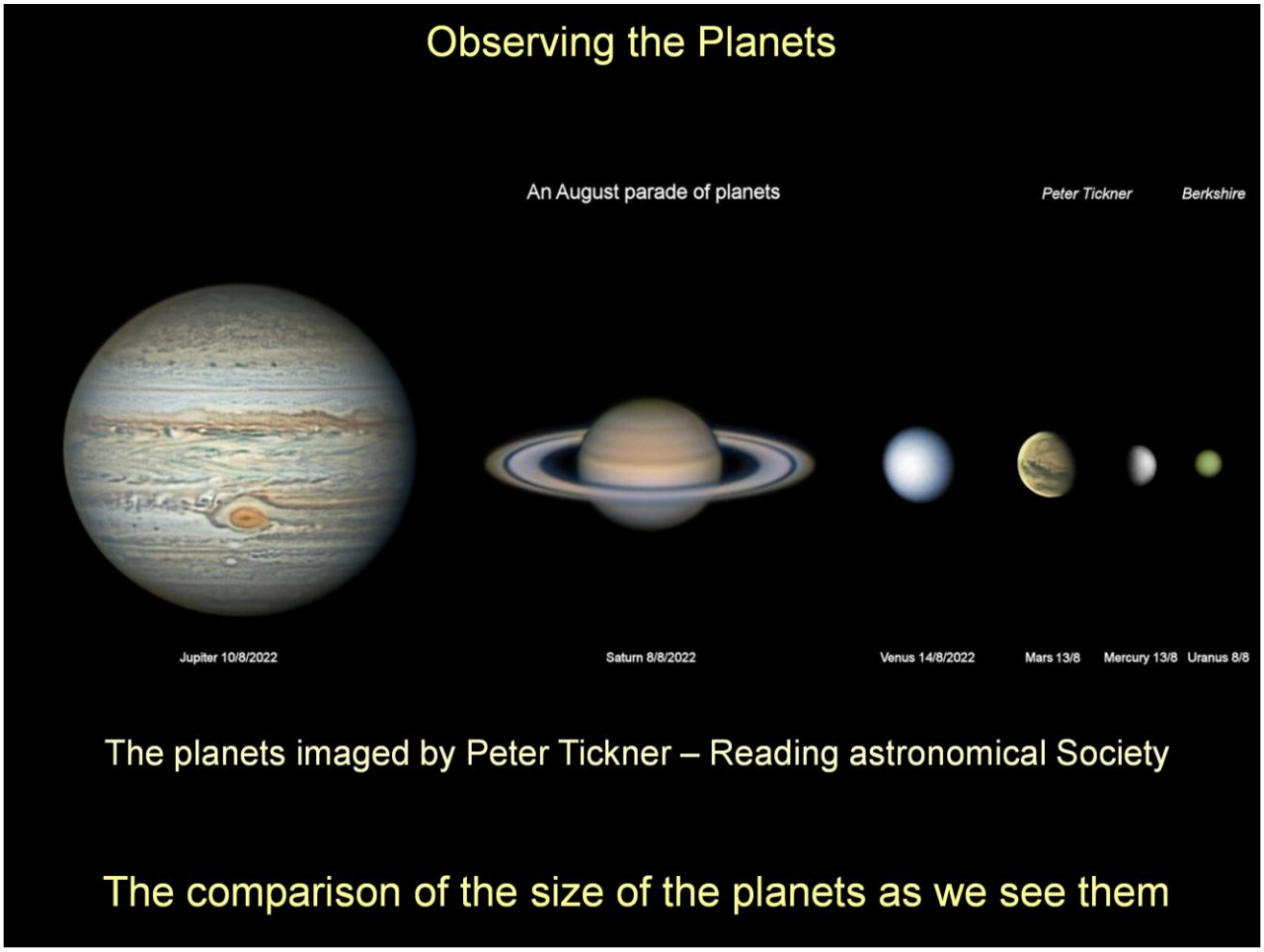
The four inner planets are gathered close to the Sun in the chart above.

Beyond the Gas Giant Planets are the orbits of the outer icy frozen planets Neptune and Uranus.

These planets are almost the same size and about four times the diameter of Earth.

Their orbits are spaced even further apart.

Uranus 2875 million kilometers and Neptune 4504 million kilometers from the Sun



Jupiter is the largest of the planets and the most impressive to see.
It has four large moons that are easy to see using a small telescope.
Using a high magnification the cloud band markings can be seen.
It is even possible to see the Great Red Spot.

