Voyager BULLETIN

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Neptune Images

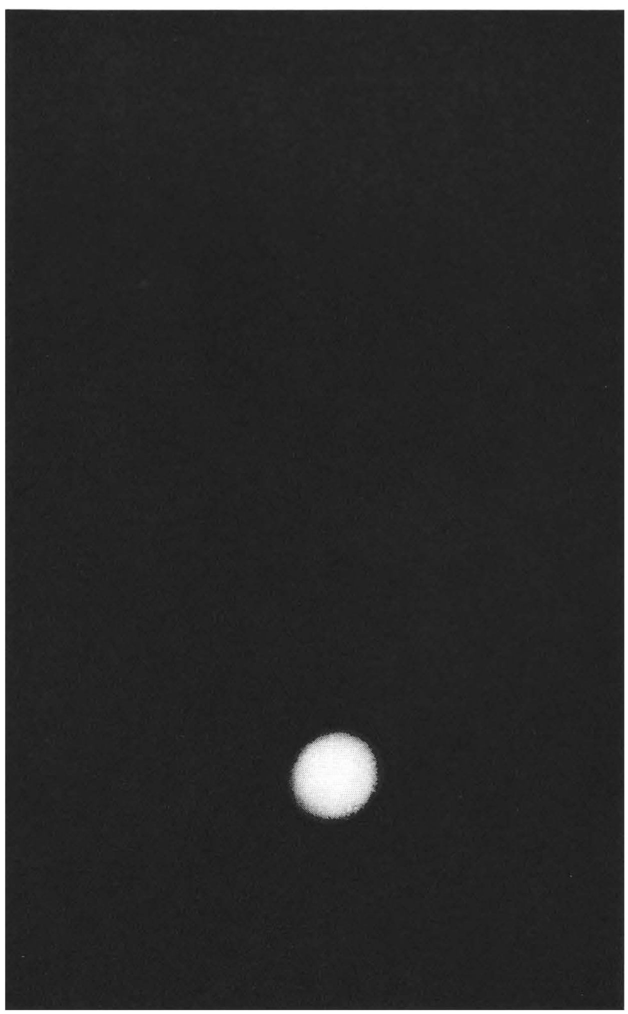
The resolution of Voyager 2 images of Neptune now exceeds that of Earth-based images. Neptune is now about 8 pixels (picture elements) in diameter (a Voyager image frame is 800×800 pixels). The image below was reconstructed in color from images taken through Voyager 2's narrow-angle camera's clear and green filters, using data from Earth-based telescopes to aid in the process.

Because Triton still appears smaller than a pixel, its image has been enhanced to 40 times its natural brightness to make it visible. Triton is closer to the viewer than is Neptune in this image.

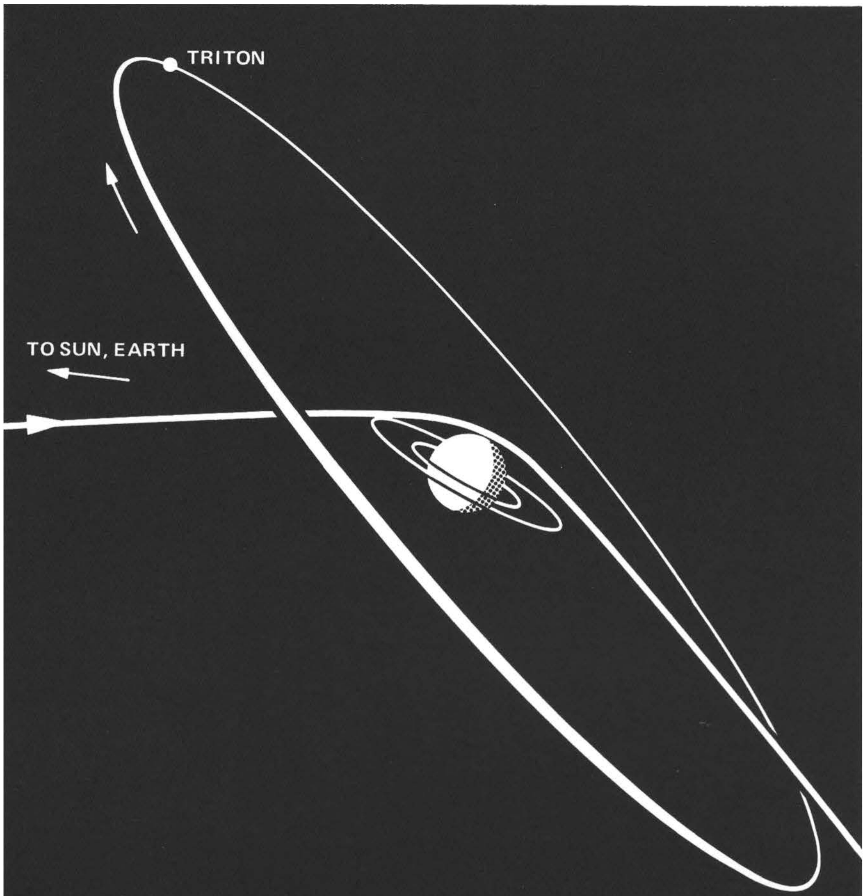
Neptune appears elongated because of slight spacecraft motion during the long (15-second) exposure, and appears bluish-green because methane gas in its atmosphere absorbs longer red wavelengths. Neptune is about 49,530 kilometers (30,780 miles) in diameter.

