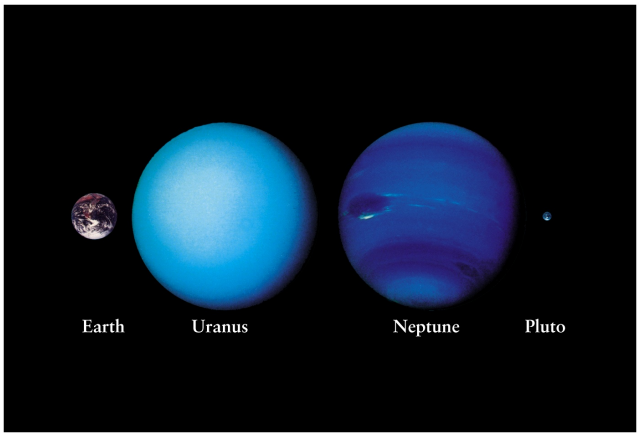
Uranus



The Jovian Planets

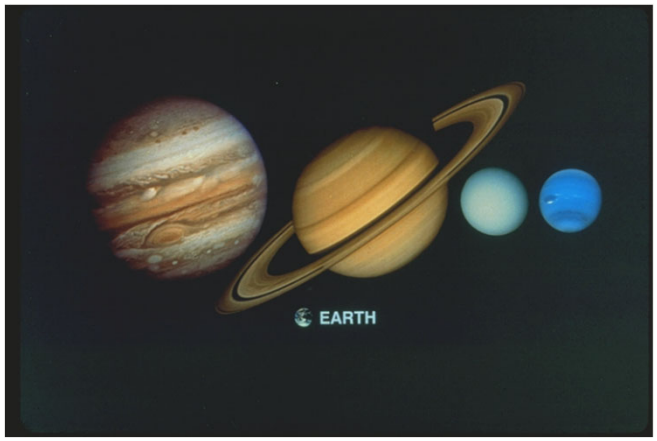
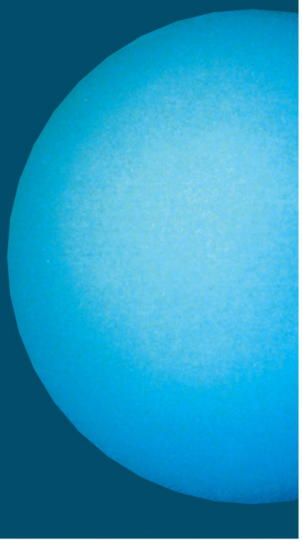


Table 16-1 Uranus Data

Average distance from Sun:	19.194 AU = 2.871×10^9 km
Maximum distance from Sun:	20.017 AU = 2.995×10^9 km
Minimum distance from Sun:	18.371 AU = 2.748×10^9 km
Eccentricity of orbit:	0.0429
Average orbital speed:	6.83 km/s
Orbital period:	84.099 years
Rotation period (internal):	17.24 hours
Inclination of equator to orbit:	97.86°
Inclination of orbit to ecliptic:	0.77°
Diameter:	51,118 km = 4.007 Earth diameters (equatorial)
Mass:	8.682×10^{25} kg = 14.53 Earth masses
Average density:	1318 kg/m^3
Escape speed:	21.3 km/s
Surface gravity (Earth = 1):	0.90
Albedo:	0.56
Average temperature at cloudtops:	−218°C = −360°F = 55 K



(NASA)

Discovery of Uranus

Uranus was discovered on March 13, 1781, by the German-English musician and amateur astronomer William Herschel, who was making a systematic telescopic survey of the sky in the constellation of Gemini. Not a point source, thought it was a comet, until orbit was established as being circular and outside Saturn's. Plotted on star charts 20 times between 1690 and 1781. Wanted to name it Georgium Sidus, in honor of George III.