Observing Jupiter

Jupiter 10/8/2022

Peter Tickner *Berkshire*

View through a small telescope

The cloud bands and four moons can be seen

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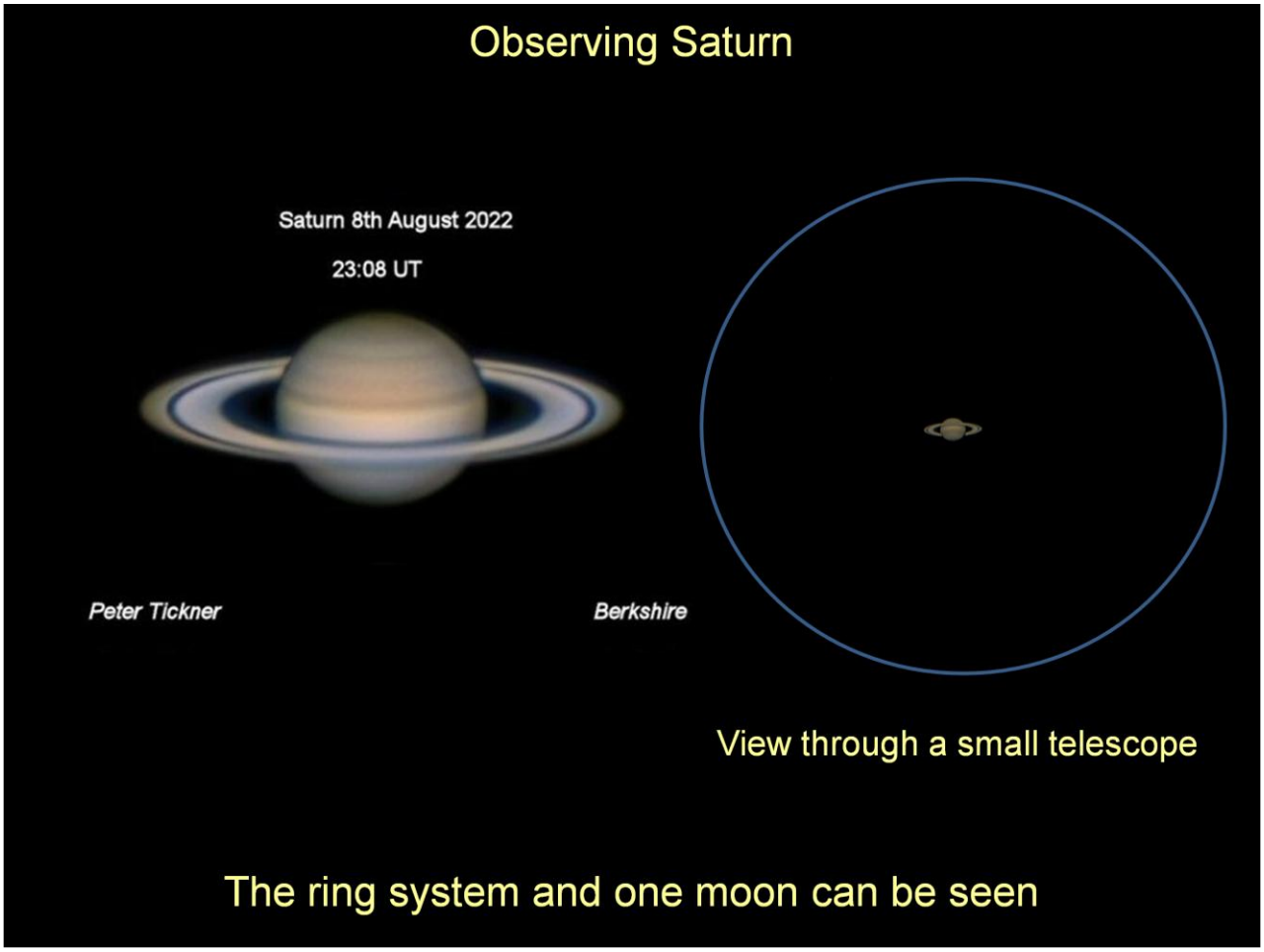


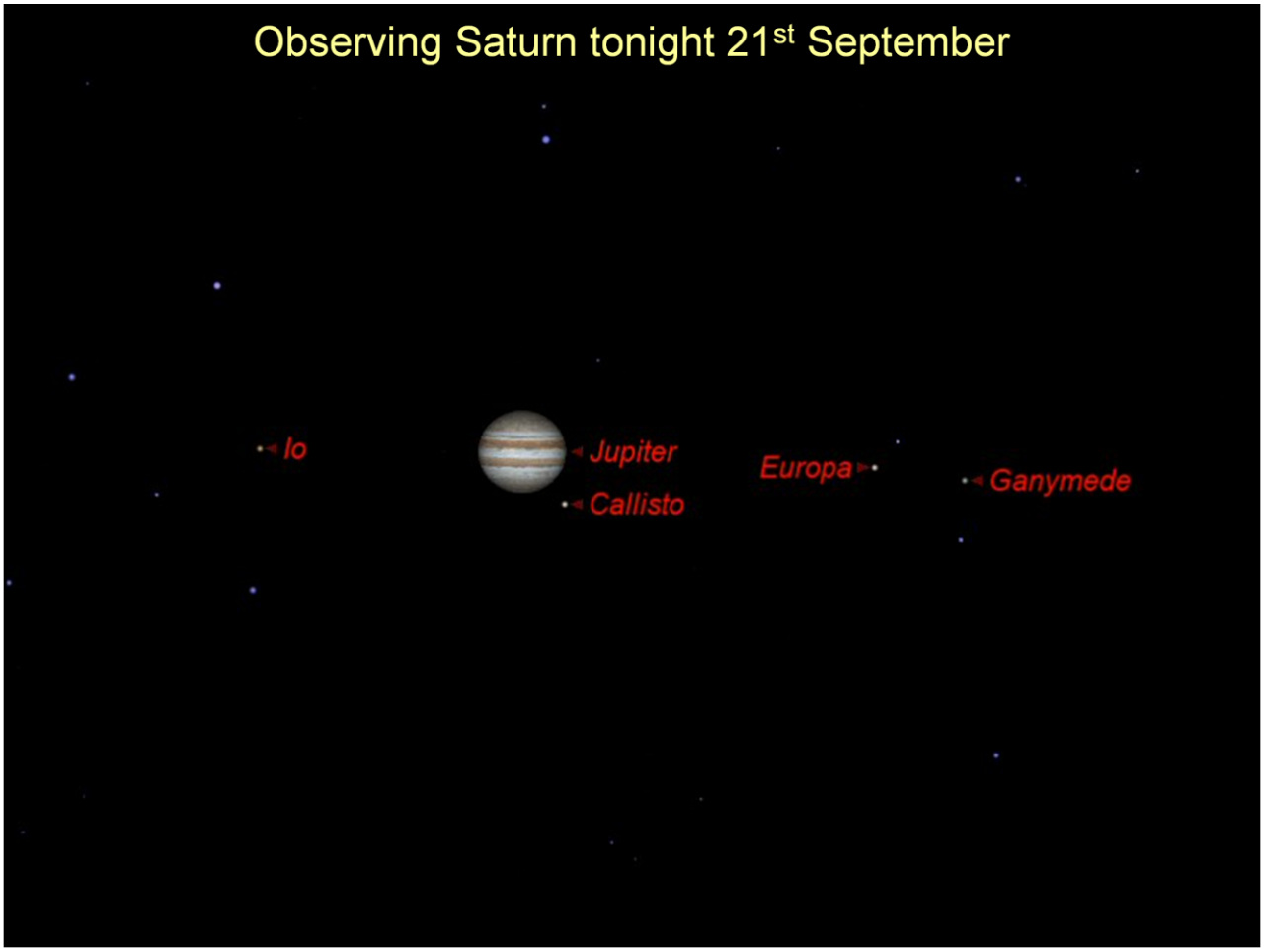
Saturn is the second most interesting planet due to its magnificent ring system.

