

THE RINGED GIANTS – JUPITER AND SATURN

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If one were touring our solar system travelling outward from Earth, after passing the orbit of Mars there would be a large region about 554 million kilometres (or 340 million miles) across where there are no planets. Then Jupiter would be encountered at 5.2 Astronomical Units distance from the Sun (1 A.U. is approximately 150 million kilometres or 93 million miles). Saturn lies nearly twice the distance from the Sun as Jupiter. Jupiter and Saturn inspire much wonder, Jupiter for its size and Saturn for its beautiful rings. Saturn has very extensive rings which are easily observed from Earth. But Jupiter also has rings, though they are hard to see, being made up of microscopic dust. Both Jupiter and Saturn rotate very rapidly and would have a 'day' of roughly 10 hours. Jupiter is much more massive than all the other planets in our solar system, about 318 times the mass of Earth. Saturn, which is the next largest planet, is about 95 times the mass of Earth. This makes Jupiter's mass more than double the combined mass of all the other planets. Yet, even this is only about one thousandth of the mass of our Sun. Because its mass is so great, Jupiter has a large effect on the motions of some other objects in the solar system. Jupiter and Saturn are often called 'gas giants', though calling them 'fluid planets' would be a more accurate description. Liquids and gases are both considered fluids in science. Jupiter and Saturn are made up of both gases and liquids. Jupiter and Saturn's outer layers are gas, but at the high pressures that exist deeper inside, the gases condense to liquids. This means Jupiter and Saturn do not really have a solid surface, though deep in their centres there may be a solid core. They are both made up of over 80% hydrogen gas, with helium the next most abundant element. There are also small amounts of methane, ethane, and ammonia. Naturalistic origins theories for the formation of large gaseous planets have been based to a large degree on Jupiter and Saturn. From a creation perspective, these planets, which are giants compared to Earth, show the greatness and creativity of the Creator-God. Today large gaseous planets are believed to exist orbiting other stars. These planets are often compared to

Jupiter and Saturn by planetary scientists. Usually these extrasolar planets have orbits very different from Jupiter and Saturn in our solar system.

Earth is found within what is called the 'inner solar system', generally considered to be from Mars inward toward the Sun. Earth's orbit defines a plane called the ecliptic, which is used to measure how inclined orbits are in the entire solar system. All the planets, with the exception of Pluto, have orbits close to this plane in inclination. All the planets in the inner solar system are rocky planets, though Venus, Mars, and Earth have gaseous atmospheres. But in the outer solar system we find there are four large gaseous planets, Jupiter, Saturn, Uranus, and Neptune. Then there is Pluto, which seems like a kind of 'misfit' in that its orbit is more elliptical than the other planets, and is also more inclined. There is debate today over whether to consider Pluto a true planet or not.

There are many small objects in the solar system and small bodies such as the asteroids and comets are very influenced by the gravity of Jupiter and Saturn. Between Mars and Jupiter the large 'gap' without a planet is generally known as 'the asteroid belt'. Asteroids are not always confined to just this region, however. There has been a significant effort in recent years to search for asteroids that come close to Earth's orbit. Objects that come near Earth's orbit are called Near Earth Objects, or NEO's. Some asteroids are found at a distance from the Sun that makes them very influenced by Jupiter's gravitational pull. One group of asteroids, known as the Trojans, actually share Jupiter's orbit. There are also clearly 'gaps' in the asteroid belt where Jupiter has pulled objects away from certain positions. There are also a few unusual small objects that have orbits taking them beyond Jupiter and even beyond Saturn. In 1977 an object called Chiron was discovered in an orbit between Saturn and Uranus. The region near Neptune is now often called the transneptunian region. Also, we now know there are a number of objects located beyond Neptune. There has been much interest in these objects among astronomers in recent years. These objects have come to be known as Kuiper Belt Objects, or KBO's. Some believe that short period comets (that require less than 200 years for one orbit around the Sun) originate from the Kuiper Belt region beyond Neptune. Comets are also very influenced by Jupiter and Saturn. In 1994 the Shoemaker-Levy comet (SL-9) was photographed colliding with Jupiter. The SL-9 comet had orbited the Sun but it passed close enough to Jupiter at some point to allow Jupiter to capture it. This capture took place approximately two years prior to when the collisions occurred. When the comet got close enough to Jupiter, the gravitational tidal forces pulled it apart. Later, a number of impacts with Jupiter were seen in July 1994 over a period of about one week. Though comets had been observed disrupting into fragments before, the case of SL-9 was the first opportunity on record to observe an actual collision of those fragments with a planet. Some comets have their orbits drastically altered by Jupiter, or they may be captured by it, but they do not break up as Shoemaker-Levy did. This is a general picture of the outer solar system and how Jupiter and Saturn influence the solar system.