Appearance and Rotation

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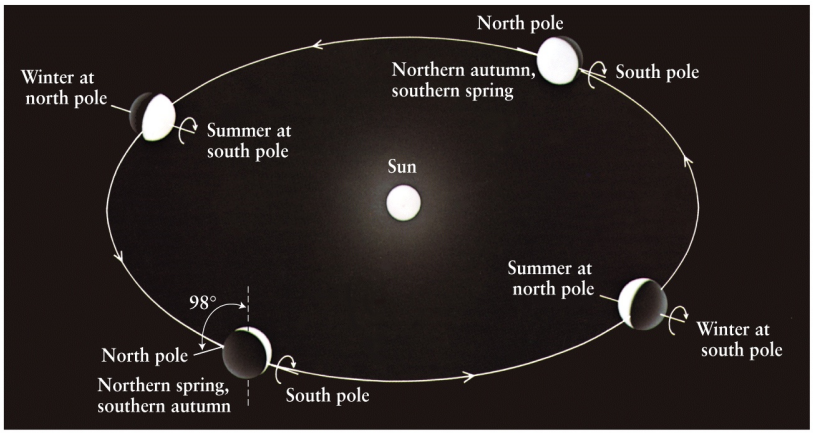
Cannot see much through a telescope. The rotation period of Uranus is 17^h14^m. The axis is tilted by 98^o with respect to the north direction. This unusual tilt creates very strange seasons, with each pole alternately tipped toward the Sun for about 40 years at a time.

Hemisphere Orientations



Universe by Geller, Freedman, and Kaufmann

Exploration

Voyager 2 in 1986.
Voyager carried 11 instruments.

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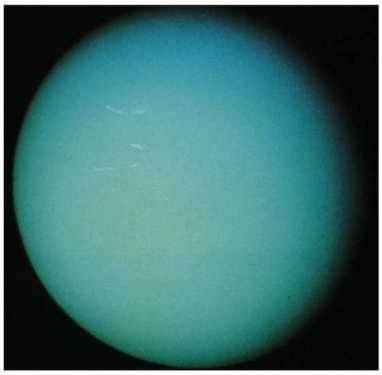

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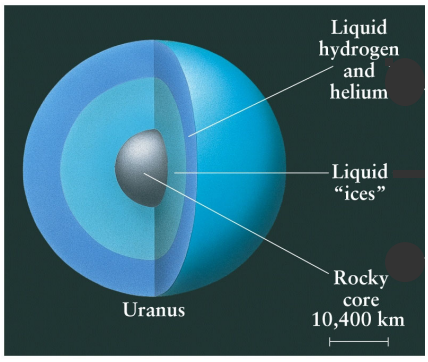
Composition and Structure



Universe by Geller, Freedman, and Kaufmann

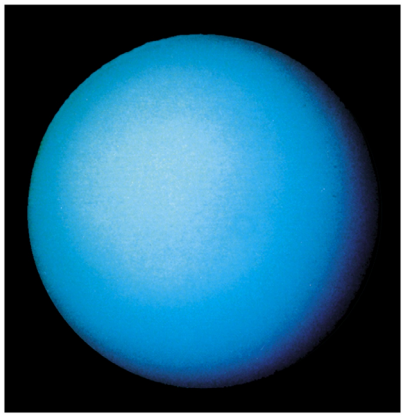
Scientists believe Uranus does not have any metallic hydrogen. On Jupiter and Saturn, the cores constitute only a few percent of the total mass. However, most of the mass of Uranus (and Neptune) resides in the cores, demonstrating that these two planets were unable to attract massive quantities of hydrogen and helium. The core is composed of heavier materials − presumably the original rock-and-ice bodies.

Internal Heat Source

Uranus may or may not have an internal heat source, and, if so, astronomers do not know what causes it.

Atmosphere and Clouds

Composition is primarily H and He, although methane (CH_4) and ammonia (NH_3) were identified first. Uranus' atmosphere has about the same abundance of helium as does Jupiter's.



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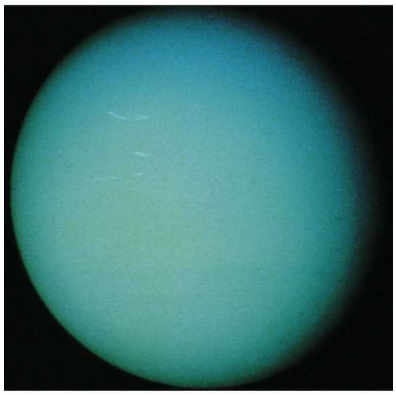
Atmosphere and Clouds

Unlike Jupiter and Saturn, Uranus is almost entirely featureless at nearly all wavelengths. The basic atmospheric structure of this planet should resemble that of Jupiter and Saturn, although the upper clouds are composed of **methane**, rather than **ammonia**.

The absence of an internal heat source suppresses convection and leads to a stable atmosphere with little visible structure. The troposphere is hidden from view by a deep, cold, hazy stratosphere.