As Saturn is twice a distant as Jupiter it appears much smaller (half the diameter).

It is also much fainter at about 15 times fainter than Jupiter appears.

Saturn has one large moon that is easy to see.

A larger telescope will show up to five other smaller moons.



The moons of Jupiter can be seen to move during one evening.

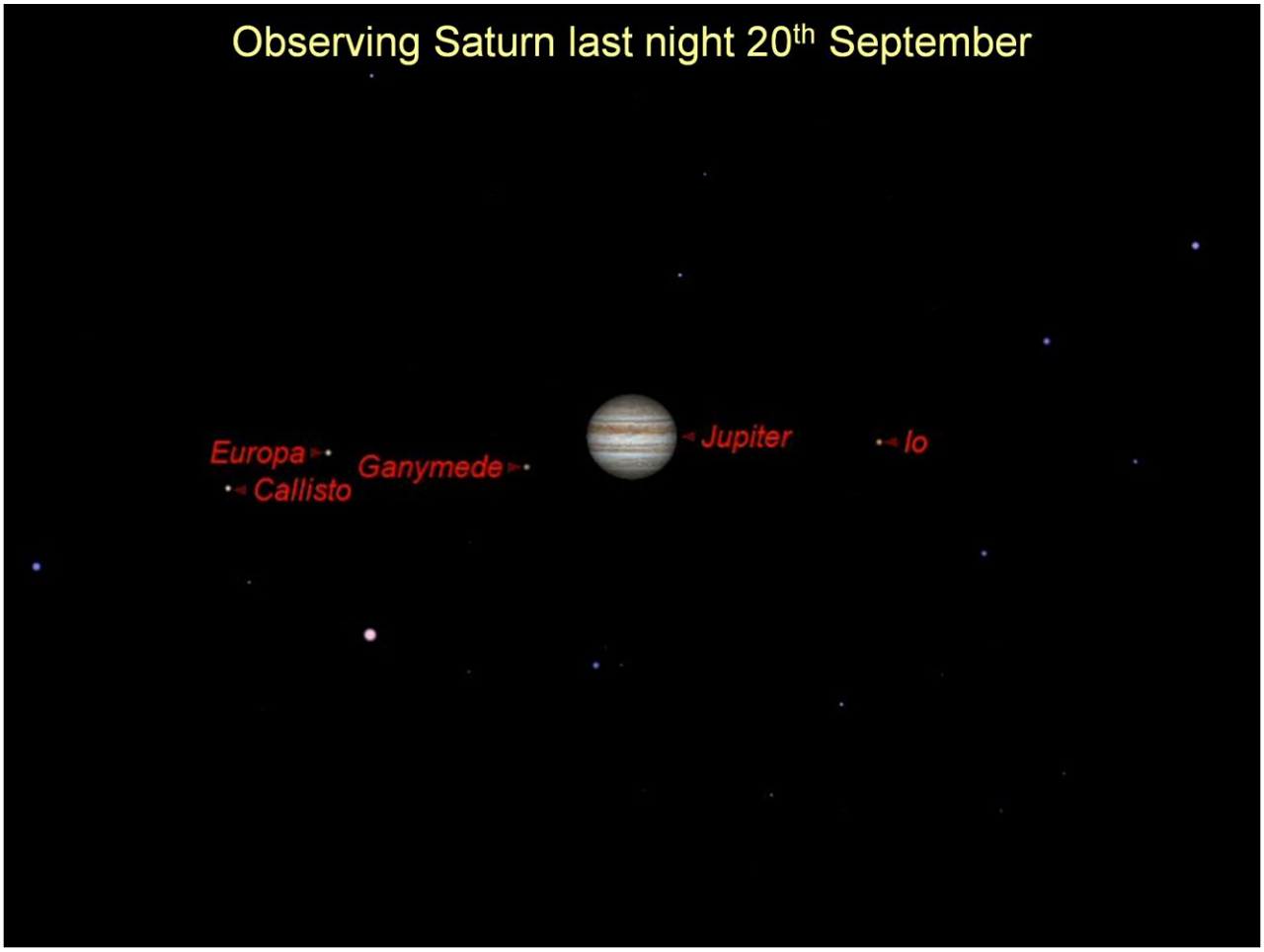
The moons can be distributed around Jupiter in any pattern.

