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VOYAGER 1 EXAMINES JUPITER

NASA's Voyager 1 will conduct the most detailed
scientific examination ever made of Jupiter, five of its
major satellites and the violent environment of the
Jovian domain during the first week of March.

After 18 months of flight, the instrument-laden
spacecraft will make its closest approach to the
Solar System's largest planet on March 5, taking
pictures and making measurements.

The spacecraft crossed the orbit of Sinope, the
most distant of Jupiter's 13 moons on Feb. 10 and will
spend more than six weeks swinging through the Jovian
system en route to the ringed planet Saturn and its
retinue of moons.

Only four months behind is Voyager 2, an identical
spacecraft bound for a close encounter with Jupiter on
July 9. Voyager 2 also will go to Saturn and may
continue on to Uranus.

The two-spacecraft expedition could span a decade and is expected to produce a wealth of new information on as many as 15 major bodies of the outer Solar System.

Many scientists believe that the giant outer planets may hold secrets to the origin of the Solar System, that they have changed little since their formation, and that their hydrogen-rich atmospheres may be similar to Earth's atmosphere in its geologic past. Voyager data thus may shed new light on the early history of the Solar System and on the origin of our own planet.

Voyager 2 was launched first, (Aug. 20, 1977) from Cape Canaveral, Fla., aboard a Titan Centaur rocket. On Sept. 5, Voyager 1 was boosted onto a faster, shorter trajectory, overtaking and passing its sister spacecraft before the end of the year. At Saturn encounter, Voyager 1 will be about nine months ahead.

Using Jupiter's enormous gravity, the trajectories will be bent and the Voyagers accelerated for the Saturn leg of the mission. Voyager 1 will arrive at Saturn in November 1980 and Voyager 2 in August 1981. An option exists to change the Voyager 2 trajectory at Saturn for a January 1986 Uranus encounter.

After completing their planetary missions, both spacecraft will search for the outer limit of the solar wind, that boundary somewhere in our part of the Milky Way where the influence of the Sun gives way to the other stars of the galaxy.

Each Voyager uses 10 scientific instruments and its spacecraft radio system to study the planets, their principal satellites, Saturn's rings, the magnetic and radiation regions surrounding the planets and the interplanetary medium.

The Voyagers carry telescope-equipped, slow-scan TV cameras; cosmic ray detectors; infrared spectrometer-radiometers; low-energy, charged-particle detectors; magnetometers; photopolarimeters; planetary radio astronomy receivers; plasma detectors; plasma wave instruments and ultraviolet spectrometers.

More than 80 scientists make up the Voyager science investigation teams.

The television investigation will result in as many as 50,000 pictures of Jupiter, Saturn, Saturn's rings, 11 of their moons and open space near the planets in a search for new Jovian and Saturnian satellites. Uranus, its newly-discovered ring system and one or more moons also may become targets for the Voyager 2 cameras.

The other Voyager instruments will study the planetary and satellite atmospheres and ionosphere; the magnetospheres of Jupiter and Saturn and the relationships between these regions and the solar wind that streams from the Sun through interplanetary space; and radio signals from Jupiter which, after the Sun, emit the strongest radio noise in our sky. Other objectives include all-sky surveys of interplanetary space and the measurement of cosmic rays which invade the Solar System from other regions of the galaxy.

Measurements of Voyager's radio communications waves will provide information on the gravitational fields and atmospheres of the planets and their satellites, the rings of Saturn, the solar corona and general relativity.

Until recently, our knowledge of Jupiter and Saturn was only rudimentary. Ground-based studies by optical, infrared and radio astronomy have defined the most basic properties of Jupiter and Saturn and their satellites and hinted at the unique scientific potential of these systems. Even less is known about Uranus and its environs.

In 1973 and 1974, Pioneer 10 and Pioneer 11 made reconaissance flights to Jupiter. As the spacecraft sped past Jupiter, their instruments began to reveal the complexity of its atmosphere and the extent and strength of the Jovian magnetosphere.

(Both spacecraft are still operating. Pioneer 11 will fly close by Saturn in September this year.) Building on the Pioneer experience, Voyager is the next step in the exploration of the Jovian and Saturnian systems.

Jupiter and Saturn are by far the largest planets and together account for more than two-thirds of all the moons in the Solar System Jupiter's diameter is 11 times that of Earth and the planet contains more matter than all of the other planets and moons combined. With 13 known moons, four of them the size of small planets, Jupiter is a kind of miniature Solar System. Saturn has 10 satellites and a spectacular ring system which appears to be made up of tiny pieces of ice and snow.

Both planets are giant gaseous and liquid balls, composed mostly of hydrogen and helium, with no apparent solid surfaces. They have their own internal energy sources, radiating more energy than they receive from the Sun. Their atmospheres are driven by the same forces that act on Earth's atmosphere, but on a much larger scale. Major cyclones, like the Great Red-Spot on Jupiter, are thousands of miles across and persist for decades and even centuries.

Jupiter has a powerful magnetic field and is surrounded by radiation belts similar to the Van Allen belts around Earth, but thousands of times more intense.

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The vast, rapidly spinning magnetosphere makes Jupiter a major source of several types of radio radiation.

The four largest satellites of Jupiter -- Io, Europa, Ganymede and Callisto -- provide a varying and fascinating microcosm of unique worlds. Some are believed composed largely of rock, some largely ice and water. Their surfaces may range from lunar-like cratered plains, to salt-covered beds of extinct seas, to exotic landforms created of ice and mud. Totally unfamiliar geologic forms are expected.

Most of Saturn's satellites apparently are composed mainly of ice. Titan, (Saturn's moon), has, in addition, a relatively extensive atmosphere. Scientists expect that organic molecules are being created today in Titan's atmosphere.

The spectacular rings that encircle Saturn are not well understood; they may be the remains of a satellite that came too close and was crushed by the strong tidal forces of the planet; or they may be remnants of material from the birth of the Solar System that never coalesced to form a moon.

Jupiter orbits the Sun at a distance of 778 million kilometers (483 million miles). One Jupiter year equals 11.86 Earth years. Jupiter's day is 9 hours, 55 minutes long.

