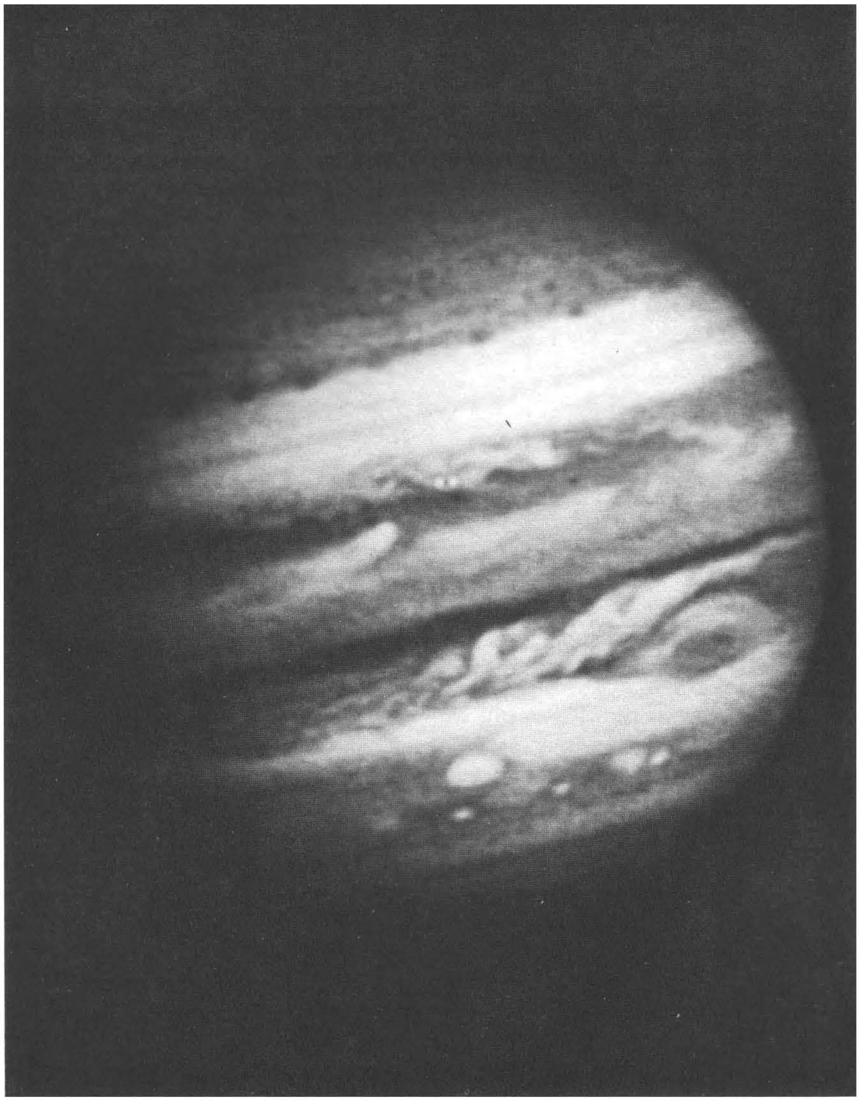
MISSION STATUS BULLETIN

VOYAGER

December 15, 1978

No. 28



DYNAMIC JUPITER — Revealing more detail than the very best groundbased telescopic photographs, this Voyager 1 image of Jupiter, taken December 10 from 83 million kilometers (52 million miles) shows the Great Red Spot (lower right) surrounded by a colorful and turbulent atmosphere. The entire visible surface of Jupiter is made up of multiple layers of clouds, composed primarily of ammonia ice crystals colored by small amounts of materials of unknown composition. Near the center is a bright convective cloud and an associated plume which has been swept westward (to the left) by local currents in the planet's equatorial wind system. This same atmospheric feature was seen prominently in the Pioneer 10 and 11 spacecraft pictures of Jupiter taken four and five years ago this month. Below and to the left of the Great Red Spot is a white oval cloud, one of three which formed nearly 40 years ago in the south temperate region. This picture was taken with a slow-scan TV camera equipped with a 1500 millimeter focal-length telescope. The color image was recreated from three TV frames, each taken through a different filter — green, orange and blue.