Scientists expect to be able to see giant cloud systems on Neptune as Voyager 2 continues to approach the planet. Closest approach to the planet will be on August 25, 1989.

Triton appears reddish-yellow, an effect caused by absorption of ultraviolet and blue wavelengths. Organic materials derived from methane may exist on the moon's surface or in its atmosphere. Triton is about 3,600 kilometers (2,200 miles) in diameter. It orbits Neptune at about 355,000 kilometers (220,600 miles) and is retrograde—it orbits in a direction opposite that of Neptune's rotation. The plane of its orbit is inclined about 160° to Neptune's equator. It is believed that Triton always keeps the same face toward Neptune (a phenomenon known as synchronous rotation).



Voyager 2 captured this inbound view of Neptune and its large moon Triton on May 9, 1988 from 685 million kilometers (426 million miles).



The positions of Neptune and Triton are shown on May 9, 1988, when the image on page 1 was obtained. This view is shown at a 90° angle from the flight path.

The spacecraft is inbound from the left. Triton is in a retrograde orbit at an angle of 160° to Neptune's equator and a period of 5.88 days.

What does Neptune look like?

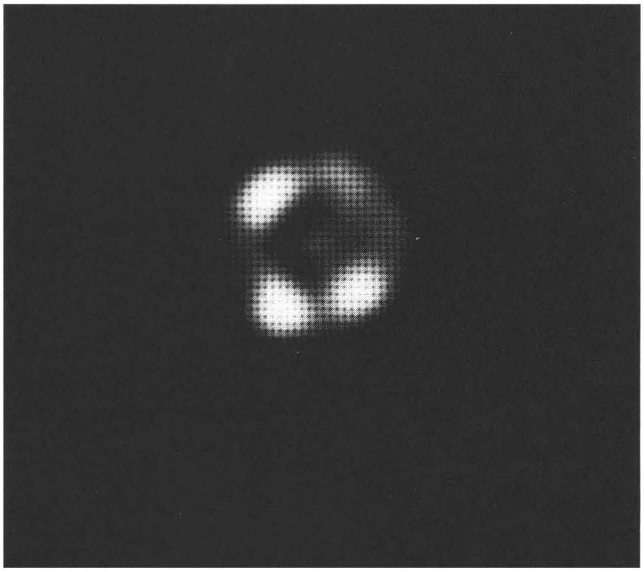
What will Neptune look like as Voyager 2 sails ever closer? Will we see the wild and brilliant oranges and whites of Jupiter? The muted butterscotch of Saturn? Or the tranquil blue of Uranus? The answer is probably none of these. What we will see in Neptune's atmosphere depends upon what gases are in the atmosphere, the temperature of the planet, what chemical processes are taking place, the wind speeds on the planet, and other effects. At 30 AU, the amount of sunlight that Neptune receives is 900 times less than what Earth receives, and less than half of what Uranus receives. And yet, Neptune's temperature is almost identical to that of Uranus. This must be due to heat coming from Neptune's interior. The low level of incoming light and heat and much higher (than Uranus) level of internal heat are sure to have a profound effect on processes in Neptune's atmosphere.