Saturn orbits at 1.42 billion km (883 million mi.).
It completes one orbit every 29.46 Earth years. A day on
Saturn is 10 hours, 14 minutes long. The widest visible
ring has a radius of about 137,000 km (84,500 mi.) at its
outside and width of about 26,000 km (16,000 mi.).

Voyager scientific operations began shortly after
launch with observations of the Earth and Moon. Fields
and particles measurements have been made almost constantly
during the long cruise.

The Jupiter reconnaissance spans nearly eight months
during 1979 -- from early January until August.

Voyager 1 began its "observatory" phase on Jan. 4, 1979,
studying large-scale atmospheric processes on Jupiter and
phenomena associated with the relationship between Jupiter's
magnetosphere and the large inner moons.

Voyager 1 makes its closest approach to Jupiter at
4:42 a.m., PST*on March 5 at a distance of about 278,000
km (172,750 mi.) from the visible cloud tops. Activity
will reach a peak during the "near encounter" phase, a
39-hour period surrounding closest approach.

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*The spacecraft actually flies closest to Jupiter at 4:05
a.m., PST on March 5, 1979. But if one were able to watch
the event from Earth, the eye would see the close encounter
37 minutes, 40 seconds, later -- the time it takes light to
travel nearly 680 million kilometers (422 million miles).
The same is true using the Voyager radio to watch the event.
Hence, all times listed here are in Earth-received time.

The spacecraft instruments will continue studying
the Jupiter system until early April.

Planetary operations for Voyager 2 will begin in late
April and continue through early August. Closest approach
to Jupiter -- this time at an altitude of about 644,000 km
(400,000 mi.) -- will occur shortly after 4 p.m. PDT July 9.

The trajectory for each spacecraft is unique and was
designed for specific observations at both Jupiter and

Saturn. Voyager 1 will fly past Jupiter just south of the
equator, while the second spacecraft makes its Jupiter
pass deep in the southern hemisphere.

Although Voyager 1's encounters with Jupiter's inner
moons occur after the spacecraft swings past the planet,
Voyager 1 began photographing them two weeks earlier --
Callisto Feb. 18, Ganymede Feb. 25, Europa March 1, Io
March 2 and tiny Amalthea (the closest to Jupiter) March 4.

Voyager 1 flies to within 19,000 km (11,800 mi.) of
Io at 7:51 a.m. PST on March 5; Ganymede 112,000 km (69,600
mi.) at 6:53 p.m., March 5; and Callisto, 124,000 km
(77,000 mi.) at 9:47 a.m. on March 6. The closest Voyager 1
will come to Europa will be 732,000 km (455,000 mi.) at
9:56 a.m. March 5.

The Voyager 1 close passage at Io was designed to
send the spacecraft through the so-called Io flux tube, a
magnetic link between Io and Jupiter. The flux is a cylin-
drical zone where charged particles spiral along the Jovian
magnetic lines of force as they pass through Io. Voyager 1
will spend about five minutes in the flux tube under the
south pole of the satellite.

Another Io phenomenon to be examined by Voyager 1's
instruments is a cloud of sodium vapor surrounding the
satellite. Because Io's surface is believed to be a source
of sodium, the cloud may be generated by intense radiation
bombardment of the surface material.

The Voyager 1 trajectory also carries the spacecraft
behind Jupiter, relative to Earth and the Sun. As Earth
disappears behind Jupiter, then emerges after two hours
of occultation, the changes in the signal characteristics
of the spacecraft radio link with Earth will give informa-
tion about the vertical structure of the atmosphere,
ionosphere and clouds. As the Sun is occulted by Jupiter,
the ultraviolet spectrometer tracks the limb of the planet
observing similar scattering effects on sunlight as it
penetrates the atmosphere. The Earth occultation experiment
begins at 8:14 a.m. PST March 5, and continues until
10:20 a.m.

Sun occultation extends from 9:07 a.m. to 11:24 a.m.

At Saturn, in late 1980, Voyager 1 will conduct Sun and Earth occultation experiments with the planet, the moon Titan and Saturn's rings. If Voyager 2 goes on to Uranus, occultations may be possible with the planet and its rings.

Voyager 2 will fly past Jupiter's satellites on the inbound passage as follows: Callisto on July 8 from 220,000 km (136,000 mi.) and Ganymede and Europa on July 9 from 60,000 km (37,000 mi.) and 201,000 km (125,000 mi.), respectively. It will not repeat the close flyby of Io.

NASA's Office of Space Science has assigned management of the Voyager Project to the Jet Propulsion Laboratory, (JPL) a government-owned facility in Pasadena, Calif., which is managed for NASA by the California Institute of Technology.

JPL designed, assembled and tested the Voyager spacecraft, and conducts tracking, communications and mission operations. JPL operates the Deep Space Network for NASA's Office of Tracking and Data Systems.

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NASA program manager is Rodney A. Mills and the JPL
project manager is Robert J. Parks. Dr. Milton A. Mitz
is NASA program scientist. Dr. Edward C. Stone of Caltech
is project scientist.

Estimated cost of the Voyager Project, exclusive of
launch vehicles, tracking and data acquisition and flight
support activities, is $343 million.

(END OF GENERAL RELEASE. BACKGROUND INFORMATION FOLLOWS.)

VOYAGER CRUISE PHASE

Voyager 2, first of two spacecraft launched during the 1977 opportunity, lifted off Complex 14 at Cape Canaveral , Fla., aboard a Titan Centaur launch vehicle at 10:29 a.m. EDT on Aug. 20. Liftoff occurred less than five minutes into the window on the first day of the 30-day launch period.

Sixteen days later, an identical spacecraft, Voyager 1, was boosted into a faster, shorter trajectory which would carry it past Jupiter four months earlier than Voyager 2 and Saturn nine months earlier than its twin. The second launch was delayed four days when it was not immediately certain that Voyager 2's science boom had fully deployed and locked itself in place. Voyager 1 lifted off at 8:46 a.m. EDT on Sept. 5, 1977.

