Voyager

B U L L E T I N

MISSION STATUS REPORT NO. 84 **JANUARY 30, 1989**

Update

Voyager 2 is 4.36 billion kilometers (2.71 billion miles) from Earth. Neptune lies 298.95 million kilometers (185.76 million miles) and slightly more than six months ahead. With a velocity of about 18.9 kilometers per second (42,380 miles an hour), Voyager 2 travels over a million miles a day.

The radio science team is completing an eight-week period of solar observations. Each year, when the Earth moves to the opposite side of the Sun from the spacecraft, the spacecraft's radio signals can be used to probe the atmosphere of the Sun. Strong, measurable changes occur in Voyager 2's radio signal as the signals pass through the solar corona. Radio scientists will study small-scale (about 100 kilometers) variations of plasma (hot ionized gases) in the solar region, as well as map the plasma density of the solar wind and corona.

Encounter Period Overview

The Neptune encounter period will officially begin on June 5, 1989, eighty-one days before Voyager 2's closest approach to Neptune. The first 62 days are called the "observatory" phase, and will consist of continuous observations of the Neptunian system and numerous pre-encounter calibrations (checkouts) of Voyager 2's instruments. Science observations will include repeated scans across the entire Neptunian system with the ultraviolet spectrometer to look for neutral hydrogen and excited ions. The imaging cameras will monitor long-term atmospheric motion on the planet and search for ring arcs and satellites. A trajectory correction maneuver is scheduled for August 1.

On August 6, 1989, nineteen days before closest approach, the "far encounter" phase will begin. By then, at least two narrow-angle camera frames will be required to capture the entire planet and the ring-arc region. Satellite observations, detailed ring observations, and infrared observations of Neptune will begin. Two trajectory correction maneuvers are scheduled during this period, on August 15 and August 21, to fine-tune the spacecraft's flight path.

The "near encounter" period, from August 24 to August 29, will contain all of the highest value Neptune science, including a distant look at tiny Nereid, a close swing over Neptune's north pole, and a close look at Triton, as well as characterization of Neptune's magnetic field and searches for possible ring arcs and other satellites.

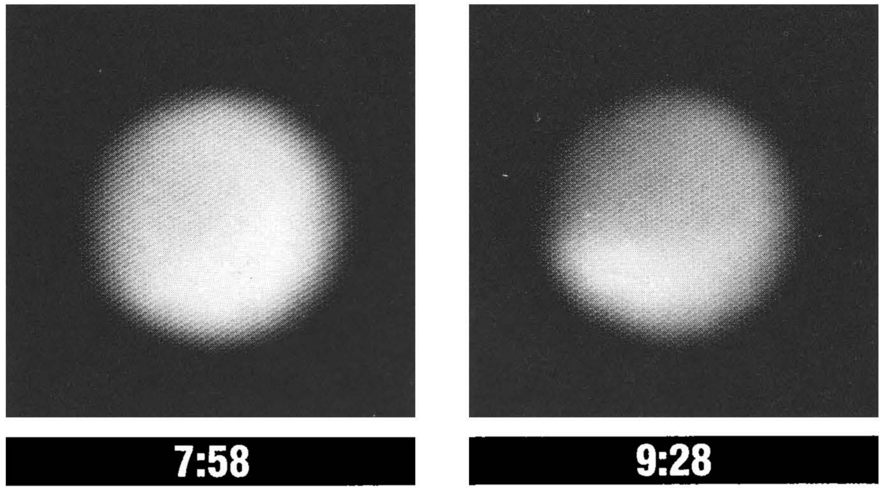
Voyager 2 will pass about 4,850 kilometers (3,000 miles) above the cloudtops of Neptune at about 76° north latitude (which would be far north of the Arctic Circle on Earth, for example). This will be Voyager 2's closest approach to any object in the solar system since it left Earth nearly twelve years ago.

Voyager 2's aimpoint at Neptune has been carefully chosen to bend the flight path sharply below the equator again, where Voyager 2 will intercept Neptune's large moon Triton at a distance of about 40,000 kilometers (25,000 miles) five hours after the spacecraft's closest approach to Neptune.

Once past Neptune, Voyager 2 will continue to observe the Neptunian system on a continuous basis for five more weeks, until October 2, 1989. Observations of the dark side of Neptune and post-encounter calibrations will be important activities during this post-encounter period.

Neptune will be Voyager 2's last planetary encounter, but the spacecraft's job will be far from over. Both Voyagers 1 and 2 will continue to return data on magnetic fields and charged particles in space, and their ultraviolet spectrometers will continue to observe ultraviolet sources among the stars. Voyager 2 will

Images of Neptune taken over a five-and-one-half hour period on July 14, 1988 clearly show cloud features moving across the disk as the planet rotates. These Images were taken at 6190 angstroms, the same wavelength as the methane-band filter on Voyager 2's wide-angle camera. (Times shown are GMT.) (H. Hammel, JPL)



also join the search for the edge of the heliosphere, that area of space dominated by the Sun's magnetic field. The planetary adventures of Voyager 1 and Pioneers 10 and 11 are over and they are already searching for the heliopause, a boundary region between the Sun's magnetic influence and interstellar space. Scientists will recognize that the spacecraft is approaching the heliopause when the spacecraft senses the termination shock where the solar wind, traveling at supersonic velocities up to a million miles an hour, abruptly decreases to about one-fourth that velocity. Perhaps by the next century, one of these spacecraft will pass beyond the heliopause into true interstellar space.

