Voyager Bulletin

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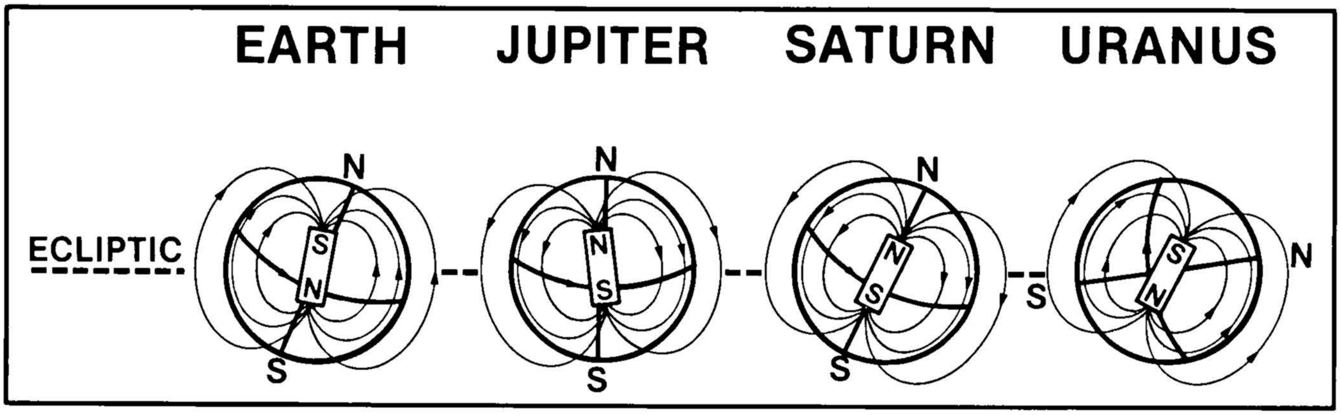


A planet's rotational axis is not necessarily perpendicular to the ecliptic plane, the magnetic axis is not necessarily aligned with the rotational axis, and the magnetic poles do not always correspond to the rotational poles. In the case of Uranus, the magnetic axis is inclined 55° below the rotational axis, which is inclined 8° below the ecliptic. In this diagram of Earth, Jupiter, Saturn, and Uranus (not to scale), the rotational axes are shown by straight solid lines bisecting the planets; the magnetic axes are shown by the bar magnets; the ecliptic plane is the dotted line through the center of the diagram; and the direction of rotation and wind flow is shown by the arrowhead on the curved line at each planet's equator. Magnetic field lines extend into space and form a "cage" around a planet, trapping charged particles and sweeping them around in space as the planet rotates.

The Magnetosphere

Voyager 2 discovered that Uranus not only has a magnetosphere, but that it is a very large and wonderful magnetosphere.

One may think of a magnetosphere as a windsock-shaped object surrounding a planet, with its head toward the Sun and its tail streaming behind it in the solar wind. The magnetosphere is formed when energetic particles are trapped within a planet's magnetic field lines. Earth, Jupiter, and Saturn all have substantial magnetospheres—in fact, were it visible, Jupiter's magnetosphere would appear to an observer on Earth to be larger than the full moon. Mercury has a small magnetic field, while Venus and Mars have virtually no magnetic fields. Uranus' magnetic force is about the same as that at Saturn and Earth.

Envisioning a bar magnet in the interior of Uranus, this magnet is tilted 55° below the rotation axis, which is already tilted 8° below the ecliptic plane. In addition, the polarity of this bar magnet is similar to the situation at Jupiter and Saturn and opposite to the situation at Mercury and Earth. (Earth's south magnetic pole is currently near its north rotational pole; there is evidence that the Earth's polarity has reversed many times in the past.)

The combined effect of the extreme tilt of the magnetic axis and the tilt of the rotational axis is that the planet's magnetotail is swept around in space like a corkscrew. Plasma in the tail undergoes magnetic field reversals as the magnetic axis rotates.

The character of a planet's magnetic field can provide clues to the interior of the planet. A magnetosphere indicates that an electrically conducting region within the planet is being mechanically stirred. Uranus' magnetic field is probably generated in electrical currents in its ion-laden ocean layer.

As charged particles are swept around with the rotation of a planet's magnetic field, natural radio signals are created. Radio emissions from Uranus were not detected until January 16, much later than expected. The radio emissions are used to determine the rotation rate of the planet's interior, where the magnetic field is generated.

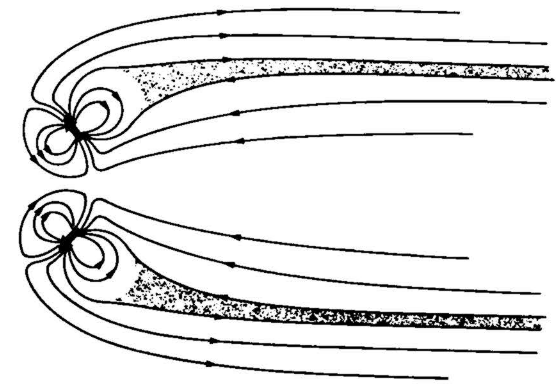
At the boundary of the solar wind and a planetary magnetosphere, a shock wave exists. Voyager 2 experienced the Uranian bow shock over 17,000 kilometers from the planet on January 23, 10-½ hours before closest approach. Three hours later, the spacecraft passed out of the turbulent magnetosheath area and into the magnetosphere proper.