Jupiter

Jupiter and Saturn have more moons than any of the other planets in our solar system and a number of moons have been discovered in recent years. In the year 2003 alone, 21 new moons were discovered orbiting Jupiter. New telescope technology has made it possible to detect fainter objects than ever before. Jupiter is now known to have 61 natural satellites (Saturn has 31). The majority of these are smaller than 200 km diameter, in fact, the newly discovered moons at Jupiter are all probably smaller than 5 km in diameter. This is based on estimates of their sizes, not precise figures. For Jupiter, 36 of its 61 moons travel retrograde around Jupiter, opposite to the direction Jupiter spins. Seven of Saturn's moons travel retrograde. The retrograde moons are usually found to be grouped near each other. This strongly suggests there was one object that was broken apart in a collision some time in the past. But the eccentricities of the orbits of these new moons do not suggest they were captured like SL-9, unless some force dramatically altered their orbits since their capture. Present processes cannot explain how there could be enough collisions or captures to produce so many objects as we now find among Jupiter's moons. This may imply a catastrophic event or process in the past to explain moons and craters. Planetary scientists have suggested that in the early history of the solar system (over 4 billion years ago in their view) comets were captured by Jupiter with much higher frequency. In the evolutionary view of the solar system, moons are generally believed to form as the planet forms, by the dust and other particles pulling together from the nebula that the whole solar system came from. But there are difficulties with this concept for the formation of some moons.

For Jupiter, the well known satellites are Io, Europa, Ganymede, and Callisto, which are referred to as the Galilean moons, after Galileo who discovered them. These moons are comparable to our Moon in size, though Ganymede and Callisto are larger. Each of these moons has interesting unique characteristics. The Galilean moons of Jupiter are easy to observe with even a very small telescope. Planetary scientists have encountered very challenging mysteries for each of them. For Io, it is the high heat output and active volcanoes. With Europa, it is the nature of the interior and whether there is liquid water under the surface. For Ganymede, it is the variety of geological structures on its surface. For Callisto, one mystery is the unusual form of the rings around the Valhalla impact basin. This is one of the largest impact sites in the outer solar system, with concentric ridges forming a structure nearly 3,000 km in diameter. Yet, in several respects it does not have a shape or proportions like other large craters.

Scientists have attempted to explain how natural processes alone would be sufficient to explain how large gaseous planets might form from a nebula in space. The theory has it that the nebula would collapse by gravity into a spinning disk of dust, gas, ice, and mineral grains. The microscopic solid particles would collide and stick together, forming larger and larger macroscopic objects. Then these objects, called planetesimals, would pull more and more material onto them by gravity. It is believed that if a solid core 10 Earth masses in size formed in this way, this would be enough to pull large amounts of the gas in the disk onto the solid core, thus forming a gaseous planet. The bigger the solid core became before the disk could dissipate and become too thin, the bigger the gas planet would be in the end. As this process takes place there are other processes occurring in the Sun that at one point would drive large amounts of gas out of the solar system. This puts a time limit on the formation of the solid planet core. For Saturn, planet formation models imply there would not be enough time for the core to get large enough before the gases dissipate. Thus, Saturn by the naturalistic evolutionary approach, would not be as large as it is found today. The same problem could affect Jupiter.

Jupiter is a powerhouse of energy in the solar system. Though it is very large, it spins on its axis very rapidly. It also has a very powerful magnetic field and gives off one million million Watts of energy in the form of radio waves! Considering the radio waves and heat given off by Jupiter, it gives 1.67 times the energy that it receives from the Sun. In December of 1995 the Galileo spacecraft sent a probe into Jupiter to collect data on its gases. It found several things surprising to planetary scientists. Temperatures and wind speeds were higher than expected, which suggests there is heat coming from the interior somehow. This type of energy and heat issue may be easier to explain assuming Jupiter is young rather than billions of years in age (Samec, 2000, pp.3-4). There were other surprises in the composition of the gases in Jupiter from the Galileo spacecraft. There was no evidence of water clouds in Jupiter's upper atmosphere, which had been expected after the SL-9 comet impact (Beebe, 1997, p.226). There continues to be research efforts to explain the data from the Galileo probe. There continue to be ongoing unanswered questions even today as scientists try to reconcile all the data.