Spring '89 Overview

Test and Training

In preparation for the first-ever encounter with Neptune, the Voyager Flight Team is undergoing a program of training and tests to familiarize all Flight Team personnel with the equipment, software, data formats, facilities, procedures, and interfaces to be used during and in support of Neptune encounter operations.

The training started in October 1988 with intra-team training. Integrated flight team training began in late January and will culminate in late May 1989 with a full dress rehearsal simulation of near-encounter activities. The near-encounter test (NET) will simulate an intensive 12-hour period of events that will occur during the real encounter in late August. The intent is to demonstrate that the spacecraft and all personnel, equipment, software, and procedures—both at JPL and within the Deep Space Network and its affiliated tracking stations—will perform as required to capture the encounter data. As in the past, the test and training exercises are intended to ferret out problems that need to be solved before encounter.

A trajectory correction maneuver (TCM) is currently scheduled for April 20. This maneuver will target Voyager 2's flight path closer to the desired aimpoint at Neptune by about 3,800 km (2,400 miles). Voyager 2 will be instructed to expend some of its hydrazine propellant to obtain a velocity change of about 0.35 meters per second (less than one mile per hour).

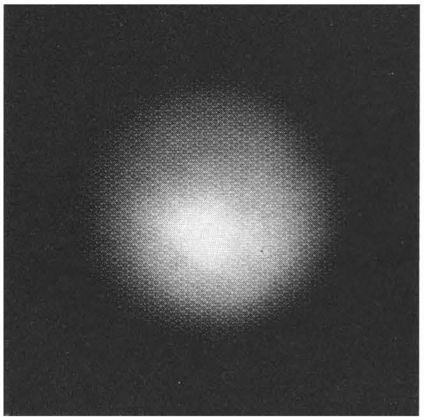
This TCM is a test of a new technique in which the spacecraft's antenna will continue to point toward Earth during the maneuver. The directional change will be achieved by causing the spacecraft to drift in the desired direction by commanding a series of turns about the roll axis.

During a typical TCM, the spacecraft is first re-oriented (usually causing the antenna to point away from Earth, and thus temporarily making it impossible to communicate with the spacecraft), and then hydrazine propellant is expelled from the thrusters, giving the desired velocity change in the desired direction.

There are at least two benefits of the new roll-turn technique: 1) communications with the spacecraft will be maintained throughout the maneuver, and 2) finer control will be achieved over the spacecraft's directional change. The roll-turn technique will be used, if needed, just days before Voyager 2's closest approach to Neptune to fine-tune the aimpoint. In April, three pairs (wind and unwind) of 180° roll turns will be used.

New News about the Neptunian System

The imminent encounter with Neptune has sparked increased Earth-based observations of Neptune's system, and some of the new information is summarized below.



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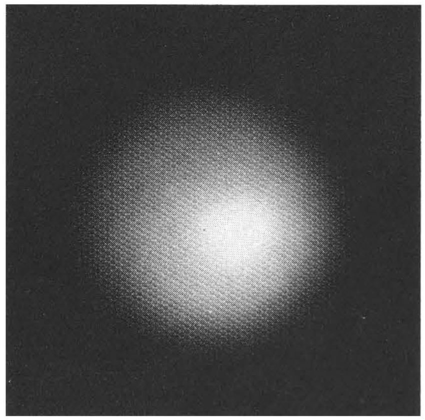

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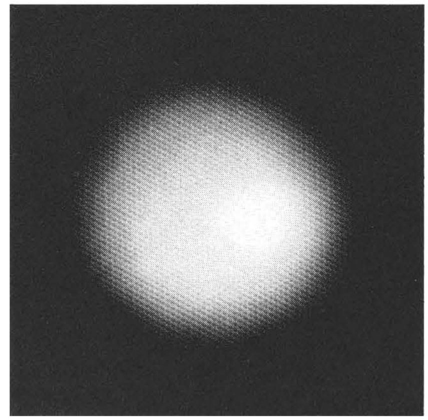

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Neptune

Using the Infrared Telescope Facility (IRTF) at Mauna Kea, Hawaii, Dr. Heidi Hammel of JPL has detected discrete cloud features moving across the disk of Neptune as the planet rotates. These features are clearly visible at 6190 angstroms, the same wavelength as the methane-band filter on Voyager's wide-angle camera. As Voyager 2 gets closer to Neptune, these features should become apparent in Voyager images. Dr. Hammel also reports that clouds at 38° south latitude have a rotation period of 17 hours, while at 30° south latitude the cloud rotation period is 17.7 hours. In addition, she reports a deep haze (down to an atmospheric pressure level of about 100 millibars) at the south pole, and a higher haze (down to about 50 millibars) at the north pole and in the northern hemisphere.