On Dec. 15, 1977, Voyager 1 caught up with and passed Voyager 2 at a distance of about 170 million km (105 million mi.) from Earth. Both spacecraft had begun passage through the asteroid belt a few days earlier -- on Dec. 10 -- Voyager 1 exiting Sept. 8, 1978, and Voyager 2 on Oct. 21. The debris-strewn asteroid belt, which circles the Sun between the orbits of Mars and Jupiter, is about 360 million km (223 million mi.) wide and, at one time, was believed to present a hazard to intruding spacecraft. The Voyagers were the third and fourth spacecraft to make such a crossing, following the early Jupiter reconnaissance flights of Pioneer 10 and 11 in 1973 and 1974.

First of a series of trajectory correction maneuvers to refine flight paths and assure precise arrival times and encounter distances was executed by Voyager 1 on Sept. 11, 1977, and by Voyager 2 on Oct. 11, 1977. Voyager 1's initial maneuver was conducted in two parts and was completed on Sept. 13. A second maneuver was executed Oct. 29, 1977 and a third on Jan. 29,1979. Additional maneuvers were scheduled for Feb. 20 and March 16. A trajectory correction maneuver for Voyager 2 was conducted on May 3, 1978, with the third and fourth maneuvers planned for May 26 and June 27, 1979.

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Two major engineering problems -- one with each
spacecraft -- arose during the long cruise phase of the
mission.*

During a calibration of Voyager 1's scan platform on
Feb. 23, 1978, the platform's azimuth gears slowed and
stalled to a standstill. During the next three months,
engineers determined that a small amount of soft, pliable
debris -- apparently retained in the unit during its as-
sembly -- had found its way into the gears. By maneuvering
the platform through the problem area, the bits of debris
were crushed by the gears, freeing the platform.

Voyager's scan platform, upon which are mounted the
planet-tracking instruments, including the two television
cameras,can be rotated on two axes for precision pointing.

Voyager 2's primary radio receiver failed on April 5,
1978, and the spacecraft's computer command subsystem auto-
matically switched in the backup receiver. Unlike the
Voyager 1 scan platform problem which has been resolved,
Voyager 2's radio emergency remains a concern. Only a
single receiver is available to the spacecraft which may
be expected to operate through Uranus encounter -- January
1986 -- and it is functioning with a faulty tracking-loop
capacitor.

The existing receiver can no longer normally follow
a changing signal frequency. Telecommunication engineers,
however, have developed a technique of determining the
frequency at which the receiver is listening, then com-
puting the frequency at which the Deep Space Network station
must transmit commands. This procedure has worked suc-
cessfully since mid-April.

Because of the loss of the redundant receiver capability,
a backup mission sequence was transmitted to Voyager 2 on
June 23 and stored in the on-board computer. The backup
sequence assures a minimum science activity at both planets
in the event ground command capability is lost. The se-
quence can be updated periodically.

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*Minor problems with several science instruments on each
spacecraft have occurred during the mission. Status of
these problems has changed periodically during the past
18 months and is expected to change throughout the mission.
A detailed status report on each instrument will be
available prior to Jupiter encounters in March and July.

During the long cruise, numerous tests and calibrations have been conducted to allow scientists to evaluate their instruments and the acquired data.

All of the instruments on both spacecraft made measurements during the cruise -- interplanetary magnetic fields, the solar wind and sky scans by the spectral instruments -- ultraviolet spectrometer, infrared interferometer and spectrometer and photopolarimeter.

Analysis of cruise data acquired by the Plasma Science instrument on both spacecraft is underway -- data from Voyager 1 to about 4.5 astronomical units (AU) and from Voyager 2 to about 4.2 AU had been processed by the end of 1978. (An astronomical unit is the average distance between the Sun and Earth, about 150 million km (93 million mi.).

The Magnetometer investigators measured direction and strength of magnetic fields in interplanetary space for correlation with the plasma data.

The Low Energy Charged Particles experiment has obtained good data on solar flare and interplanetary particles and Jovian electrons.

The Planetary Radio Astronomy experiment has defined the polarization characteristics of Jupiter's radio emissions. It also measured for the first time Earth's polarization in the frequency range of 100 to 300 kilohertz -- information valuable for comparison with Jupiter data.

Voyager 1's Plasma Wave instrument, which measures waves of charged particles moving in space in several frequency ranges including the audio, demonstrated its sensitivity by recording the operating sounds of the spacecraft itself. Motions of the scan platform and firings of the attitude control gas thrusters were detected by the instrument.

The television camera system has been exercised throughout the flight. Two weeks after launch, as part of an optical navigation and video recording and playback test, Voyager 1 captured both the Earth and the Moon in the same picture. The two crescent bodies, never before portrayed together, were more than 11 1/2 million km (7 million mi.) from the spacecraft camera.

By Dec. 10, 1978, still 85 days and 85 million km (53 million mi.) from Jupiter, Voyager 1's narrow-angle TV camera obtained a series of pictures of the planet revealing more detail than the very best ground-based telescopic photographs. Only a few Jovian disk images obtained by Pioneer 10 in December 1973 and Pioneer 11 in December 1974, during their final 24 hours of approach to the planet, exceed the resolution in the distant Voyager pictures.

The December pictures as well as others obtained during periodic camera calibrations have shown dramatic changes in the visible appearance of Jupiter during the past four years. These broad-scale differences in the huge features of the planet have been observed also by Earth-based astronomers.

Voyager 1's Jupiter observatory phase, that segment of the mission when all science activity was directed toward the planet, its satellite system and the Jovian environment within the solar system, began on Jan. 4, 1979, with the spacecraft 61 million km (38 million mi.) from Jupiter and continued through the month.

Activities during the 26-day period were designed to provide scientists with a long-distance, long-term look at the entire Jovian system and Jupiter's large-scale atmospheric processes in preparation for near encounter operations on March 4 and 5.

The narrow-angle television camera recorded four images, each through a different color filter, every two hours -- the time it takes Jupiter to rotate 72 degrees -- providing a zoom effect at five selected longitudes. The pictures are being studied to determine the most interesting and most rapidly changing planet features for possible retargeting of imaging sequences closer in.

During a four-day period beginning Jan. 30, the narrow-angle camera took a picture of Jupiter ever 96 seconds using three color filters. Some 3,500 images are being processed into a color record of the planet's rapid rotation with a new color image each three degrees for 10 full Jupiter days.