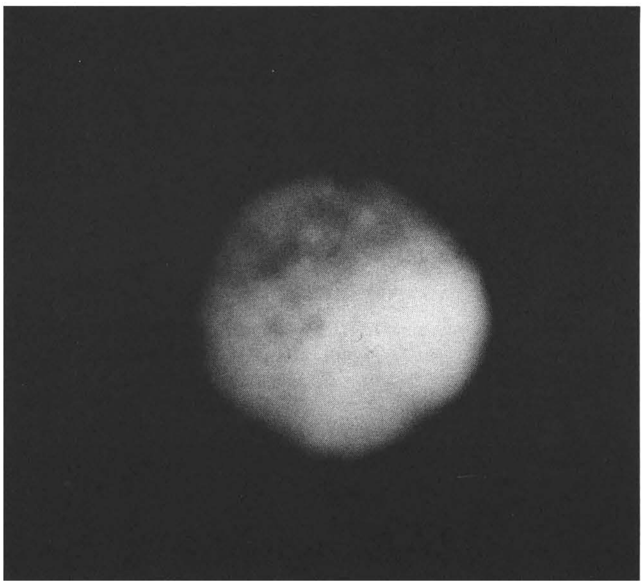
While Neptune's atmosphere is primarily composed of hydrogen and helium (as are the atmospheres of the other outer planets), about two-and-one-half to three percent of the atmosphere is methane (on Earth we commonly know it as "natural gas"). The methane at Neptune absorbs longer wavelengths of red light, and thus only the blues and greens are reflected to us, giving Neptune its bluish-green color.

Voyager 2 is still more than a year and more than 600 million kilometers (370 million miles) from Neptune. In images taken to help navigate the spacecraft, the planet appears featureless. However, using Earth-based telescopes, astronomers have seen large-scale bright cloud features on the planet that have changed over the last several years. Although these features are seen at infrared wavelengths inaccessible to Voyager, as the spacecraft continues to approach the planet, similar features should become apparent in Voyager images.

Each Voyager spacecraft carries a narrow-angle 1500-mm reflector telescope and a wide-angle 200-mm refractor telescope. Each is equipped with a vidicon (a TV camera tube), shutters, filters, power supply, and other electronics. Each camera has eight filters: two clear, two green, and one each of violet, blue, orange, and ultraviolet on the narrow-angle camera, and blue, clear, violet, sodium (yellow), green, orange, and two methane filters on the wide-angle camera. Thus, the cameras can detect wavelengths in the range from 3450 angstroms (ultraviolet) to 6200 angstroms (visible orange). (The human eye can see in the range from about 3800 to 6800 angstroms.)

In May 1983, photographs of Neptune taken from Earth showed three bright cloud features—each about the size of Earth—rotating around Neptune. Two were in the southern hemisphere and one in the northern hemisphere. The images were taken by Dr. Richard Terrile of JPL and Dr. Bradford Smith of the University of Arizona, using a highly sensitive charge coupled device (CCD) camera and a planetary coronagraph on the





Images taken from Earth-based telescopes in 1983 (top) by Terrile and Smith and in 1986 (below) by Hammel show dynamic changes in Neptune's atmosphere.

2.5-meter du Pont Telescope at the Carnegie Institution's Las Campanas Observatory in Chile. They observed in the 8900-angstrom wavelength band, a methane band (one angstrom is one ten-billionth of a meter). The clouds are believed to consist of methane ice crystals very high in Neptune's gaseous atmosphere. The clouds are thought to be higher than the rest of the visible atmosphere. They reflect sunlight before it penetrates deep enough in the atmosphere to be absorbed by the methane and thus the clouds appear brighter than the rest of the planet.

Images taken since 1986 by Dr. Heidi Hammel of JPL, using a CCD on the University of Hawaii's 2.2-meter telescope at Mauna Kea Observatory in Hawaii, show that the bright cloud in the northern hemisphere is now gone. Dr. Hammel observed a general brightening in the southern hemisphere at several different methane wavelengths, including one (6190 angstroms) that is the same wavelength as the methane filter on Voyager's wide-angle camera. By the spring of 1989, cloud features may become apparent in Voyager images taken through the methane filter.

Frederick L. Scarf

Dr. Fred Scarf, principal investigator for Voyager's plasma wave science investigation, died July 17 in Moscow. Dr. Scarf had been in Moscow to attend an international space meeting; he was co-investigator for the plasma wave investigations on the Soviets' dual-spacecraft Phobos mission to Mars, launched July 7 and 12.