Sometime all the moons will appear to one side or the other.

Another evening they all may be on the other side.

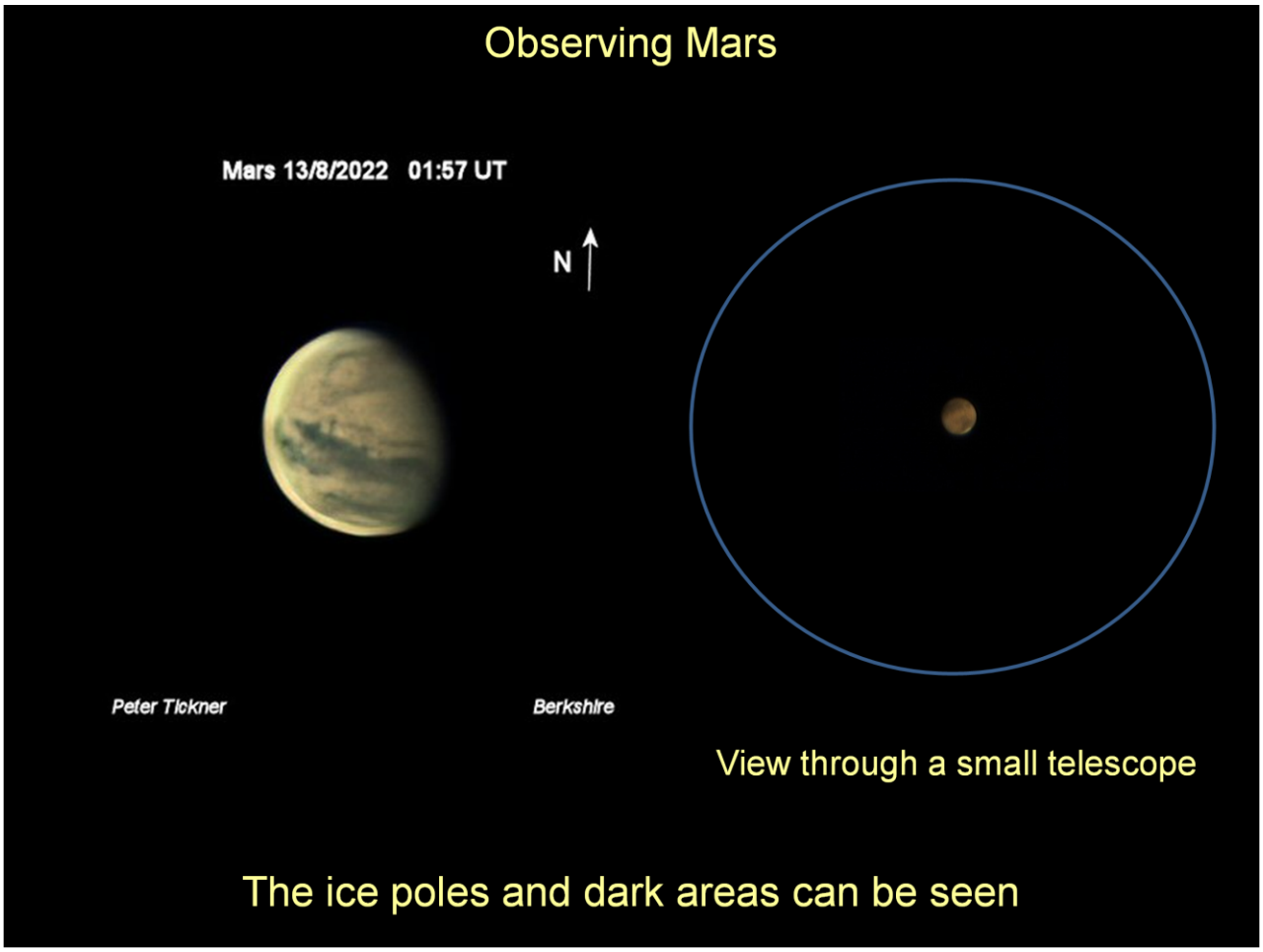
Tonight Io is to the left of Jupiter and the other moons are to the right.

On the following chart Io is on the right and the other moons are on the left.



On the chart above Io is position to the left of Jupiter.

On the previous chart for tonight Io in to the right.