Voyager 2 operations have been at a low level since December 1978 and will resume a more active pace at the beginning of the observatory phase in late April 1979.

VOYAGER 1 SCIENCE EXPERIMENTS

Voyager 1's science experiments at Jupiter fall into three broad classifications:

1. Jupiter's atmosphere and its dynamics, studied by:

    o Imaging;

    o Infrared Interferometer Spectrometer and Radiometer;

    o Ultraviolet Spectrometer;

    o Photopolarimeter;

    o Radio Science.

2. Five of the satellites of Jupiter -- Io, Europa, Ganymede, Callisto and Amalthea, studied by:

    o Imaging;

    o Infrared Interferometer Spectrometer and Radiometer;

    o Ultraviolet Spectrometer;

    o Photopolarimeter;

    o Radio Science

3. Jupiter's magnetic field and its interaction with the solar wind and the satellites, studied by:

    o Plasma Science;

    o Low-energy Charged Particles;

    o Cosmic Ray;

    o Magnetometers;

    o Planetary Radio Astronomy;

    o Plasma Wave;

    o Radio Science.

Magnetic Fields Investigation

The magnetic field of a planet is an externally
measurable indication of conditions deep within its interior.
Four magnetometers aboard Voyager 1 gather data on the
planetary magnetic fields at Jupiter, the satellites, solar
wind and satellite interactions with the planetary field
and the interplanetary (solar) magnetic field.

The magnetometers allow the interplanetary medium to
be examined -- the tenuous, ionized and magnetized gas that
forms the solar wind.

The Sun constantly emits electrically charged particles --
mostly protons and electrons -- from the ionization of hydrogen.
Those particles are in the fourth state of matter, called
plasma. The other three states are solid, liquid and neutral
gas. The plasma is of extremely low density, less than 100
particles per cubic centimeter; it fills all interplanetary
space and forms the solar wind. Because it is ionized
(contains either more or fewer electrons than in its neutral
state), the solar wind is an electrically conducting medium.

The solar wind is deflected by planetary magnetic fields
(such as the Earth's and Jupiter's), and streams around and
past the obstacles, confining the planet's magnetic field to
a region called the magnetosphere.

The shape of Jupiter's magnetic field is not very well
understood. Because Voyager 1 and Voyager 2 arrive four
months apart, scientists can make long-term, continuous
measurements of the solar wind near Jupiter and of the
magnetosphere itself as it changes size and shape under
changing pressure of the solar wind.

Jupiter's magnetic field is shaped much differently
from Earth's. The planet's rapid rotation rate may be one
explanation, for the magnetic field rotates with the planet.
At great distances from the planet, the magnetic field
lines appear to form a spiral structure, which could be
explained by outward-flowing plasma, one of the things
Voyager 1 will search for.

Interactions between the large satellites and Jupiter's
magnetosphere depend on the properties of the satellite and
its ionosphere, on the characteristics of the field-and-
particle environment and on the properties of Jupiter's
ionosphere.

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A strong factor in the choice of Voyager's flight path was the desire to observe the region of interaction between Jupiter and the satellite Io, called the flux tube. The flux tube is defined by the magnetic lines of force from Jupiter that pass through Io. An electric current up to 1 million amperes is believed to flow through the flux tube, producing dramatic effects.

Voyager 1 will pass through the Io flux tube about 20,500 km (12,750 mi.) from the satellite. The spacecraft is scheduled to spend about 4½ minutes in the tube and make the first direct observations of the puzzling phenomenon.

Jupiter emits decametric radio bursts (from 10 to 40 megahertz) that are probably connected with plasma instabilities within Jupiter's ionosphere. Io appears to have some influence on those radio emissions by way of the flux tube.

Cosmic Ray Investigation

Cosmic rays are the most energetic particles in nature and are atomic nuclei, primarily protons and electrons. They comprise all natural elements known to man. Over certain energy ranges and at certain periods of time, the content of cosmic rays is similar in proportion to that of all the matter in the Solar System. Generally, however, their composition varies significantly with energy, indicating to scientists that a variety of astrophysical sources and processes contributes to their numbers.

Cosmic rays may, as we search for their origins, tell much about the Solar System and its origins and processes. Cosmic rays are material samples of the galaxy, and may reveal how stars synthesize the various elements in their interiors.

Voyager's Cosmic Ray investigation will address the energy content, origin and acceleration process, life history and dynamics of cosmic rays.

Planetary Radio Astronomy

One goal of the planetary radio astronomy (PRA) investigation is to search for lightning in Jupiter's atmosphere, since lightning has been postulated as a catalyst for the formation of life. Together with the Plasma Wave experiment and several optical instruments, PRA may be able to demonstrate the existence of lightning on Jupiter, if it does exist.

It is thought that lightning in an atmosphere of hydrogen, methane, ammonia and water could set off reactions that eventually form complex organic molecules.

The PRA will measure radio emissions from Jupiter in the low-frequency range from 20 kHz to 40.5 mHz. (AM radio stations broadcast at frequencies between 550 and 1,600 kHz.) Scientists say emissions ranging in wavelength from less than one centimeter to thousands of meters can result from wave-particle-plasma interaction in the magnetosphere and ionosphere of Jupiter.

While scientists are sure Io plays an important role in the pattern of Jupiter's radio emissions, the big satellite appears not to have anything at all to do with Jupiter's 1 mHz emissions, at least in the low-frequency ranges. Preliminary results from early Voyager data show no correlation between 1 mHz bursts and Io in the low frequencies.

Infrared Interferometer Spectrometer and Radiometer

Jupiter, with its colorful and distinctive bands of clouds, has puzzled scientists for centuries: Why are the bands -- light zones and dark belts -- so well-defined? What gives them their color? How deep is the cloud cover? What lies beneath it?

Voyager's Infrared Interferometer Spectrometer and Radiometer (IRIS) will probe the atmosphere for answers to those questions. Jupiter's satellites also will be explored.

Each chemical compound has a unique spectrum. By measuring the infrared and visible radiation given off and reflected by an object, scientists can learn a great deal about atmospheric gas composition, abundance, clouds, haze, temperatures, dynamics and heat balance.

