Jupiter
Frequently Asked Questions (FAQ)

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Why do we want to go to Jupiter?

Jupiter, together with its four largest moons, which range from the size of the Earth's moon to the size of the planet Mercury, are in some ways analogous to a mini-solar system, Jupiter being analogous to the sun as the central body, and Jupiter's moons being analogous to the planets. By studying this mini-solar system, it should be possible to better understand the actual solar system, how it originated, and what processes affect its evolution.

What are the main physical and orbital properties of Jupiter?

Jupiter is the largest planet in the solar system. Jupiter's radius is eleven times that of Earth, so over 1000 Earths could fit inside Jupiter. Jupiter is more massive than all the other planets combined, having a mass 318 times the Earth's mass. Jupiter spins about its axis with a spin period of 9 hours 55 minutes, about 2.5 times as fast as the Earth spins. There are only small seasonal effects on Jupiter since its spin axis is almost perpendicular to its orbital plane. Jupiter orbits the sun at a distance of 5.2 times the distance of the Earth from the sun. A Jupiter year, the time to complete one orbit about the sun, is 11.9 Earth years.

What is the composition and structure of Jupiter?

Jupiter is composed mostly of hydrogen and helium, the same elements that compose most stars. In fact we expect that Jupiter has basically the same chemical and elemental composition as the sun. If Jupiter were about 80 times more massive, it could produce energy the same way that the sun does, by converting hydrogen into helium. Jupiter does in fact emit its own energy in the form of infrared radiation, but this energy comes from heat left over from the formation of Jupiter 4.5 billion years ago, and heat produced today due to the slight contraction of the planet under the action of its own gravity.

We do not have any direct information on the interior structure of Jupiter, but theoretical models of the interior exist constrained by measurements of Jupiter's mass, volume, and slightly non-spherical shape caused by its rapid spin. We expect that at the center of Jupiter is a rocky core of about 30

Earth masses made approximately from the same rocky materials that the Earth is made from. Surrounding the rocky core and extending to about half the radius of Jupiter, we expect there to be a region of what is termed liquid metallic hydrogen. This form of hydrogen occurs under extreme pressure and temperature, such as exists deep in the interior of Jupiter, and is an electrically conducting liquid form of hydrogen.

Since it is electrically conducting, fluid motions in this region almost certainly produce Jupiter's strong magnetic field, about 10 times stronger than the magnetic field of the Earth. This situation is analogous to the way in which the magnetic field of the Earth is generated by fluid motions in the liquid iron core, which surrounds the inner solid iron core at the center of the Earth. We know about the Earth's interior from earthquake studies, but we do not have such information about Jupiter. Outward beyond the liquid metallic hydrogen region, there probably exists a slurry of liquid hydrogen and helium mixed with gaseous hydrogen and helium. Farther out from the center, hydrogen and helium exist totally in the gaseous phase. This is the region called the atmosphere, and it is the upper part of the atmosphere that will be sampled by the Galileo Probe. Although only the upper atmosphere will be sampled, the information obtained will help understand even the deep interior, because we will obtain basic information on how temperature is related to pressure, a relation that is expected to be true even in the interior regions. Additionally, the chemical composition of the atmosphere will give clues about Jupiter's interior.

In addition to the main constituents hydrogen and helium, the atmosphere of Jupiter contains various trace species, such as ammonia, methane, sulfur, water, and various hydrocarbons. As mentioned before, it is expected that Jupiter will have amounts of the above compounds in the same relative proportions as the sun. However, departures from solar composition may occur and give important insights into how Jupiter was formed and the nature of processes in the inaccessible interior. The Galileo Probe will directly sample the atmosphere and determine its composition, an extremely important science objective.

It is on the basis of a solar composition for Jupiter that we expect there to be three cloud layers in the atmosphere, one composed of ammonia ice crystals, a second cloud deck of ammonia hydrosulfide, and below that a water cloud deck. It is the ammonia cloud layer that we see in pictures of Jupiter. Ammonia ice is colorless, yet we see colorations in the pictures, implying that there must be other compounds mixed in with the ammonia ice. These other compounds, called chromophores, have not been identified, although several possibilities have been suggested. The lower two cloud layers have never been directly observed, and therefore we do not know for sure if they exist, or what their characteristics are if they do exist. Identifying and characterizing the cloud layers is a prime objective of the Galileo Probe.