Uranus' rings and the satellites Miranda, Ariel, and Umbriel are within the sunward magnetosphere. As the satellites orbit, they cut a swath through the charged particles in the magnetosphere.

In the outer magnetosphere, the particles are mostly ionized hydrogen, quite different from Earth, Jupiter, and Saturn.

Uranus also possesses radiation belts similar in intensity to Earth's Van Allen radiation belts. The darkness of the satellites and rings may be a result of radiative separation of hydrogen and carbon from the methane ice on their surfaces.

The temperature of the hot plasma of the radiation belts exceeds 500 million degrees, yet the density is so low that exposed flesh would freeze instantly.



The large offset between Uranus' rotational and magnetic axes causes the planet's magnetotail to twist as the planet rotates as seen in these mirror images.

The Rings

The Uranian ring system seems to be distinctly different than the rings of Jupiter or Saturn. Radio observations showed that the Uranian rings seem to be composed mostly of boulder-sized particles, greater than 1 meter in diameter. However, a very tenuous distribution of fine dust seems to be spread throughout the ring plane. Such dust may be formed by collisions between larger ring particles, and is thought to be swept out of the ring system in some way.

The rings also vary slightly in color, indicating slightly differing composition in different rings.

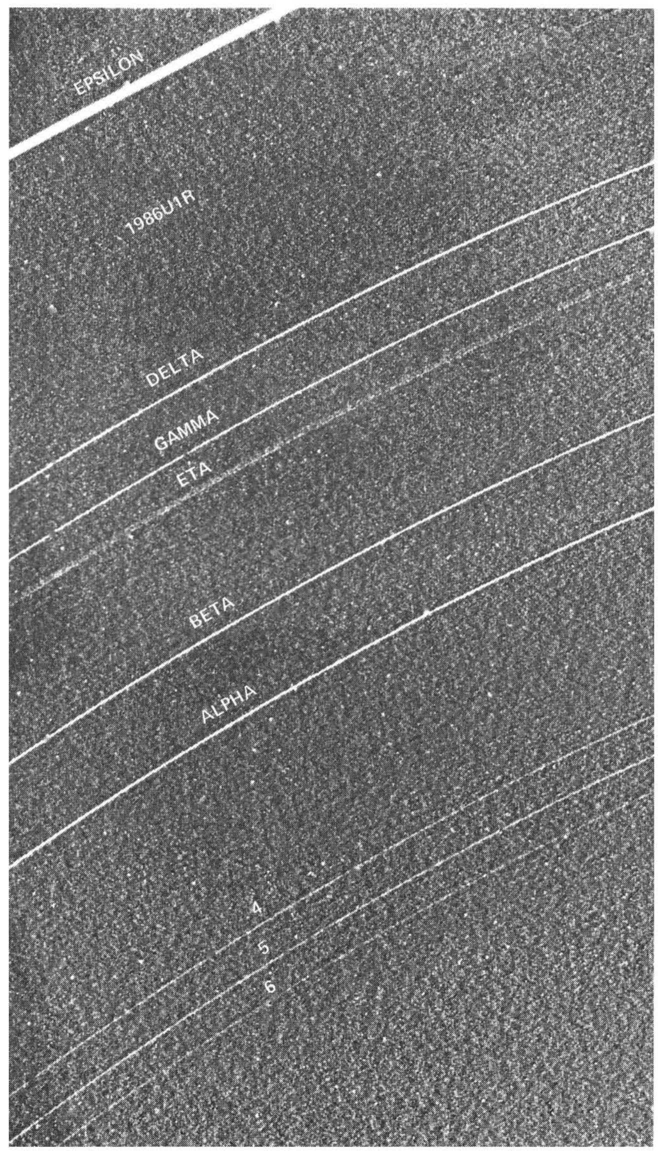
While no braided rings were found, there may be a number of very narrow or even incomplete rings (arcs). The mechanism for these is unknown.

The discovery of two tiny satellites flanking the epsilon ring strengthened the theory of "shepherding moons" developed from observations at Saturn. Such moons appear to be the mechanism that keeps ring material orbiting a planet rather than escaping into space.

Other small satellites were expected to be seen in the rings, but the data are still being analyzed.

As Voyager 2 crossed the plane of the rings (but far outside the rings themselves) the plasma wave instrument detected a large number of dust impacts on the spacecraft. This diffuse dust cloud or ring may be several thousand kilometers thick. Voyager 2 crossed the ring plane about 115,000 kilometers from the center of the planet, inside the orbit of Miranda.

Mountains of data remain to be analyzed. The photopolarimeter, for example, returned 1.5 million discrete measurements as it watched starlight stream through the rings, while the radio experimenters obtained 5 billion measurements which have to be shuffled 1 million times in 1 million steps to account for diffraction of the radio signal.



Voyager 2 1/23/86 1.12 million km (690,000 mi.)

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National Aeronautics and
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Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

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Status Bulletin Editor: Anita Sohus .... (818) 354-4438
Public Information Office .... (818) 354-5011
Recorded Mission Status .... (818) 354-3051