Hydrogen, deuterium (heavy hydrogen), helium, methane, ammonia, ethane and acetylene have been identified in Jupiter's atmosphere above the upper clouds. Deeper measurements -- through holes in the clouds -- indicate the presence of water, deuterated methane, germane and phosphene.

Once the composition of an atmosphere is determined, knowledge of its absorption properties can be used to measure the temperature at various depths as it changes with pressure.

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Jupiter's clouds appear to form well-defined layers in the atmosphere; above the clouds is a tenuous haze. The ease with which those structures absorb or emit infrared radiation and light permits determination of cloud depth and state (i.e., ice or aerosol).

Satellite composition and temperature maps will be constructed using the distinctive spectral signatures of ices and minerals found on the surfaces. Together with pictures of the satellites, the maps can be used to study the geology and evolution of the bodies, and how they differ with distance from Jupiter.

Photopolarimeter

By studying the way sunlight is scattered by the atmosphere of Jupiter and the surfaces of its satellites, Voyager's photopolarimeter can answer many questions about those bodies.

Eight wavelengths in the ultraviolet and visible regions of the spectrum from 2,350 to 7,500 Angstroms, are measured in intensity to determine the physical properties of the atmosphere of Jupiter (perhaps even seeing evidence of lightning and auroral activity), the satellite surfaces and the sodium cloud around Io.

The photopolarimeter will examine both the large-scale and micro-scale structure and properties of the clouds of Jupiter. It will measure the vertical distribution of cloud particles, and the particle size and shape, and provide inferences on atmospheric composition.

Similar studies will define the structures of major planetary features such as the Great Red Spot, zones and belts. The photopolarimeter will search for evidence of crystalline particles in those features and will gather data on the effects of scattering and absorption of sunlight by the particles.

Jupiter's atmosphere will be compared with others that are already fairly well known -- those of Earth and Venus.

The photopolarimeter will study the density of atmospheres at the satellites, if atmospheres exist there, the texture and composition of the surfaces, the bulk reflectivity and the sodium cloud around Io.

The spectral reflectivity of a body can help determine its surface composition, whether it is rock, dust, frost, ice or the remains of meteors.

In 1973 scientists first suggested that gases escaping from a satellite atmosphere might not be able to escape the gravity field of the main planet, and would form doughnut-shaped clouds around the planet. That kind of cloud has been found in the vicinity of Io; it is composed primarily of sodium and hydrogen. It may extend as far as the orbit. of Europa.

Io appears to be covered with evaporite salts, including atomic hydrogen, sodium, potassium and sulfur and perhaps magnesium, calcium and silicon. They appear to be sputtered off Io's salt-covered surface into its atmosphere by charged atomic particles trapped in Jupiter's strong magnetic field.

Radio Science

The radio that provides tracking and communication with Voyager also explores the planets and space.

Measurements of Voyager's radio signals provide information on gravity fields and atmospheres of Jupiter and its satellites, the solar corona and general relativity.

Changes in frequency, phase, delay, intensity and polarization of radio signals between spacecraft and Earth provide information about the space between the two and forces that affect the spacecraft and alter its path.

When the spacecraft moves behind a body as viewed from Earth (called occultation), radio waves coming from the space-craft pass through the ionosphere and atmosphere on their way earthward. Changes in signal characteristics during those events give information about the vertical structure of the ionosphere, atmosphere, clouds and turbulence.

Imaging

Astronomers have photographed Jupiter since at least the late 1800s, starting first at Lick Observatory in California and continuing later at Lowell Observatory in Arizona. Until about 1960, photography of Jupiter was conducted in a more-or-less random way: if the night was clear and some time was available at the telescope and someone was inclined, he might take a picture of Jupiter. The next opportunity might not come for weeks.

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That will work for an object like the Moon or Mars, but Jupiter is all weather -- every observation ever made of the planet is of weather and weather patterns -- there is nothing else to see. Random photos of Jupiter are of limited value: like taking an occasional picture of the cloud shrouded Earth and then trying to forecast the weather. It doesn't give you much good information.

In the early 1960s, astronomers changed their observational approach to one in which they took pictures of Jupiter every hour all night long, on every night that was good for observing. Many of those pictures were of poor quality, far from the textbook examples.

But they contain a wealth of information. In 10 years astronomers learned more about Jupiter than they had learned in all the time that preceded the new program.

They discovered: There is a periodic oscillation in the movement of Jupiter's Great Red Spot. The spot moves slowly around Jupiter, it isn't anchored at one longitude. But the spot does not wander smoothly; it moves, then stops, then moves again. These oscillations occur almost precisely every 90 days.

Another discovery: The Great Red Spot is not a smooth blemish, but is a giant vortex. It has been compared with a hurricane on Earth. Observers do not know if the vortex phenomenon exists all the time or only occasionally.

A third example: There appears to be a semipersistent high-velocity jet stream at a constant latitude in Jupiter's northern hemisphere. The current flows in the same direction as Jupiter rotates. Planetary observers have measured the velocity of the winds at 170 meters a second (380 miles an hour).

But for its velocity, that jet stream resembles the same phenomenon on Earth. Earth's stream meanders north and south, carrying storms from the tropics to temperate latitudes and from the Artic southward. But Jupiter's rapid rotation, a day is less than 10 hours long, nails the northern stream to one constant latitude.

There may be many more features like these on Jupiter. But even though astronomers try to photograph the planet every hour, every night, they are at the mercy of Earth's moist, turbulent atmosphere. Often observers have seen something there, but have been unable to identify it. Ground-based pictures cannot answer the flood of questions scientists ask about the planet: The Voyager observations are expected to explore this in detail.

While the two Pioneer spacecraft saw Jupiter at high-resolution for only a few days, the two Voyagers will take high-resolution pictures of Jupiter for almost eight months.

That is enough to provide a significant advance in our knowledge of the planet.

The satellites, meanwhile, are another story. They are bodies the size of the moon and the planet Mercury that cannot be clearly seen because they are too far away. One Earth-based photo of Io suggests an orange hue at the poles and a whitish appearance near the equator. A picture of Ganymede taken by one of the Pioneers suggests mottling on the surface.

