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Astronomy and Space Science
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Juno – Planetary Mission

Juno is a planetary mission to Jupiter that launched August 5, 2011 from Cape Canaveral, Florida. It arrived at Jupiter on July 4, 2016. Juno is a NASA space probe orbiting the planet Jupiter. It was built by Lockheed Martin. All its instruments and components came from all over the world. It was shipped in pieces to the Kennedy Space Center. NASA's Jet Propulsion Laboratory manages the mission for the principal investigator, Scott Bolton of Southwest Research Institute in San Antonio, Texas. The maximum speed of the Juno Spacecraft is 164,700 mph and Juno's speed is close to 10 times the speed of a space shuttle. Its orbital height above Jupiter is 2,672 miles and its speed on orbit is 0.1056 miles/s. Juno's mission is planned to last five years with its end date set for 2021. The cost of Juno's mission in 2011 was 1.1 billion.

According to Roman Mythology, Jupiter, the king of the Roman Gods created a barrier of clouds around himself to hide his mischief. The goddess Juno, Jupiter's wife, was able to see through the clouds and see his true self. This relates to Juno's mission of looking through Jupiter's clouds to reveal its secrets and help understand its origin. The objectives of the Juno mission to Jupiter is to see how the planet formed, whether it contains a solid core and the origin of its mass magnetic field. It has been theorized that Jupiter was the first planet to form in our Solar System so that if we come to understand the origins of Jupiter, we can begin to develop the

knowledge of how planet Earth was formed. Some say that Jupiter was formed at the same time as the Sun. However, Jupiter has much heavier elements such as carbon and nitrogen.

The spacecraft that launched Juno was an Atlas V551. At launch, it has a very large mass of 7,992 pounds which consisted of 3,513 pounds of spacecraft, 2,821 pounds of fuel and 1,658 of oxidizer. It is an orbiter mission. The Juno team had to perform two deep space maneuvers and seven trajectory correction maneuvers. Juno was travelling so fast that it needed to slow down carefully or else it would have flown off its path and have been lost in space. Twenty-six months after launch, Earth provided a boost to Juno's velocity, sending it on the correct path to Jupiter. Juno took five long years to travel to Jupiter and in the process, it was pelted with numerous impacts of space rocks and space dust.

When Juno arrived at Jupiter it needed to get into Jupiter's orbit and avoid its dangerous radiation. Juno is the first space mission to operate a solar powered space craft. It needs to constantly be exposed to sunlight. There are 18,698 individual solar cells on the spacecraft. It is also the first mission to orbit a gas planet from the North Pole to the South Pole. Juno will orbit Jupiter 37 times. And the spacecraft will execute flyby every 14 days.

Some questions Juno hopes to answer is: What is Jupiter's atmosphere like? How does the weather stay so stable? What are the magnetic and gravity fields of Jupiter and how do they affect the atmosphere of Jupiter?

According to the "First Science From Juno at Jupiter (NASA News Audio with Visuals), Every 53 days Juno streams by Jupiter a few thousand miles above the clouds. JunoCam shows a large wave of clouds 50 km across. Juno travels very fast and can travel from the North Pole to the South Pole in 2 hours. The information that Juno obtains from these quick fly-bys can tell us

about the Magnetosphere. Juno is about looking inside Jupiter. It will be done in three techniques. The first way is to look at the gravity field, where you are looking down to ice, rock, core. The second way is using the metallic hydrogen layer, maybe where the magnetic field gets created. Lastly, it will investigate the top part of the atmosphere, where the clouds and atmosphere are, this is done with microwaves.

According to the lead researcher Scott Bolton, “Our ideas were totally wrong about the interior structure, about the atmosphere and even about the magnetosphere.” Juno has changed the previous notions about Jupiter. (<https://www.space.com/32742-juno-spacecraft.html>) With Juno, we can't see directly inside of Jupiter, but we can use its tools to see the density variations and movements under the clouds that can alter the gravitational field above the surface.

According to the findings from early images, Jupiter is a turbulent planet with many storm systems and very large polar cyclones. Astronomers thought it was very uniform and not very exciting, but it is very different than expected. Every part of Jupiter is unique and is dynamic under the surface of the clouds. Some examples of this was Juno finding an enormous “fuzzy” core instead of a smaller, dense core as expected. This new data that was found shows that Jupiter is not all uniform inside. Very different from where you look at it. There were also magnetic field experiments done to show the direction and magnitude of the magnetic field. Researchers found that the magnetic field was stronger where they thought it would be weak and vice versa.

Jupiter from the poles looks very different from Jupiter at the equators. At the Poles, there are cyclones and anticyclones. The North and South Poles look very different from one another. Beautiful Auroras were found over the South Pole of Jupiter. These particles that make Jupiter's auroras glow are very different from those that make the Northern and Southern lights

on Earth. In May 2017, Juno collected a picture of Jupiter's ring from inside out and looks onto Orion's belt. Juno obtained many images of Jupiter's Great Red Spot, which is a storm that has persisted for very long. Juno found that the Great Red Spot is at least 50 times deeper than Earth's oceans and warmer at the base than at the top. Scientists are interested in why it has been appearing to be shrinking in the past few decades.

Other brand new and unexpected finding was that there a band of ammonia from the top of Jupiter to as deep as we can see. (about 350 km) There are different variations in ammonia based on latitude. South tropical zone shows a lot of storms scattered across the subtropical zones. Ice crystals of water ice and ammonia ice.

According to Nature International Journal of Science, Jess et.al., monitored Juno and the change in frequency, known as the Doppler shift, of radio waves sent back to Earth. These tiny differences in the signals revealed intricate details about the distribution of mass on Jupiter.

Some previous missions to Jupiter was the Pioneer 10 and 11 in 1973-4 that took the first images of Jupiter in a flyby mission. In 1979, Voyager 1 and 2, discovered the rings around Jupiter, clouds and storms and volcanoes on the Jupiter's moon IO. In 1992 Ulysses collected data about Jupiter's magnetic field. Galileo explored Jupiter and its moons from 1995-2003. Galileo probe measured its composition to learn about atmosphere. In 1996 Galileo measures the intense radiation on Jupiter and dropped a probe below the clouds. The results of this mission were very different from what scientists thought. The composition of Jupiter was much more diverse than what originally thought. Some future missions to Jupiter, will be the NASA's Europa Clipper spacecraft that will arrive at Jupiter in the late 2020's or early 2030's

Juno wanted to have citizen scientists participate in a planned space mission. This unique part of Juno, allows participants to use the JunoCam instrument. The public votes on what to take pictures of. This big campaign with Juno is meant to connect and combine Science, Art and Music. Apple has tried to distribute Juno related music was that made from the sounds taken from the 4th flyby of Jupiter.

As stated earlier, Juno's mission will shed light on how early Jupiter was formed. To date, the findings of Juno have been amazing and unexpected. The data that is collected will help many future generations. Rethinking and discovering how Jupiter looks might also affect how we look at Saturn, Uranus and Neptune.

References

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