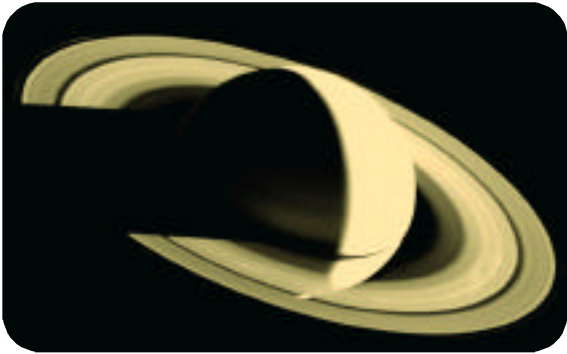
Jupiter and Saturn have now been observed over a significant period of years by various research efforts. Their various bands of clouds and occasional storms have been studied a great deal. Jupiter and Saturn both change their appearance over time. A very visible feature on Jupiter is the 'Great Red Spot'. This spot has been observed to exist for at least 150 years. It is essentially a giant hurricane. The Red Spot is located between two streams of gas that move in opposite directions (Beebe, 1997, pp.33, 35). South of it there are mild winds moving eastward; this is the same direction as the motion due to the spin of the planet. North of the Red Spot there are very strong westward winds. If Jupiter were highly tilted the different amounts of solar radiation falling on Jupiter's Northern and Southern hemispheres could explain this. But because Jupiter is only tilted 3 degrees, the reason for the dramatic contrast between the North and South equatorial winds is a mystery. The Red Spot also varies in its position along Jupiter's longitude (Beebe, 1997, p.36). From about 1930 to 1982 the Red Spot drifted over 270 degrees eastward in longitude, which is about 3/4 of the way around the planet! The size of the Red Spot has varied as well, but the size change is only in the horizontal dimension. The vertical dimension of the spot has stayed nearly constant for years. The reasons for these changes in the Red Spot are not known. The spot also speeds up and slows down

See inside back cover for image captions

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over periods of days to weeks, relative to the spin of the planet. Much is still not understood about Jupiter's Great Red Spot.

Saturn

In June 2004 the Cassini spacecraft will enter orbit around Saturn. The Cassini spacecraft will remain in orbit around Saturn for some years, similar to how the Galileo spacecraft has done for Jupiter. Cassini will collect much new information about the rings of Saturn, Saturn's moons, and the planet itself. Of special interest is that Cassini is equipped with a probe that will detach from Cassini and descend into the atmosphere of Saturn's moon Titan. Titan is unique in the solar system as having an atmosphere that is more dense even than Earth's. This probe is known as Huygens and was built by the European Space Agency. The Huygens probe has been designed to function even if it lands in liquid methane, which may exist on Titan's surface. Cassini was launched in 1997. Cassini made two flybys of Venus, one flyby of Earth, and another flyby of Jupiter, all to pick up speed to make the trip to Saturn.

Saturn has been called the most beautiful planet in the solar system, mainly because of its extensive system of rings. Saturn is nearly double the distance from the Sun as Jupiter and has the lowest density of all the planets, being about 70% of the density of water. Saturn is tilted more than Jupiter (27 degrees) and this makes the appearance of the rings vary dramatically over periods of several years. Saturn requires about 29.5 Earth years to complete one revolution around the Sun; Jupiter requires nearly 12 Earth years to do the same. Saturn's colour is a yellow with some white cloud features. Jupiter's colour is more reddish to brown. It is not really known for certain what makes this difference in colour, because the composition of Saturn is very much like Jupiter. Saturn is made up mostly of hydrogen and helium, though the proportion of helium seems to be less than that for Jupiter. Saturn has very strong eastward winds in a wide belt around its equator. These winds have been clocked at speeds of about 1440 kilometres per hour (900 miles per hour) or more. This is much faster than any winds on Jupiter. There are also occasionally some large storm systems in the equatorial region that last for periods of months. In December 1994 one of these storms, about the size of Earth, was observed by the Hubble Space Telescope. The rapid winds on Saturn make the rotation period (a Saturnian 'day') at the equator about 25 minutes less than it is near Saturn's poles. At the poles Saturn's 'day' would be about 10 hours 39 minutes. Saturn also possesses a strong magnetic field, though not nearly as intense as that of Jupiter. The strong winds as well as the average temperature of Saturn imply an internal energy source of some kind. In fact, Saturn gives off three times the amount of energy it receives from the Sun (Baughner, 1988, p.207).