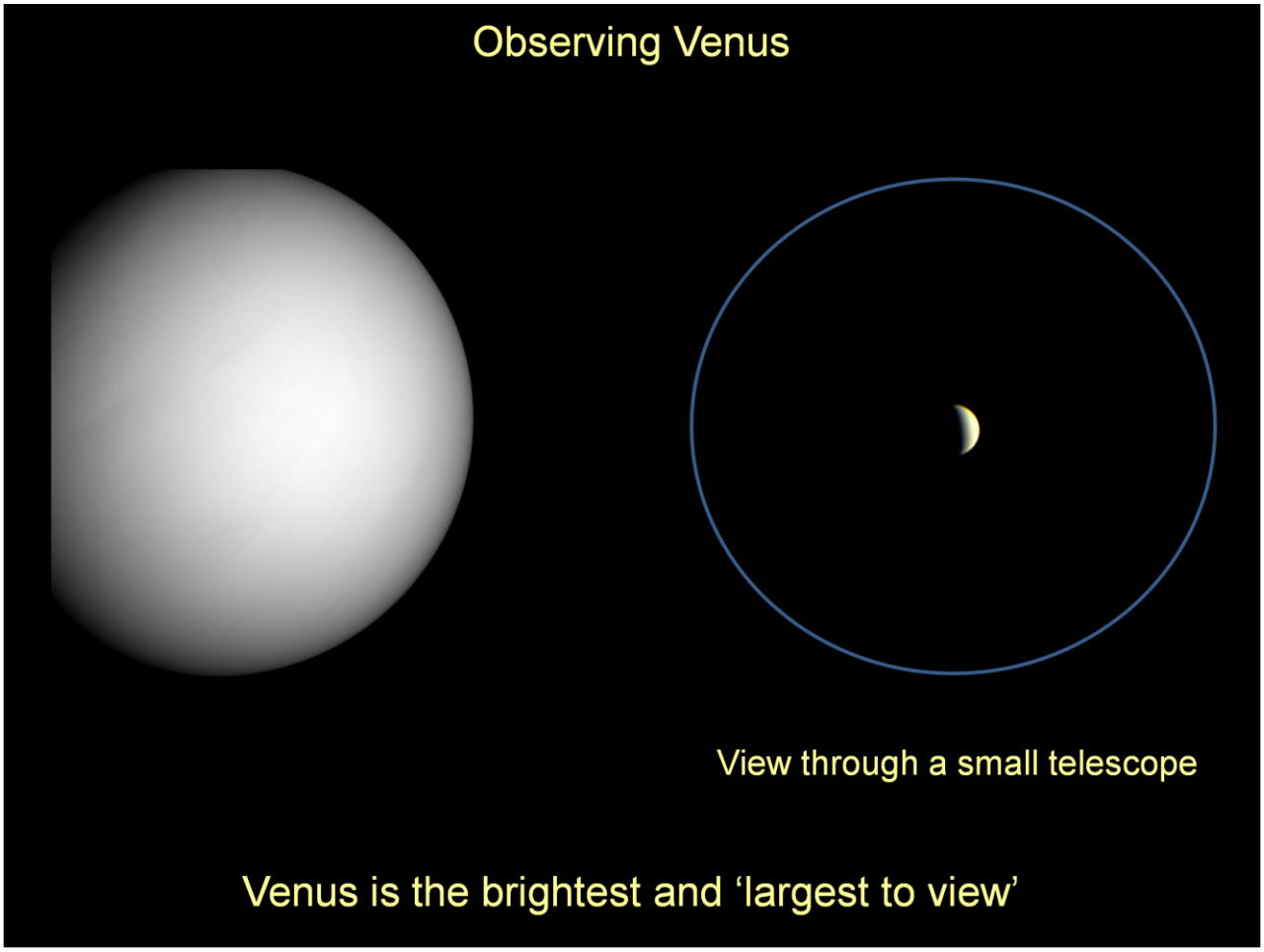
Mars is the second nearest planet to Earth.

The distance between Earth and Mars can vary quite significantly due to their elliptical orbits.

When they are at their closest the ice poles can be seen.

Some of the dark markings can also be seen when they are close together.

This year the two planets will be about mid distance apart.