NASA
National Aeronautics and
Space Administration

Recorded Mission Status (213) 354-7237

Status Bulletin Editor (213) 354-4438

Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California 91103
AC 213 354-4321

The Voyager Spacecraft

(This is the tenth in a planned series of brief explanatory notes on the spacecraft and its subsystems.)

Part 10 — Plasma Investigation

Deep space has long been characterized as a cold, dark void. In truth, it is none of these. It is filled with planets, stars, dust, and clouds of low density, high-speed, ionized gases called plasma, which originates from both the Sun and other stars.

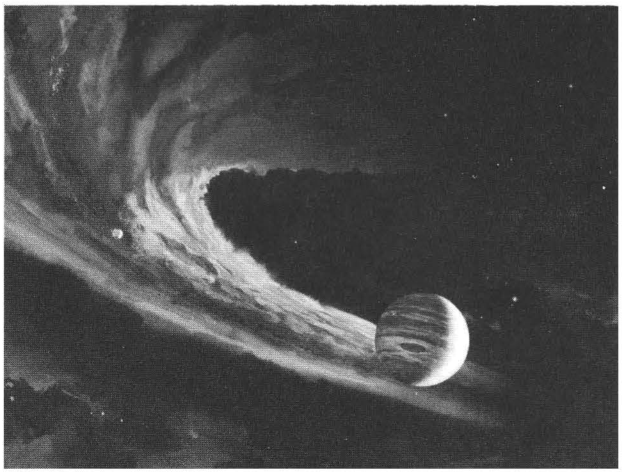
Travelling at supersonic speeds (averaging 400 kilometers or 250 miles per second), plasma streams from the Sun in all directions, forming the solar wind. When the solar wind interacts with the earth's magnetic field, many interesting phenomena result, such as the northern lights and large geomagnetic storms. Similar effects have been observed at other planets.

Voyager's plasma experiment, one of the array of fields and particles investigations, will measure plasma properties including velocity, density, and temperature for a wide range of flow directions in both the solar wind and magnetospheres.

Interstellar Ions, Solar Winds and Donuts

As are all of Voyager's fields and particles instruments, the plasma experiment (PLS) is designed to explore a range of environments — interplanetary space, planetary systems, and interstellar space.

During interplanetary cruise, the principal scientific objective is to study the properties and radial evolution of the solar plasma. A complete description of plasma properties in this region requires detailed information not only about the speeds and directions of plasma ions and electrons but also about the direction and strength of the magnetic field. For this reason, PLS data reduction is being carried on as a joint effort by the plasma and magnetometer investigators. Analysis of cruise data is now proceeding routinely; data from Voyager 1 has been processed from launch to about 4.5 AU and data from Voyager 2 to about 4.2 AU.



A wide, donut-shaped ring of hydrogen partially encircles Jupiter, while thinner rings of hydrogen and sodium trail the path of Io in this artist's conception.

A secondary cruise objective is to search for ions formed from the neutral interstellar gas. This gas is ionized by ultraviolet light from the Sun and by charge exchange with ions of the solar wind. Initially, at least, ions formed from the interstellar gas have different properties than ions of the solar wind: interstellar ions travel in different directions and are expected to have a different energy distribution. It is hoped that tracking of these two factors will allow a separation of ions from the two sources.

At Jupiter, the PLS experiment team will study the interaction of the solar wind with Jupiter; the sources, properties, form, and structure of the Jovian magnetospheric plasma; and the interaction of the magnetospheric plasma with Jupiter's Galilean satellites.