But the Galilean satellites' discs are only 1/25th the apparent diameter of the planet Mars and 1/12th the size of the planet Mercury in the eyepiece of a telescope. They are, one scientist says, too small to show anything that can be taken seriously.

So no one knows what those big, Moon-sized objects look like. Scientists admit they will be surprised by the satellite pictures from Voyager no matter what they look like.

Io, for example, probably has a surface covered with fresh-looking craters. Europa's surface is probably covered with ice, but no one knows the depth. If the ice is a few centimeters thick, Europa may look like Earth's Moon covered with snow; if the ice is tens of meters or kilometers thick, then all bets are off.

Ganymede and Callisto are probably almost entirely ice. But they must contain some silicates and they surely contain some radioactive material. Therefore, there is some internal heat so that at depth the moon is probably mostly liquid water. How does that heat reach the surface? Uniformly? Or in convection cells as happens on Earth? If it is uniform, then Ganymede and Callisto may be bland, whitish, round ice-covered objects that show little. If the heat radiation is not uniform, then the satellites may look like almost anything.

Impact craters on the icy satellites may be spectacular features, if the body penetrated deep enough to reach liquid water. But ice flows and in a relatively short time the scars should disappear.

- more -

Finally, there is an Earth application for the new knowledge from the Voyager images of Jupiter:

The inner planets -- Venus, Earth and Mars -- have atmospheres dominated by solar heat that arrives at the equator and flows by a variety of methods toward the poles. The equator, therefore, is hotter than the poles.

But Jupiter is not that way. Jupiter's atmospheric temperature does not appear to be dependent on latitude. There's a lot of heat moving from within Jupiter to the surface without any regard for where the equator is, or the poles or even where the Sun is. It wells up uniformly everywhere.

On Earth one region is different from all the rest. It is a convective region called the Intertropical Convergence Zone (ITCZ). In that region near the equator, warm, moist air wells up to high altitudes. The moisture is condensed out of the air which then becomes very dry and cold. That dry, cold air moves outward and descends again, warming as it does. On either side of the zone, where the dry air reaches the surface, there is an arid, nearly useless desert. North Africa is the classic example.

There is a similarity, then, between Earth and Jupiter, one that may allow scientists studying the two planets to assist each other.

Low-Energy Charged Particles

The Low-Energy Charged Particle instrument (LECP) is a strong coupling factor in Voyager's complement of fields and particles investigations, contributing to many areas of interest, including the solar wind, solar flares, particle accelerations, magnetic fields, cosmic rays and satellite surface structure.

Two detectors allow measurements during the long interplanetary cruise and the encounters. The wide dynamic range, combined with wide coverage in energy and species, allows characterization of almost all energetic particle environments that Voyager traverses.

The LECP measures particles traveling 2,400 to more than 150,000 km (1,500 to more than 90,000 mi.) a second. High-energy particles travel at or near the speed of light -- 299,792 kms (186,282 mi./s).

Observations of particle accelerations aid in better
understanding of solar flare processes, cosmic ray accelera-
tions and processes in Earth's magnetosphere.

Next to the Sun, Jupiter is the Solar System's most
powerful radio source. The reasons for that are not under-
stood completely, but may come from the interaction between
Jupiter and Io. The Io-Jupiter interaction could be of
importance in understanding other astrophysical radio sources.

Scientists also believe fusion research might benefit
from Voyager's studies of trapped radiation around Jupiter.
Particles in confined plasmas, forced to fuse in the laboratory,
release enormous amounts of energy. Scientists are trying to
control that energy source to solve some terrestrial problems.
Jupiter is easily able to confine charged particles in its
magnetosphere.

Plasma Experiment

Traveling at supersonic speed, averaging 400 kms (250 mi./s),
plasma streams in all directions from the Sun, forming the solar
wind. When the solar wind reacts with Earth's magnetic field,
many phenomena result, such as the northern lights and
geomagnetic storms. Similar events have been observed at
other planets.

Voyager's plasma instrument measures plasma properties
including velocity, density and temperature for a wide range
of flow directions in the solar wind and planetary magnetospheres.

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

Io is known to have a tenuous atmosphere made up of
atoms of sodium, sulfur and perhaps other species. The
atmosphere extends around part of the Io orbit.

Although the plasma investigation cannot observe the
neutral atoms of these clouds directly, the neutral gas is
eventually ionized and becomes part of the Jovian magneto-
sphere plasma. The instrument has been designed to detect
ionized sodium and sulfur close to the orbit of Io.

It is possible, too, that Ganymede, fourth satellite
out from Jupiter (Europa orbits between Io and Ganymede),
has a ring of neutral particles that serve as a source for
ions in the Jovian magnetosphere. If that is the case, the
plasma instrument should detect some of those ions when
Voyager is near Ganymede's orbit.

Jupiter's magnetosphere extends into space at least
100 times the planetary radius. Since Jupiter's radius is
about 71,400 km (44,000 mi.), that places the leading edge
of the magnetosphere about 7 million k (4.2 million mi.) or
farther from the planet. That distance appears typical for
a quiet magnetosphere. On at least two occasions the
magnetopause -- edge of the magnetic field -- was found at
50 planetary radii, half the other distance. It is probable
that the magnetosphere is compressed when the solar wind's
pressure increases.

During Voyager 1's encounter with Jupiter, the pressure
of the solar wind at Jupiter and the size of Jupiter's
magnetosphere can be predicted using data from Voyager 2 --
farther from Jupiter and closer to the Sun. By comparing
data from both spacecraft during the Voyager 1 encounter,
scientists will try to show how the Jovian magnetosphere
reacts to changes in the incoming solar wind.

Voyager's first encounter with Jupiter's magnetosphere
will be detected when the spacecraft crosses the bow shock
wave, a region of demarcation between the solar wind and the
Jupiter environment. Voyager 1 is expected to cross the
bow shock about Feb. 26, a week before closest approach.

Immediately behind the bow shock is a transition region
called the magnetosheath that separates the solar wind from
the magnetosphere. The inner boundary of the magnetosheath,
the magnetopause, separates the modified solar wind plasma in
the Jovian magnetosheath from the plasma in the magnetosphere
proper. Plasma in the magnetosheath slows down and is heated
by passage through the bow shock. Plasma in the magnetosphere
comes from several sources -- Jupiter's ionosphere, ions from
satellite surfaces and atmospheres, and the solar wind.