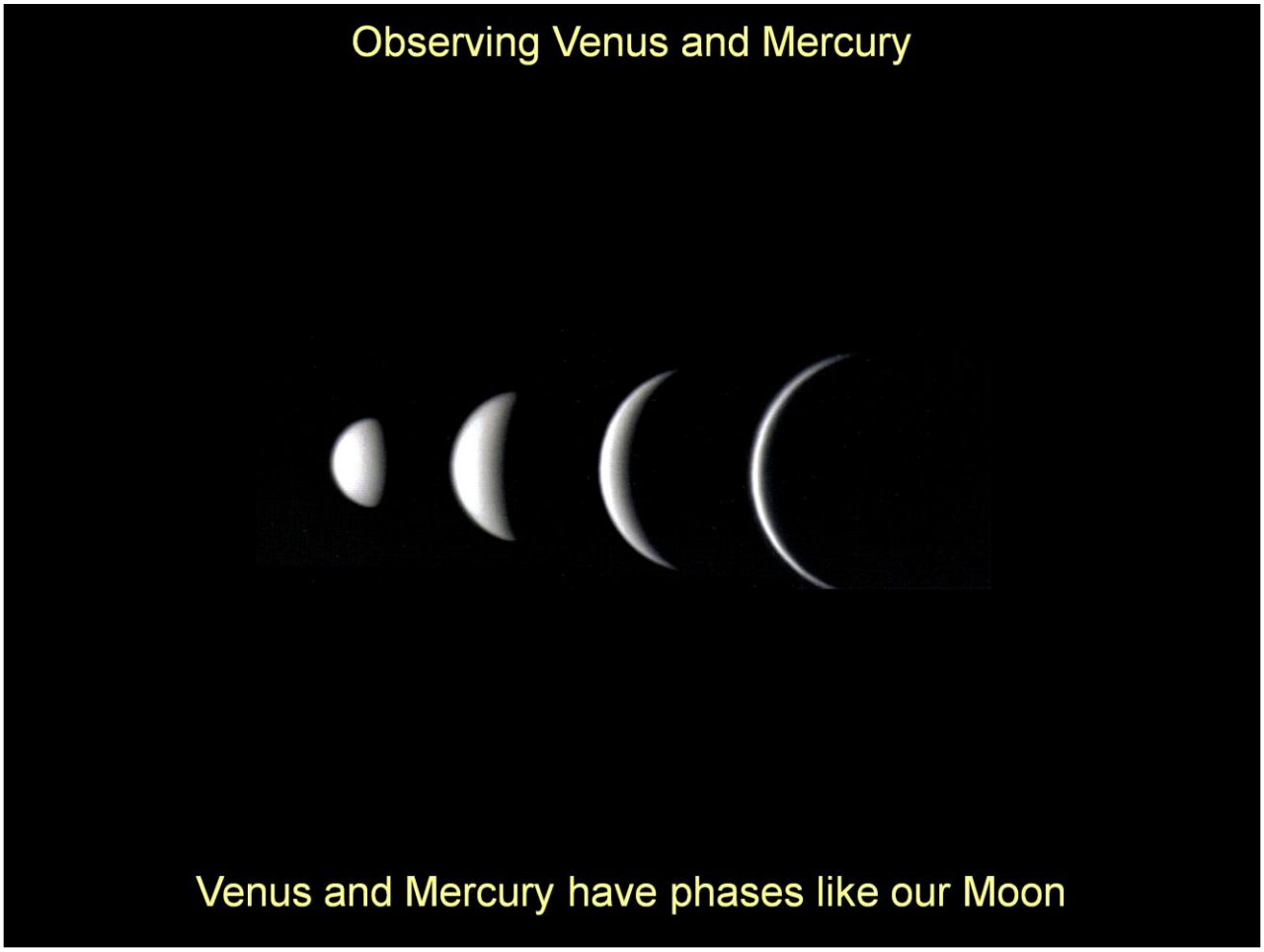


Venus is the closest planet to Earth so it appears the biggest and brightest.

As its orbit in inside of the orbit of Earth we see phases like those seen on the Moon.

It is called an inferior planet because it orbit is inside the orbit of Earth.

Venus is completely covered with thick white cloud so no surface detail can be seen.



From our vantage point on Earth we see Venus and Mercury pass behind the Sun.

So as Mercury and Venus move around the Sun they are illuminated from different directions.

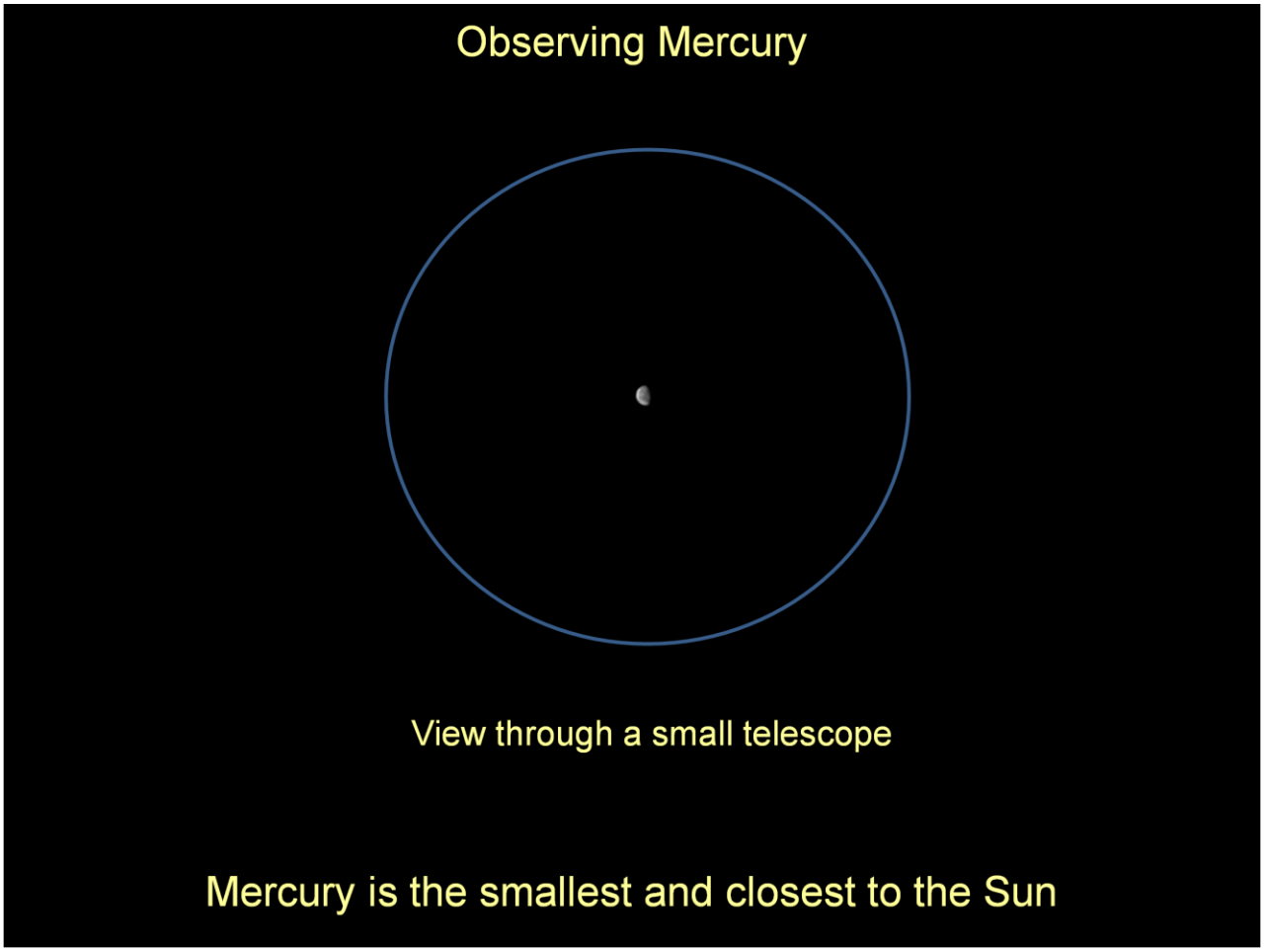
They also appear to change size, when on the other side of the Sun they look smaller.

