

FIGURE 3-17¹



An image of Uranus, captured by Voyager 2 in 1986.

amounts of ultraviolet light, called dayglow, radiated from the sunlight hemisphere.

Uranus has a magnetosphere with intense radiation belts and radio emissions. Its magnetic field axis is tilted 60° to the rotational axis. This magnetic field is comparable to Earth's in intensity, but it is more irregular because it is offset from the planet's center. Uranus' magnetic field may be generated by an electrically conductive, super-pressurized ocean of water and ammonia located between the planet's atmosphere and rocky core. A rotating cylindrical magnetotail extends at least 10 million km (6 million miles) behind the planet. It is twisted into a long corkscrew shape by the planet's extraordinary rotation.

Uranus has narrow rings that are distinctly different from Jupiter's and Saturn's. These rings are very dark and are composed mainly of large icy chunks several feet across. Intense irradiation may have darkened any methane trapped in their icy surfaces. Collisions between the ice chunks may create the fine dust that appears to be spread throughout the ring system. Atmospheric drag due to a hydrogen corona that *Voyager 2* observed around Uranus may cause dust particles to spiral into the planet. Incomplete rings and varying opacity in several of the main rings suggest

that the ring system may have formed after Uranus. Ring particles may be remnants of a moon that was broken by a high-velocity impact or torn apart by gravitational effects.

Uranus's Moons

Uranus has five large moons and at least twenty-two small moons. The largest moons appear as tiny bright dots through our large telescopes. Titania was the first moon discovered, in 1787, and Miranda the last, in 1948. *Voyager 2* found that the moons are dark gray ice-rock conglomerates, composed of about 50 percent ice, 20 percent carbon and nitrogen-based materials, and 30 percent rock. Miranda, the smallest of the five larger moons, has the strangest appearance. It has huge fault canyons as deep as 20 km (12 miles), terraced layers, a chevron feature, large relief mountains, ridges, and rolling plains. This mixture of different terrain types on older and younger surfaces suggests that Miranda has been affected by tectonic activity, violent impacts, and tidal heating caused by Uranus's gravitational pull.

Uranus' two largest moons, Titania and Oberon, are about half the size of Earth's moon. Ariel has the brightest and possibly youngest surface, with many fault valleys and what appear to be extensive flows of icy material. Titania has huge fault systems and canyons that provide evidence of past geologic activity. Umbriel and Oberon have the darkest appearance of Uranus' largest moons. Their surfaces are heavily cratered and old, indicating little past geologic activity. Ten smaller moons of Uranus were discovered by the *Voyager 2* spacecraft. Puck, the largest of these, is 155 km (96 miles) in diameter. The smaller moons are composed of more than half rock and ice. Uranus' other small moons were discovered by the Hubble Space Telescope and Earth-based telescopes.

Neptune

Like Uranus, the planet Neptune has a thick hydrogen, helium, and methane cloud cover that gives it a bright blue appearance. Long bands and several large spots are also visible in Neptune's atmosphere. When *Voyager 2* flew within 5,000 km (3,000 miles) of Neptune in 1989, the planet was more distant from the Sun than Pluto. The eight thousand images *Voyager* sent back gave us our first good look at the Neptunian system (FIGURE 3-19). Neptune's discovery was a triumph for theoretical astronomy. Uranus did not follow the path Newton's law of gravity predicted it should. Astronomers John Adams