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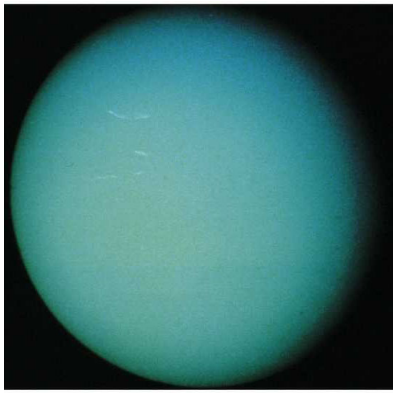
Weather

In spite of the strange seasons induced by the 98^{o} tilt of its axis, Uranus' basic circulation is east to west, just as it is on Jupiter and Saturn. The mass of the atmosphere and its capacity to store heat are so great that the alternating 40-year periods of sunlight and darkness have little effect.

Voyager measurements showed that the temperatures are a few degrees higher on the dark, winter side than on the hemisphere facing the Sun, which is not understood.



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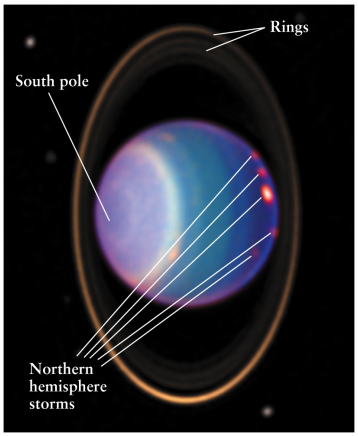
Storms and Winds

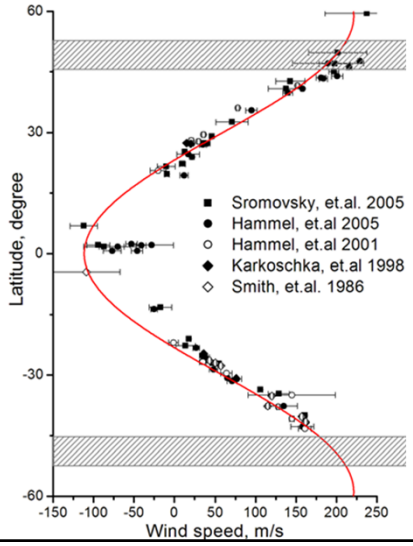


NASA

Voyager saw no storms.

This Hubble IR picture reveals several clouds, though.

Storms and Winds



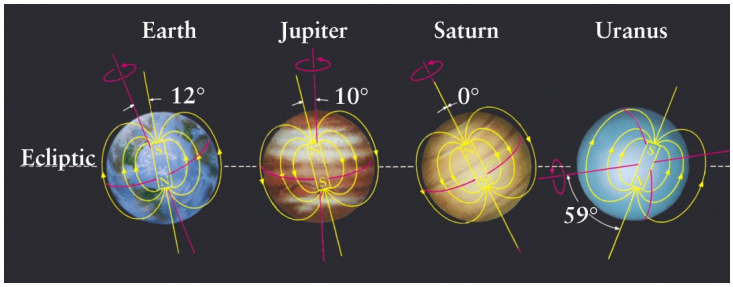
The wind speeds range from 350 - 800 km/hr.

Wind speeds are **faster at the poles** than at the equator.

Magnetosphere

The magnetic field was not discovered until the Voyager flyby. Its strength is comparable to that of Saturn's, about what would be expected from the size of the planet. However, the orientation of the magnetic field is very different.

It is offset from the center of the planet, by about one-third of its radius. In addition, the magnetic field is tilted by 60° with respect to the axis of rotation.



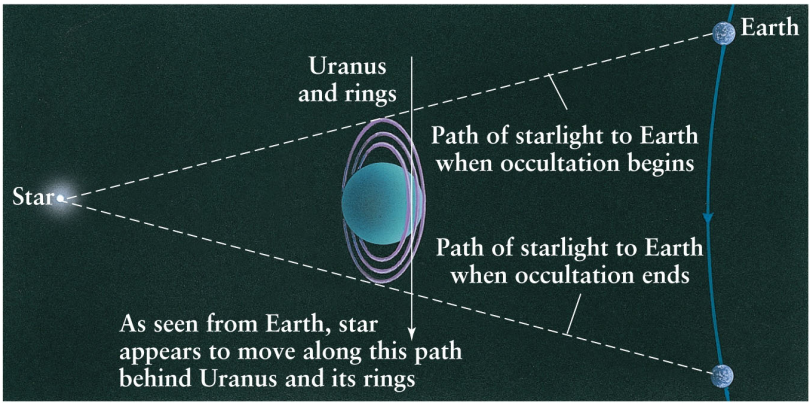
Universe by Geller, Freedman, and Kaufmann

Magnetosphere

Presumably the magnetic fields of the outer planets are generated in much the same way as the field of the Earth. All of these planets spin rapidly, so there is a ready source of energy to power their internal magnetic generators. Jupiter and Saturn have large interior regions of metallic liquid hydrogen that act like the liquid iron core of the Earth.