When between the Sun and us they are closer and appear bigger.

On the opposite side of the Sun the side facing us appears fully illuminated.

When to either side of the Sun they appear half illuminated (like the half Moon).

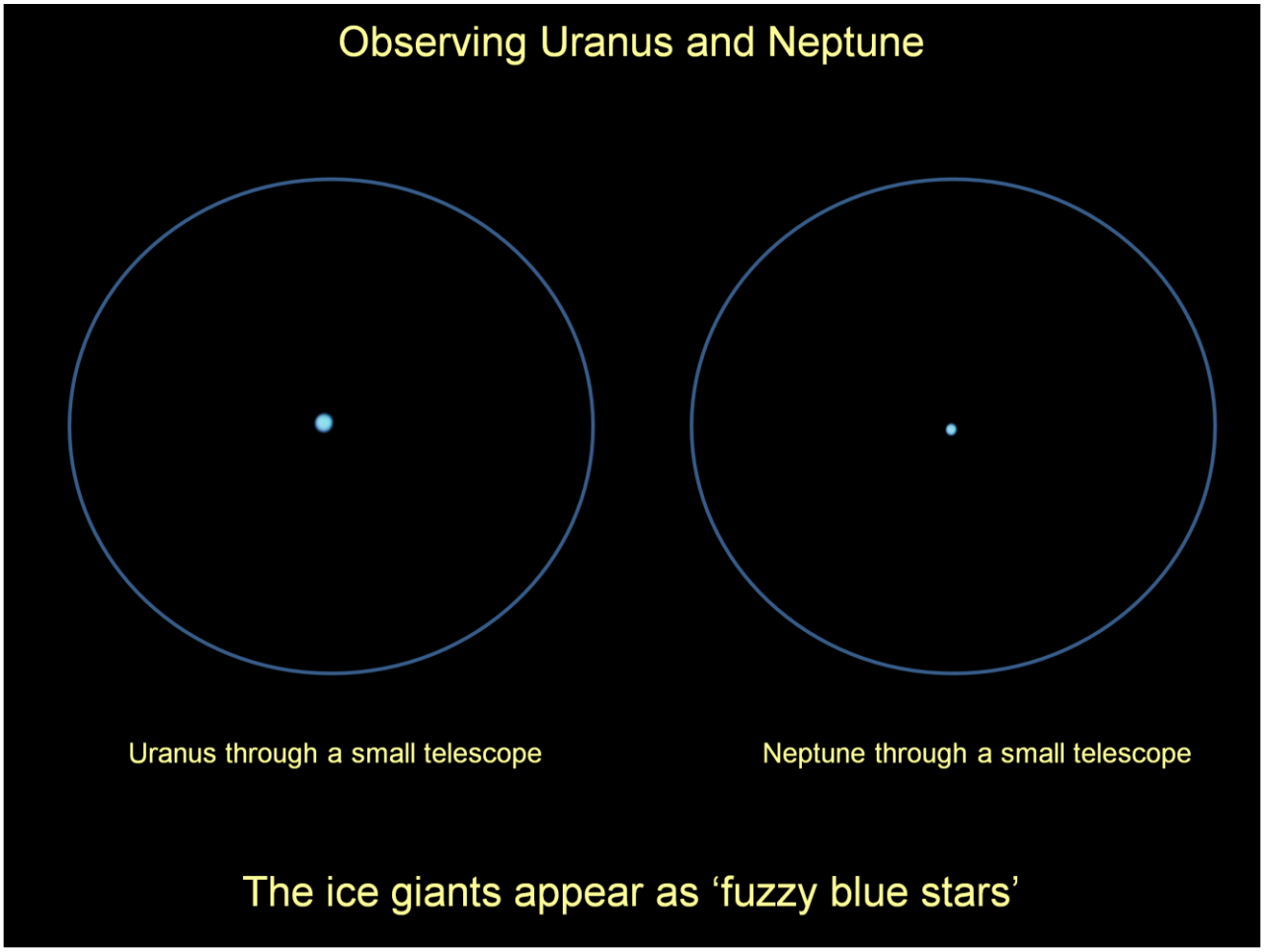
When almost in line with Sun on the Earth side they appear as a thin crescent.



The two inner planets do not have moons these are MERCURY and VENUS and they are closest to the Sun.