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.
The farther from the planet, the more the centrifugal force
causes stretching of the magnetic field lines, more or less
parallel to Jupiter's equator.

The stretched field lines form a thin disk that confines
the particles within an intense, thin sheet of current flowing
around the planet.

Plasma Wave Experiment

The Solar System is filled with a low-density, ionized
gas called plasma. That plasma composed entirely of atoms
that are broken apart into electrons and charged positive
ions, is a good electrical conductor with properties that
are strongly affected by magnetic fields.

Plasma sources include the Sun, the planets and perhaps
some of their satellites. Low-density plasmas are unusual;
ordinary collisions between ions are unimportant, and
individual ions and electrons interact with the rest of
the plasma by means of emission and absorption of waves.

Localized interactions between waves and particles
strongly control the dynamics of the entire plasma medium,
and Voyager's plasma wave instrument will provide the first
measurements of these phenomena at the outer planets.

Plasma waves are low-frequency oscillations that have
their origins in instabilities within the plasma. They are
of two types -- electrostatic oscillations or electromagnetic
waves of very low frequency.

The plasma wave instrument measures the electric field
component between 10 and 56,000 Hertz. By way of comparison,
Voyager's magnetometers measure the magnetic vectors of
electromagnetic plasma waves below 10 Hz, while the
planetary radio astronomy instrument measures waves with
frequencies above 20 kHz.

Plasma ions and electrons emit and absorb plasma waves.
While the resulting particle-wave interactions affect the
magnetospheric dynamics of the outer planets and the
properties of the distant interplanetary medium, they have
never been directly observed in those regions, since plasma
waves cannot generally be observed far from their source and
since there have been no previous wave studies at the outer
planets.

Voyager is therefore returning the first direct observations of wave-particle interactions at great distances from the Sun. Some effects to be studied include heating of solar wind particles at the outer planet bow shocks, acceleration of solar wind particles that produce high-energy trapped radiation, and the maintenance of boundaries between the rotating inner magnetospheres and the solar wind streaming around the planets.

Another objective of the plasma wave investigation is to study the influence of wave-particle effects on the interactions between the inner satellites and the planet's rapidly rotating magnetosphere.

Control of Jupiter's decametric radio bursts through coupling of Io's ionosphere with Jupiter's magnetic field is an example.

Special intensive plasma wave measurements will be made as Voyager 1 passes through Io's flux tube, where strong current systems are driven by Io's motion through the Jupiter magnetosphere.

Io is thought to have salt deposits on its surface that are weak conductors.

As Io moves through Jupiter's magnetic field, it produces current flow along the magnetic field lines connecting Io to Jupiter, the flux tube.

Detection of lightning bolts in the atmosphere of Jupiter would also be significant, as described earlier. The plasma wave instrument searches for "whistler" signals that escape into the magnetosphere from lightning discharges.

The descending-scale signal that is characteristic of lightning is caused by scattering of similar velocities when the direction of travel is along magnetic lines of force: higher frequencies arrive at the receiver sooner than lower frequencies. Using the high-rate telemetry usually reserved for transmission of imaging data, the Plasma Wave instrument will play to Earth the entire audio signal of space -- plasma waves, spacecraft power, thruster firing and other instruments.

Ultraviolet Spectrometer

Voyager's ultraviolet spectrometer will study the composition and structure of Jupiter's atmosphere and the tenuous atmosphere surrounding at least one satellite.

- more -

Two ultraviolet techniques have been developed to probe
a planet's atmosphere without entering that atmosphere:

o Airglow observations of the weak emissions high in
the atmosphere -- where collisions between atoms and molecules
are rare.

o Measurements that look through the atmosphere at the
Sun, reading its ultraviolet radiation to measure absorption
and scattering by the planet's atmosphere as the spacecraft
moves into shadow.

Airglow observations measure atomic hydrogen and helium
in the upper atmosphere by recording the resonance scattering
of sunlight. Resonance scattering is what happens when atoms
and molecules absorb solar UV at specific wavelengths and
reradiate at the same wavelengths. That differs from
fluorescence, in which the activating wavelength is absorbed
and energy is reemitted at different wavelengths. It is also
possible that auroral-type emissions will be observed at
Jupiter.

As the spacecraft moves behind Jupiter, the planet's
atmosphere passes between the Sun and the UV spectrometer.
Since the gases that make up an atmosphere have identifiable
absorption characteristics at short wavelengths, the spectrometer
can measure how much of each gas is present at what temperature.

The important point is not how much sunlight enters the
atmosphere, but what happens to it after it enters -- how it
is abosrbed and scattered.

INVESTIGATION	PRINCIPAL INVESTIGATOR	INSTRUMENTS AND FUNCTIONS
Imaging Science	Bradford Smith, Team Leader University of Arizona	Two TV cameras with 1500 mm, f/8.5 and 200 mm, f/3 optics, multiple filters, variable shutter speeds and scan rates. Wide-angle field of view, 56 x 55 millirad (about 3 deg square). On scan platform.
Infrared Interferometer Spectrometer	Rudolf Hanel, Goddard Space Flight Center	Spectrometer-radiometer measuring temperatures and molecular gas composition, with narrow, 1/4-deg field of view, producing measurements every 48 sec; on scan platform.
Ultraviolet Spectrometer	A. Lyle Broadfoot, Kitt Peak National Observatory	Grating spectrometer measuring ion, atomic, and small-molecular gas abundances; spectral range 400-1600 Angstroms, on scan platform.
Photopolarimeter	Charles Lillie, Univ. of Colorado (Cruise phase) Charles Hord, Univ. of Colorado (Encounter phase)	200-mm telescope with variable apertures, filters, polarization analyzers, and PMT detector· on scan platform.
Plasma	Herbert Bridge, MIT	Dual plasma detectors one aligned toward Earth/Sun and one perpendicular, with detection ranges from 4v to 6kv.
Low Energy Charged Particles	S. M. Krimigis, Johns Hopkins Applied Physics Laboratory	Dual rotating solid-state detector sets, covering various ranges from 10kev to more than 30Mev/nucleon.
Cosmic Ray	R. E. Vogt, Caltech	High-energy, low-energy, and electron telescope systems using arrays of solid-state detectors, several ranges from 0.15 to 500Mev/nucleon.