The second satellite from the planet, Io, is known to be a source of neutral hydrogen, potassium, and sodium atoms which form an incomplete donut-shaped ring (torus) close to the orbit of Io. In addition, there is an ionized cloud of sulfur associated with Io which has been observed by ground-based telescopes. Although the PLS cannot observe the neutral atoms in these clouds directly, the neutral gas is eventually ionized and becomes part of the Jovian magnetospheric plasma. The PLS has been designed to detect ionized sodium and sulfur close to the orbit of Io.

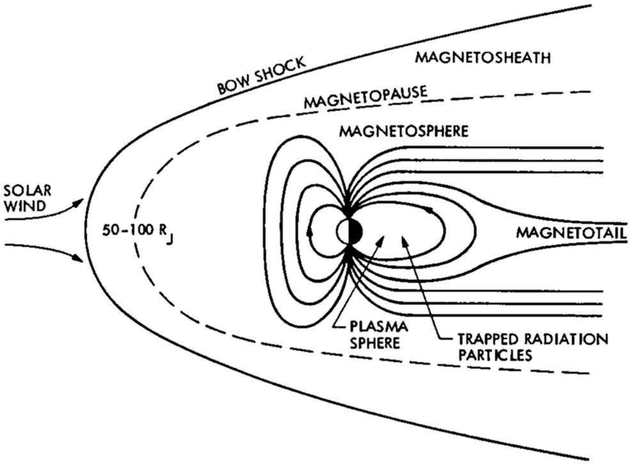
It is possible that Ganymede, the fourth satellite from the planet, may also have a ring of neutral particles which serve as a source for ions in the Jovian magnetosphere. If that is the case, the PLS should detect some of these ions when the spacecraft is close to the orbit of Ganymede (closest Ganymede approach will be from about 120,000 kilometers).

At Saturn, particular attention will be given to the interaction of plasma with the planet and its satellites, especially Titan. It is not yet clear if Titan's orbit is within Saturn's magnetosphere plasma envelope, or outside leaving its "wake" in the solar wind plasma instead. Voyager 1's flight path will allow exploration of either case.

Solar Wind — Magnetosphere Interactions

Jupiter's magnetosphere is enormous, extending into space a distance of about 100 times the planetary radius (100 R_J). As Jupiter's radius is about 71,400 kilometers (44,000 miles), this places the outer edge at about 7 million kilometers from the center of the planet. These distances are typical for a "quiet" magnetosphere. On two occasions, however, the magnetopause has been found at 50 R_J, and it is likely that this compression is caused by an increase in the pressure of the solar wind. During the encounter of Voyager 1 with Jupiter, the pressure of the solar wind at Jupiter and the size of the Jovian magnetosphere can be predicted from data returned by Voyager 2. In this way, comparison of PLS data from both spacecraft during the first Jupiter encounter will show unambiguously how the Jovian magnetosphere responds to changes in the incoming solar wind.

Voyager's first contact with Jupiter's magnetosphere will be signalled by the crossing of the bow shock, the line of demarkation between the undisturbed solar wind and the Jovian environment. Voyager 1 is expected to cross the bow shock about February 26, 1979, nearly a week before closest approach.



Jupiter's magnetosphere is expected to be similar to Earth's

Immediately behind the bow shock is a transition region called the magnetosheath which separates the solar wind and the magnetosphere. The inner boundary of the magnetosheath, the magnetopause, is the surface which separates the modified solar wind plasma in the Jovian magnetosheath from the plasma of the Jovian magnetosphere proper. Coming directly from the solar wind, the magnetosheath plasma is slowed down and heated by passage through the bow shock. Plasma in the magnetosphere, however, comes from several sources: the ionosphere of Jupiter, ions from satellite surfaces and atmospheres, and the solar wind.

Planetary magnetic field lines physically connect the upper atmosphere of the planet with the solar wind. The Jovian ionosphere is thought to be a source of plasma which travels along these field lines, sometimes being trapped by the planetary magnetic field and sometimes managing to escape directly into the solar wind.