Mercury is the smallest of all the planets and is not a lot bigger than our Moon.

It does have phases but it is small and close to the Sun so difficult to observe.

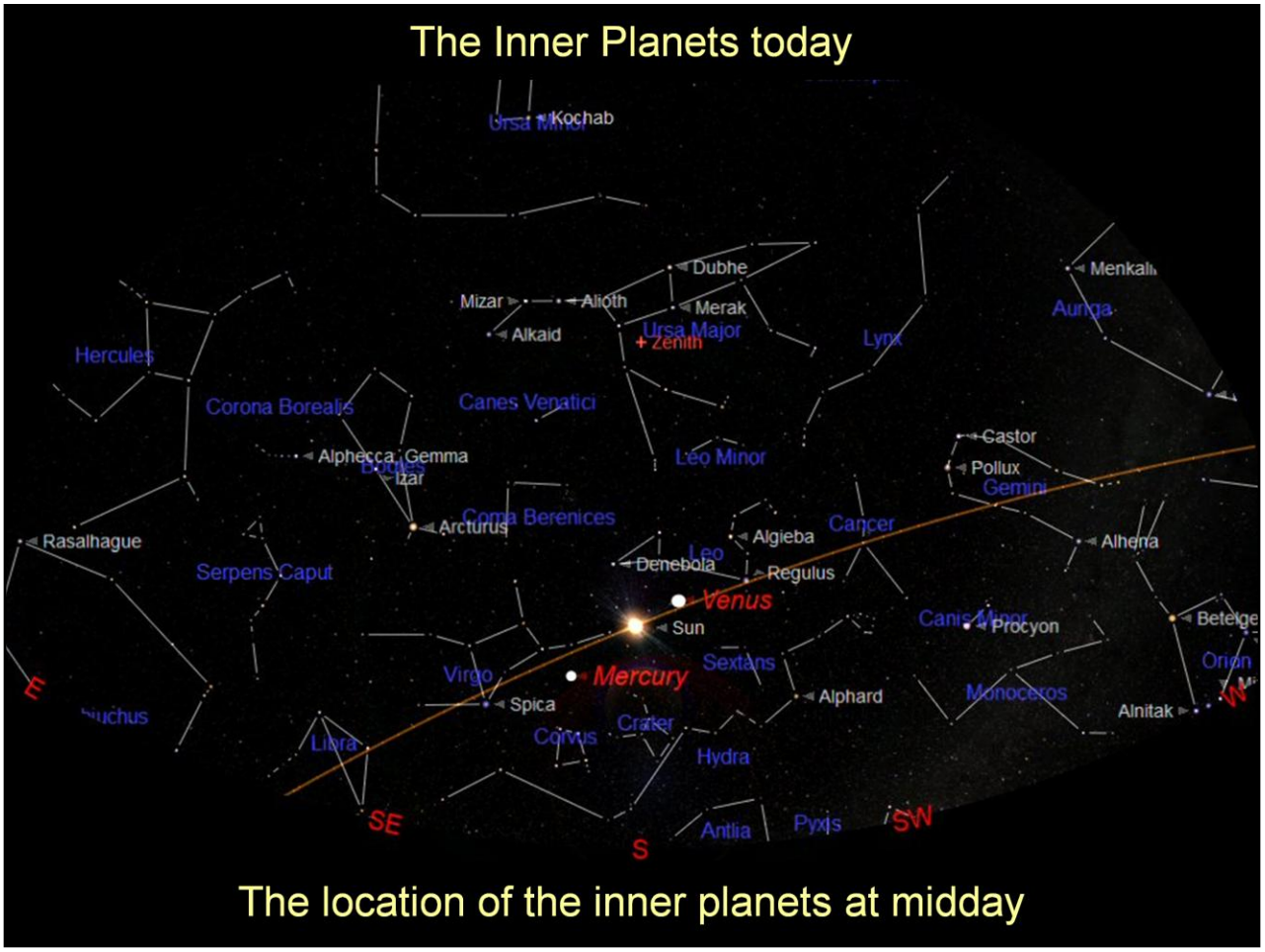


Uranus and Neptune are the most distant planets so they look rather small.

Uranus can appear as a very small disc using maximum magnification on a small telescope.

No detail can be seen but it looks like a ‘fuzzy’ blue star.

Neptune is twice as far away as Uranus so consequently it looks much smaller and fainter.



The two inner planets appear close to the Sun and cannot be observed.

As they orbit inside the orbit of Earth they are referred to as ‘Inferior Planets’.

Mercury is the smallest of all the planets and rises after the Sun.

It does have phases but it is small and close to the Sun so difficult to observe.

Venus rises just before the Sun in the east.

It is close to the Sun and is in the bright early morning sky.

Venus is in the opposite side of the Sun to us so appears small and fully illuminated.

The five outer (Superior) planets are all observable in the evening sky.

Saturn is the best positioned in the early evening and first to set in the west at 03:30.

Jupiter is the brightest and will be in the south east in the early evening and best at about 02:00.

Neptune is the most difficult to find as it is farthest away and appears small and faint.

It is positioned to the west (left) of bright Jupiter so this will help to find it.

Uranus is closer so appears brighter than Neptune and can be seen as a small blue disc in a telescope.

Mars is the last to appear in the evening sky it rises over the eastern horizon at about 22:00.

Mars will be much better to observe in December and will be at opposition on 8th December.

Beginner's Website:

naasbeginners.co.uk