In the case of Uranus and Neptune, however, **the metallic region may be in the hydrogen-water mantle**, possibly accounting for the large offset of the field from the center of the planet. Although the detailed mechanisms may not be well understood, these planets seem to meet the conditions required for the generation of a planetary magnetic field in a spinning metallic core.

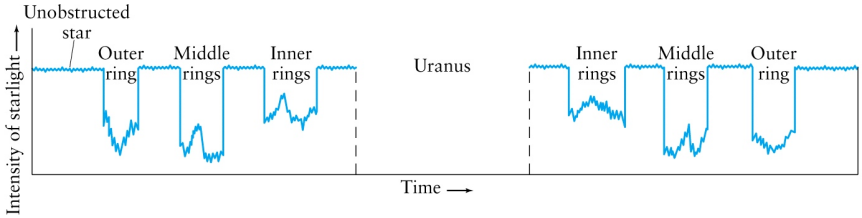
Occultation Orientation



Universe by Geller, Freedman, and Kaufmann

Uranus' Rings

The rings of Uranus are narrow and black, making them almost invisible. They were discovered accidentally in 1977, during observations of the occultation of a bright star by Uranus. About 20 minutes before its predicted occultation, the star briefly dimmed several times as it disappeared behind successive narrow rings. This pattern of ring occultations was repeated later, as the opposite side of each arc passed in front of the star. Additional occultations led to the discovery of a total of 9 narrow rings, and 2 more were added by Voyager.

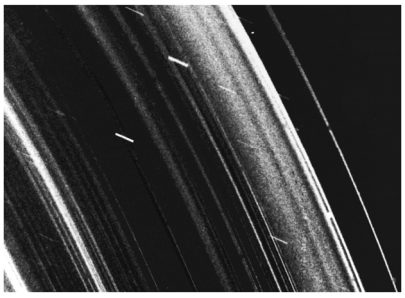


Uranus' Rings

NASA

Despite their low reflectivity (5%), they could be photographed by Voyager. With one exception, all of the other rings are narrow ribbons less than 10 km wide − just the reverse of the broad rings of Saturn.

Uranus' Rings



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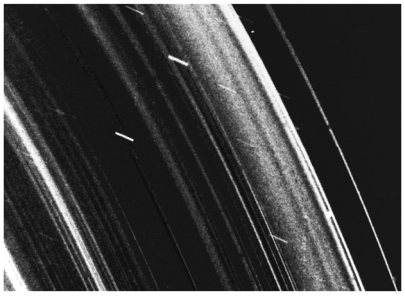
The broadest and outermost of the rings is called the Epsilon ring. The main Epsilon ring is about the width of the Saturn F ring and has an eccentricity of 0.008, although it also has a much wider component of lower density.

Uranus' Rings



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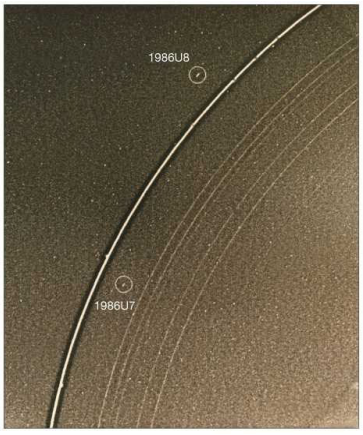
Its thickness is probably no more than 100 m, and it appears that most of the particles are relatively large − several meters or more in diameter. The Epsilon ring is at a distance of 2.2 Uranus radii − near the position of the tidal stability limit. This ring probably contains as much mass as all of the other ten rings combined.

Shepherd Satellites



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The Epsilon ring is shepherded by the moons Cordelia and Orphelia. Each is about 50 km in diameter, and they orbit about 2000 km inside and outside the ring, respectively.