Other probable sources of magnetospheric plasma are the neutral hydrogen, sodium, and potassium atoms, and the ionized sulfur observed near Io; ions from the solar wind, and finally ions from the interstellar gas.

In the inner magnetosphere, plasma trapped by the magnetic field is forced to rotate with the planet. This region of corotation may extend as far as the magnetopause, and the further from the planet, the more the centrifugal forces cause stretching of the magnetic field lines, more or less parallel to Jupiter's equator.

The stretched field lines give rise to a thin disk in which the trapped particles are confined, forming an intense, thin sheet of current flowing around the planet.

At Earth, the solar wind streams around the planet and forms a drawn-out magnetotail on the far side of the planet. A similar tail probably exists at Jupiter as well, and Voyager will make preliminary measurements in this region.

The plasma within the magnetosphere is far from quiet: the solar wind introduces disturbances such as solar flare events; satellites moving within the magnetosphere leave "wakes" similar to ships in the ocean; instabilities build. Global instabilities of the plasma, called magnetospheric substorms, cause auroral displays at Earth as the upper atmosphere interacts with the substorm. Because of the size of Jupiter's magnetosphere, the typical time scale for the development of plasma instabilities should be on the order of days, not hours, as at Earth, thus allowing more detailed study by the Voyagers as they traverse the area.

Instrumentation

The PLS uses two detector systems; one points at Earth while the other points at right angles to the Earth-spacecraft line.

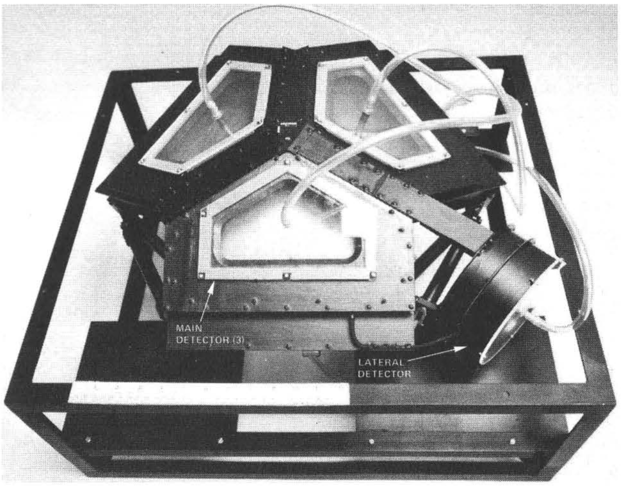
Both detector systems use Faraday cups, named after the 19th-century English physicist and chemist who studied the relationships between visible light and the electromagnetic spectrum. A conventional Faraday cup consists of a collector, several grids, and one or more apertures which define the field-of-view.

The Earth-pointed detector measures positive ions in the range from 10 to 5950 volts, and covers a broad range of possible plasma speeds from subsonic to supersonic flows. Simultaneous measurement of solar wind properties and search for interstellar ions is possible.

The Earth-pointed detector uses three Faraday cups which form three faces of a shallow tetrahedron. In this configuration, each cup views a common region of space in a different direction. This feature of the detector is new, allowing for the first time a full three-dimensional analysis of the velocity distribution function of the plasma ions. In addition, each cup views a different section of space, giving full-sky coverage when combined with spacecraft turns. This detector measures the solar wind plasma during cruise and the Jovian plasma when Voyager encounters the giant planet.

The second detector uses one conventional Faraday cup pointed perpendicularly to the Earth-pointed system and views 1/12 of the full sky. It measures both positive ions and electrons from 10 to 5950 electron volts. As the spacecraft turns, this detector will scan the sky from pole to pole.

Mounted on the science boom, the instrument weighs about 9.9 kilograms (21 pounds) and draws about 8 watts of power.