Spectrophotometry observations indicate that Neptune may have a three-layer cloud structure of icy hydrocarbons, a thin methane haze, and a hydrogen sulfide cloud.

Magnetosphere

Using the Very Large Array of antennas in New Mexico, Dr. Imke de Pater of the University of California at Berkeley has detected synchrotron radiation emissions from Neptune. Synchrotron radiation is an indication of the presence of a magnetic field, as charged particles are trapped by a planet's magnetic field and swept around in space by the planet's rotation. Dr. de Pater's calculations indicate that the strength of Neptune's field is 1/2 to 1 gauss. By comparison, the surface field strength of Earth's magnetic field ranges from 0.3 gauss near the equator to 0.7 gauss near the magnetic south pole.

Triton

Estimates of Triton's size are shrinking as some researchers now believe that the largest diameter that Triton could have is about 4,000 km (2,500 mi).

Judging from light reflected by Triton, the satellite's temperature may be about 52 kelvins (K) (about -365°F) for a diameter of 3760 ±780 km (2340 ±480 mi).

Voyager imaging observations indicate that Triton probably is relatively bright and has a somewhat hazy atmosphere, although not as hazy as the atmosphere of Saturn's moon Titan.

Atmospheric pressure models for Triton range from 86 microbars (if the atmosphere is methane only) to 17 millibars (methane and nitrogen). (One bar is the atmospheric pressure of Earth's nitrogen-rich atmosphere at the surface of Earth.)

If Triton's spin axis lies close to Triton's orbital plane instead of perpendicular to it, there may be substantial tidal heating of Triton's surface. (Tidal heating is responsible for the volcanic activity on Jupiter's moon Io.)

There is still controversy and disagreement about Triton's composition. Some laboratory experiments on the spectra of mixtures of liquid nitrogen and methane show a reasonable match to Triton spectra. In this case, solid nitrogen and methane frosts could result in a "solid ocean" of nitrogen 15 to 20 centimeters (6 to 8 inches) deep with methane ice below this.

However, telescopic observations of Triton's spectrum show seven bands of methane and one band attributed to molecular nitrogen, but the physical states—solid, liquid or gas—of these materials are not known. The astronomers who made these observations believe that frozen methane and nitrogen probably exist on the surface, but that the surface may be obscured by a thin haze of photochemical smog similar to that found on Saturn's moon Titan, and more recently, on the planet Pluto.

While water ice was suspected on Triton in data of the early 1980's, newer data do not show it. No evidence for water on Triton has been seen in photometric data in the 3 to 4 micron range. Triton's spectrum has changed significantly since about 1983 or 1984, perhaps in response to the approach of "maximum summer" (a period when the Sun will shine most directly on the southern hemisphere due to the tilt of the satellite's orbit plus the tilt of Neptune's rotational axis).

If Neptune's magnetosphere is large enough to envelop Triton, then a plasma torus may exist around Neptune, with Triton as the source. Voyager's plasma instrument should be able to detect such a torus if it exists.

Nereid

Nereid has a semimajor axis (the radius of its orbit) of 5,515,000 km, an orbital eccentricity (deviation from perfectly circular) of 0.75, and takes 360.15 days to orbit Neptune. In addition, Nereid's spin axis is tilted 27.6 degrees from perpendicular to Neptune's equatorial plane.

Current estimates of the diameter of Nereid range from 290 to 1060 km (180 to 660 mi). The satellite may be oblong in shape and have a rotation period of 2-1/3 to 4-1/3 days.

A Look at 1989 In Space Exploration

January 29	*Soviet Phobos II Spacecraft enters Mars orbit*
February	*Third Tracking and Data Relay Satellite (TDRS) launches*
April	*Soviet Phobos II lands on Phobos*
April 28	*Magellan Venus radar mapper mission launches*
June 5	*Voyager 2 Neptune Encounter period begins*
August 25	*Voyager 2's closest approach to Neptune*
October 2	*Voyager 2 Neptune Encounter ends*
October 12	*Galileo Jupiter orbiter and probe mission launches*
December 11	*Hubble Space Telescope launches*

Rings?

And finally, the question of Neptunian rings remains open. Out of 110 observed occultations of stars by Neptune, only 8 occultations produced effects that could be attributed to rings or ring arcs near Neptune. Small satellites shepherding ring particles at Neptune could be as small as 10 kilometers (6 miles) in diameter at distances of a few hundred kilometers. And, going far out on a limb, simulations show that polar rings around Neptune would be stable.

Observations and analyses of Neptune continue in support of detailed planning for the Voyager encounter next August.

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