Dr. Scarf, a theoretical physicist, was chief scientist for space research and technology at TRW, Inc., in Redondo Beach, CA. He was a principal investigator on Pioneers 8 and 9 and the Pioneer Venus Orbiter, and was instrumental in diverting the Earth-orbiting International Sun-Earth Explorer-3 [renamed International Cometary Explorer (ICE)] satellite to study the comet Giacobini-Zinner several months before an international spacecraft armada reached Halley's Comet. He was involved in several programs of the European Space Agency and the Japanese space program.

The Voyager Project extends its deepest sympathy to his family. Plans for a memorial scholarship are pending.

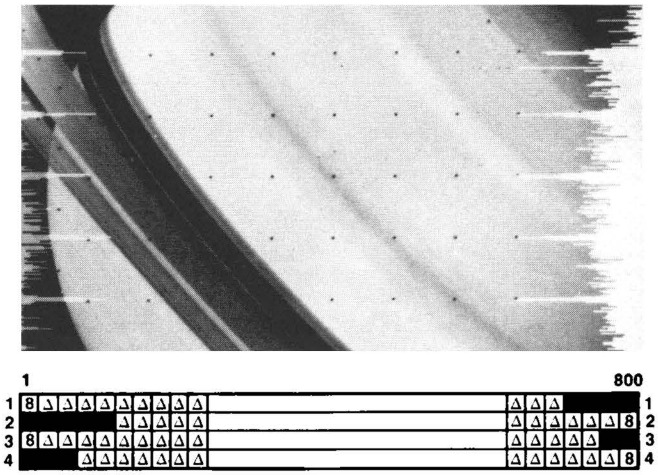
Dual Processor Programs and VLA / Goldstone Array

Voyager 2 has completed an important test this summer of its onboard computing, data receipt, and data processing on the ground in preparation for next summer's Neptune flyby. The test exercised software, hardware, and procedures that will be critical during the Neptune encounter.

Uranus is at about 20 astronomical units (AU), while Neptune is at about 30 AU. Over such a long distance, the possibility of corrupting or losing data increases—consider that a single image consists of over five million bits of data—800 lines by 800 picture elements (pixels) per line times 8 bits per pixel—and then imagine these bits strung out across 4.5 billion kilometers on their way to Earth!

Two techniques have been devised to reduce the number of bits to return images: data editing and data compression. Data may be edited either by deleting some pixels, resulting in reduced resolution of the image, or by returning only part of the scene, but at full resolution. In data compression, the absolute brightness of the first pixel of each line is sent, and then the brightness of each succeeding pixel in the line is expressed as its difference from the preceding pixel. This technique reduces the total number of bits needed to transmit an image, but preserves full size and full resolution. This reduces the bit volume by 60 to 70 percent, depending on the data format.

To accomplish this data compression, both processors of the flight data subsystem (FDS) are required. Normally only one processor is active at a time; the second is reserved as backup in case the first should fail. The program that performs this data compression is part of a pair of programs



By transmitting only the first pixel in each line, and then the difference between adjacent pixels in the remainder of the line, the number of bits per image can be greatly reduced.

known collectively as the Neptune dual processor programs.

The objectives of the Neptune Dual Processor Programs and Very Large Array/Goldstone Telemetry Array test were to exercise all of the spacecraft's data modes that will be used for encounter, to exercise modifications of the control functions for the imaging cameras, and to perform instrument checkouts or source calibrations which require the dual processor programs. In addition, this test provided the only opportunity before encounter operations begin to test the array of the Very Large Array (VLA) in Socorro, New Mexico, and the Goldstone Deep Space Communications Complex in Goldstone, California at the high data rates being planned for use during the Neptune encounter.

The technique of electronically combining the signals received at different antennas serves to increase the probability of reliably capturing the spacecraft's faint signal, by increasing the effective antenna size. The North American array will link signals from two to three antennas at Goldstone—one 70-meter dish and one or two 34-meter dishes—with the twenty-seven 25-meter (82-foot) antennas of the VLA. During the Neptune encounter, the network must capture data coming from the spacecraft at two rates: 14,400 bits per second (bps) of imaging data and of general science and engineering (GS&E) data, and 21,600 bps that contain both real-time and tape-recorded imaging and GS&E data. The data from the VLA will be sent via satellite link to Goldstone, where the data will be combined.

The Goldstone-VLA link was tested five times this summer, starting with simple tests and progressing to the full menu—the highest data rates and more complex configurations—required for Neptune encounter next summer.

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