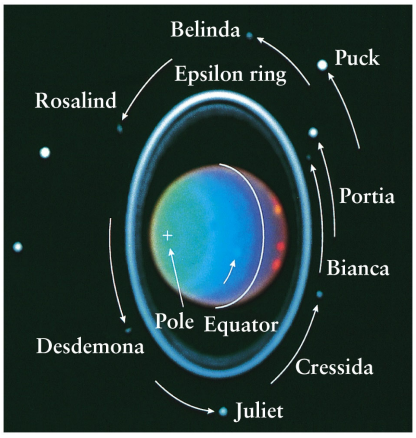
Theoretical calculations suggest that the other narrow rings should also be controlled by shepherd satellites, but none have been located. The diameter for such moons (10 km) was just at the limit of detectability for the Voyager cameras.

Moons of Uranus

The moons share the planet's 98^{o} tilt. The 15 known moons are conveniently divided into two groups: 5 larger bodies and 10 small darker moons, the latter of which are relatively close to the planet. The larger moons have diameters from 500 to 1600 km, similar to Saturn's. Their densities (1.4 to 1.6 g/cm^3) are greater, indicating that there is a smaller proportion of ice relative to rock.

Their surfaces show the spectral signature of water ice, although their reflectivity's are generally lower (20 to 40%), suggesting that their surfaces are "dirtier". The smaller satellites have only 5% reflectivity. These objects are heavily cratered and have been inactive geologically for billions of years.

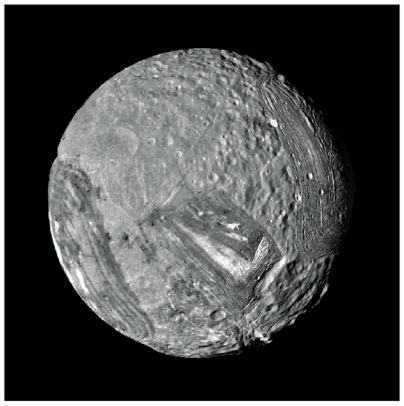
Rings and Moons



NASA

Miranda

Miranda, the smallest (484 km) and innermost of the five main moons, is the most diverse and mysterious. Its surface, like that of Ganymede, consists of both older, heavily cratered terrain and widespread younger structures that nearly defy description.

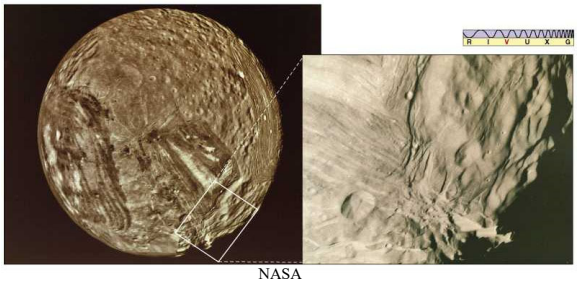


NASA

Miranda

There are great valley systems with gorges as deep as 10 km and complex oval or trapezoidal ranges of mountains. These seem to represent a type of endogenic activity, with fluids erupted to the surface in response to the internal differentiation of the object. It is not known, however, why such activity should have been confined to this one rather small satellite.

It could be that this moon partly shattered and then reassembled itself.



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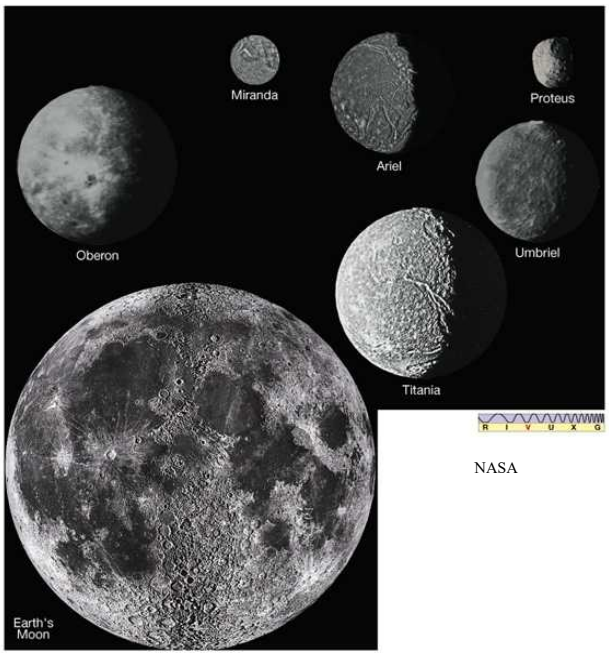
Miranda
Proteus
Ariel
Oberon
Umbriel
Titania
Earth's
Moon
R I V U X G

NASA