Investigating Team

H. S. Bridge of the Massachusetts Institute of Technology is the plasma experiment principal investigator. Co-investigators are J. W. Belcher, A. J. Lazarus, S. Olbert, and J. D. Sullivan (MIT); L. F. Burlaga, R. E. Hartle, and K. W. Ogilvie (Goddard Space Flight Center); A. J. Hundhausen (High Altitude Observatory, Unviersity of Colorado); C. M. Yeates (JPL); V. M. Vasyliunas (Max-Planck-Institut für Aeronomie, Katlenburg-Lindau, West Germany); and G. L. Siscoe (University of California at Los Angeles). The instrument was built at MIT by an engineering team headed by R. Butler.

OUTER PLANETS – The ancient gods await man as classical mythology and planetology mix in this rendering executed for the National Air and Space Museum. Jupiter, largest planet in our solar system, is named in honor of the chief god, known as Zeus to the Greeks. A sky god, his weapons are thunder and lightning. The father of Jupiter is Saturn (Cronus), leader of the elder gods, the Titans. Uranus ("Heaven") was an early Greek god, while Neptune (Poseidon), god of the sea, is a stormy brother of Jupiter. Finally, another Jovian brother, Pluto, ruled the underworld and the afterlife.

Update

Voyager 1

In these last weeks of Voyager 1's cruise phase, mission operations have been a whirlwind of activity, interleaving crucial calibrations and tests with reviews assessing project readiness.

On December 10–11, a 20-hour sequence of two rotations of the giant planet returned exciting images which will be used in selecting interesting features to be further explored during Encounter.

A target maneuver was cancelled on December 5 when a timing offset between the two processors of the on-board computer command subsystem was noticed. The 48-second difference between the two would have resulted in an aborted maneuver. Periodic target maneuvers have been executed on both spacecraft and the possibilities of rescheduling this maneuver are being explored.

One of four apertures in the photopolarimeter instrument was tested on December 6. The instrument's aperture wheel was turned to the 0.25 degree diameter aperture to test its field-of-view.

Just prior to the Near Encounter Test (December 12–14), the sun sensors/high gain antenna, scan platform pointing, and imaging optics were calibrated on December 11.

A review of the test and training activities, including the Near Encounter Test, essentially a dry-run of the activity planned and programmed for the 39 hours around closest approach to Jupiter on March 5, is scheduled for December 15.

Two weeks of relative quiet will follow, and then Voyager 1's Observatory phase will begin on January 4, 1979.

Voyager 2

The second spacecraft has been enjoying a quiet month with little activity other than periodic instrument calibrations.

Voyager in the Smithsonian

A museum piece at a tender age, Voyager holds a prominent position in the new "Exploring the Planets" gallery at the Smithsonian Institution's National Air and Space Museum, Washington, D.C.

The exhibit, which opened this fall, takes visitors on a tour of the solar system and imparts some of the knowledge scientists have acquired in exploring the planets via space missions and observations from Earth.

The largest single object in the gallery is a full-scale replica of a Voyager spacecraft, suspended from the ceiling and with all booms and antennas fully extended, including the 43-foot magnetometer boom!

Below the spacecraft, a television screen currently shows an animated film about the project, and will carry the latest information from the planet as Voyager closes in.

Other special exhibits in the gallery include a flight over Mars, a descent to Venus, relative sizes of planetary bodies (from a 10-foot diameter Jupiter to a 1-foot diameter Earth to a 1-inch diameter Ceres, the largest asteroid), computer terminal games, comparative planetology, planetary weather reports, and "Unanswered Questions" – some of which Voyager hopes to answer.

Summary

Eighty days and 78 million kilometers (49 million miles) lie between Voyager 1 and its first objective, Jupiter. While it is currently travelling at a heliocentric velocity of 14 kilometers per second, one-way communication time with the ship is 33 minutes 51 seconds, 609 million kilometers (378 million miles) from Earth.

Voyager 2 has 146 million kilometers (91 million miles) to travel in the next seven months before meeting the giant planet. One-way light time is 31 minutes 10 seconds, while its heliocentric velocity is 12.6 kilometers per second.