Are there winds in the Jovian atmosphere and why does the atmosphere have a banded structure?

Pictures of Jupiter, which always view the ammonia clouds, indicate that the clouds tend to be organized into a series of cloud bands which are oriented east-west. The bright bands, called zones, are believed to represent regions where Jovian atmosphere is rising. The darker cloud bands, called belts, are regions where the atmosphere which has risen in the zones is descending back into the deeper part of the atmosphere. By tracking cloud features in photographs taken of Jupiter over a period of time, we know that at the level of the ammonia clouds there exists a system of winds blowing basically in the east-west direction. At the equator, and extending to about 15 degrees latitude north and south, the wind blows in the same direction as Jupiter rotates (eastward), and wind speeds are about 100 meters per second, or about 200 miles per hour. Beyond 15 degrees latitude either north or south, the winds change direction and blow westward reaching speeds of about 50 meters per second. The winds continue to oscillate in direction and diminish in speed as latitude increases, until near 45 degrees latitude the winds appear to die out and the banded structure disappears. It is almost certain that the winds occur at atmospheric levels other than just near the ammonia clouds, but we do not know what the vertical extent of the wind system is either above or below the ammonia clouds. It is known that Saturn, Uranus, and Neptune also have wind systems, and their winds exceed in magnitude those so far observed on Jupiter. Since the energy available to drive winds is far less on these other planets than for Jupiter, we are presented with a major puzzle as to what causes any of these winds. Determining the vertical variation of the winds on Jupiter is a major scientific objective of the Galileo Probe, since the vertical variation will provide important clues as to how the winds are generated. The probe will be tracked during its descent through the atmosphere by the Galileo Orbiter traveling over the probe entry site, and in this way the winds can be measured.

Does Jupiter emit its own energy or does it just re-radiate sunlight?

Jupiter, Saturn, and Neptune radiate about twice as much energy to space as they receive from the sun. This is in contrast to the terrestrial planets Mercury, Venus, Earth, and Mars, which all radiate to space almost exactly the amount of energy received from the sun. In other words, the terrestrial planets are in energy equilibrium with the solar energy input, but the outer planets, at least Jupiter, Saturn, and Neptune, are not. It is theorized that the excess energy being radiated from the outer planets results from heat trapped in the interior of the planet during the time when the planet was accreting material and condensing early in the formation history of the solar system. Some gravitational contraction is continuing even at present and contributes to the energy being released. How this interior energy flow, as well as sunlight, gets distributed in the atmosphere is an important question, which relates to how and where the clouds are formed and what drives the winds. The Galileo Probe will measure the total radiative energy transmission through the atmosphere and determine in what atmospheric regions sunlight and heat from the interior get absorbed, thereby producing higher temperatures, which in turn affect cloud formation and winds.

Is there lightning on Jupiter?

We know from photographs of the night side of Jupiter taken by the Voyager spacecraft (which flew by Jupiter in 1979) that lightning occurs on Jupiter. The lightning events observed by Voyager indicated very intense lightning, about 100 times more energetic than a typical lightning flash on Earth. It is likely that the lightning is generated in the water clouds that we expect to be in Jupiter's atmosphere. However, it appears that most of the lightning occurs near 49 degrees North latitude, and not much occurs elsewhere. If this is actually the case, it is very puzzling. The Galileo Probe will detect lightning if it occurs within about 10,000 km of the probe as it is descending through the atmosphere.

What are the scientific objectives of the Galileo Probe Mission?

- Determine the temperature and pressure structure of Jupiter's atmosphere.
- Determine the chemical composition of Jupiter.
- Determine how many cloud layers exist, their location, and characterize the cloud particles as to size and number density.
- Measure the amount of helium relative to hydrogen on Jupiter to high accuracy.
- Measure the winds in Jupiter's atmosphere and determine how deep in the atmosphere the winds exist.
- Measure how sunlight, and energy coming from the deep interior, are distributed in Jupiter's atmosphere.
- Detect lightning if it occurs, measure how energetic it is, and observe the frequency of occurrence.
- Measure the characteristics of energetic protons and electrons trapped in Jupiter's magnetic field within a few Jovian radii from the planet.