Then there are the rings. Saturn's rings are beautiful and complex. Saturn has much more material in its rings than all the other rings of Jupiter, Uranus, and Neptune. Saturn's rings are over 60,000 kilometres wide; in recent studies of the rings, scientists have estimated the vertical thickness of the rings is something between 10 and 100 metres. The rings are made up of many chunks of water ice, though it is possible some of them could have rock inside. There may be small amounts of organic compounds in this ice in the ring objects (Poulet and Cuzzi, 2002, p.350). The ring objects have been estimated to have sizes ranging from 1 cm to 20 metres (Nicholson *et al*, 2000, p.499). Even with the Voyager photographs and the Hubble Space Telescope, it has not been possible so far to distinguish individual ring objects in any photograph. So, the above information on the thickness of the rings and the sizes of ring particles should be considered tentative estimates. Saturn's rings are very dynamic, with some features that have been observed to change over periods of just minutes or a few hours.

The Voyager spacecrafts made amazing discoveries about Saturn's rings. There were what looked like spokes in the rings. There was also a ring that was made up of two 'strands' with one braided around the other. The Voyager spacecraft also showed that the closer you looked, the more rings you could see. Planetary scientists have described them as 'rings within rings within rings'. Some rings had surprisingly sharply defined edges though scientists had expected them to essentially fade out gradually, assuming they were very old. The moons pull material in the rings in such a way that they could create a few of the gaps in the rings. There are also certain waves that travel through the rings due to collisions of the objects that probably produce some of the structure in the rings. But, it is not clear whether all these natural phenomena are adequate explanations of the intricate structure in Saturn's rings. It is estimated the total number of separate rings may be in the hundreds of thousands.

The origin of Saturn's rings continues to be debated. The two theories supported most by the scientific community today are 1) that there was a moon near Saturn that was broken apart either by tidal forces or by an impact, or 2) that the ring objects accreted from dust and ice particles at the time Saturn formed, but could not form into larger objects like moons. Since the Voyager mission there has been growing support for the first of these two approaches. As a result, some planetary scientists today hold that Saturn's rings are actually much younger than the planet, about 50 to 100 million years from an evolutionary perspective (McNab and Younger, 1999, p.124). Young-age creationists have also argued Saturn's rings must be young, not only because of the intricate structure and sharp edges but also because the rings are losing water as water falls onto the planet (Snelling, 1997). 'Tidal forces' refers to an effect due to gravity in a case where the force of gravity differs across distance enough to pull an object into a nonspherical shape or maybe even pull it apart. The gravitation force or tidal force from Earth's Moon pulls Earth into a slightly nonspherical shape so that Earth's diameter is greater at the equator than it is at the poles. For small objects near a planet, the tidal forces can pull the object apart in some cases. However, tidal disruption would probably not create a large number of fragments. So, tidal disruption of a former moon of Saturn into possibly millions or billions of ring objects may not be plausible in a young solar system because it probably would not generate enough objects. However, if a large collision broke up a moon only a few thousand years ago, this would generate many more objects but Saturn's rings may not be

so uniform as they are today, with most of the objects following circular orbits. The optical properties and brightness of the rings does not vary significantly as Saturn rotates (except for in the 'spokes'). There are ring objects that are in elliptical orbits and there are a few nonuniform rings at Saturn, but these are exceptions to the general rule. If a moon or moons were disrupted in the past, the fragments would tend to make the rings more and more uniform over time, due to collisions making the speeds of the objects more nearly the same. Thus, even from a creation perspective, the question of the origin of the rings is a challenging one. They could have some catastrophic origin or they could have been created with the planet. But there are multiple lines of evidence from the rings of Saturn that they cannot be billions of years in age.

Thousands of years ago the God of the Bible created two extraordinary planets in our solar system, Jupiter and Saturn. Jupiter and Saturn are both very bright in the night sky and are exciting to see even with a small telescope. These two planets serve an important purpose of protecting Earth from many impacts from comets. Because these two planets are so massive, comets are much more likely to impact with Jupiter or Saturn, than to collide with any object in the inner solar system. This tends to prevent some impacts with Earth that could threaten life. The size, beauty, and unique properties of these planets also show us the creativity and power of God, since He made them. We have so much factual data about these planets and the upcoming Cassini mission will undoubtedly bring new surprises and raise new questions about Saturn. Though we have learned much, even some very 'basic' questions cannot be answered today with any confidence, such as 'Why are Saturn and Jupiter such different colours when their compositions are so nearly the same?' With continued research and God's help, we can look forward to seeing how a creation perspective helps answer many questions about our solar system.

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