Magnetometer	Norman Ness, Goddard Space Flight Center	Two low-field triaxial fluxgate magneto-meters located roughly 10 meters from spacecraft on boom, two high-field (~20 gauss) instruments mounted on spacecraft.
Planetary Radio Astronomy	James Warwick, Univ. of Colorado	Two 10-meter whip antennas and two-band receiver (20.4-1300 kHz, 2.3-40.5 MHz), detecting planetary radio emissions and bursts and solar/stellar bursts.
Plasma Wave	Frederick L. Scarf, TRW Space and Defense Systems	Uses 10-meter planetary radio astronomy antennas with step-frequency detector and waveform analyzer to measure plasma waves, thermal plasma density profiles at Jupiter and Saturn, satellite/magnetosphere interactions, wave particle interactions.
Radio Science	Von R. Eshleman, Team Leader, Stanford University	Uses spacecraft S-band/X-band links in planet, satellite and Saturn ring occultations to perceive changes in refractivity and absorption; celestial mechanics information calculated from tracking data.

JUPITER AND ITS SATELLITES

Everything about Jupiter is enormous: when the Solar System formed, 71 per cent of the material that did not end up in the Sun went to make Jupiter.

Jupiter is the fifth planet from the Sun. It completes one orbit every 11.86 Earth years.

A day on Jupiter is complete in 9 hours, 55 minutes and 30 seconds. The extremely rapid rotation causes the planet to be flattened at the poles: equatorial radius is 71,600 km (44,490 mi.), and the polar radius is 67,000 km (41,632 mi.).

Jupiter has 13 known satellites; a 14th may have been seen by Charles T. Kowal of Caltech, who also found the 13th in 1974. The four largest satellites were discovered by the first man to aim a telescope at Jupiter - Galileo Galilei in 1609-10. Galileo's discovery that Jupiter has satellites provided evidence that the Copernican theory of the Solar System was correct and that Earth is not the center. The four satellites discovered by Galileo (grouped together and called the Galilean satellites) are Io, Europa, Ganymede and Callisto. They range in comparable size from the planet Mercury to the Moon. All will be studied by the Voyagers.

Jupiter is comprised primarily of hydrogen. Indeed, it is so massive that very little of its original material could have escaped in the 4.6 billion years since it formed. The second most abundant element in Jupiter is helium. The ratio of hydrogen to helium on Jupiter is about the same as in the Sun. The solar ratio is roughly one atom of helium for 10 molecules of hydrogen.

Three other substances have been identified spectroscopically: ammonia, methane and water. The presence of hydrogen sulfide has been inferred.

The currently popular model of Jupiter's structure begins with a small iron-silicate core only a few thousand kilometers in diameter. The core is inferred because cosmic abundances of the elements include small amounts of iron and silicates. The temperature there is thought to be about 30,000 degrees Kelvin (53,500 degrees Fahrenheit).

Surrounding the suspected core in this model is a thick layer
in which hydrogen is the most abundant element. The hydrogen
is separated into two layers. In both it is liquid, but in
different states: the inner layer, about 46,000 km (28,500 mi.)
radius, is liquid metallic hydrogen, which means that the
hydrogen is electrically conductive like ordinary metals. That
form of hydrogen has not been observed in laboratories since
it requires immense heat and pressure. On Jupiter it is thought
to exist at temperatures around 11,000 degrees K (19,300 degrees
F.) and at pressures about 3 million times Earth's sealevel
atmosphere.

The next layer -- liquid hydrogen in its molecular form --
extends to about 70,000 km (43,500 mi.). Above that layer,
reaching to the cloud tops for another 1,000 km (620 mi.) is
the atmosphere.

If the model is correct, Jupiter has no solid surface, but
exists as a rapidly spinning ball of gas and liquid almost
779 million km (484 million mi.) from the Sun.

One of the puzzles about Jupiter is the fact that it radiates
about two and a half times the amount of heat that it receives
from the Sun. Early models postulated nuclear reactions
inside the planet, or heat from gravitational contraction.
These ideas are no longer believed likely.

Because Jupiter is too small and too cold to generate nuclear
reactions, scientists now believe the excess heat being
radiated by tne planet is stored heat left over from the
primordial heat generated when the planet coalesced out of the
solar nebula. As NASA's Dr. John Wolfe writes: "Jupiter can-
not be radiating heat because it is contracting; on the
contrary, it is contracting because it is slowly cooling."

The visible surface of Jupiter consists of bands of clouds,
alternating dark and light, from the equator to about 50 degrees
latitude. These bands appear to be convection cells that are
stretched by Coriolis forces created by the planet's rapid
rotation. By convention, the light features are called zones
and the dark ones belts. The light zones appear to be regions
of greater altitude and cooler temperatures than the dark belts.
Gas warmed by the planet's internal heat rises and cools in
the upper atmosphere and forms clouds of ammonia crystals
suspended in gaseous hydrogen. At the top of the zones, the
cooler material moves toward the equator or the poles, is
deflected in an east-west direction by Coriolis forces, and
then sinks back to lower altitudes. A similar mechanism on
Earth causes the Trade Winds.

One of the most prominent features on Jupiter is the Great
Red Spot. It has been observed almost constantly since its
discovery 300 years ago by Giovanni Domenico Cassini. Its
width is almost always about 14,000 km (8,700 mi.), but its
length varies between 30,000 km (18,600 mi.) and 40,000 km
(24,800 mi.).

The Great Red Spot appears to resemble an immense hurricane
on Earth -- although it is much larger and has lasted much
longer than any terrestrial storms. At one time scientists
believed it might be a phenomenon known as a Taylor column --
a standing wave above a mountain or depression on the surface.
But the current model of Jupiter has no solid surface, and
the Great Red Spot has wandered in longitude several times
around the planet.

Other spots have been observed in the Jovian atmosphere that
are similar to but much smaller than the Great Red Spot.
They, too, appear in the equatorial regions, but have relatively
short lifetimes; the one most recently observed lasted just
under two years.

Above about 50 degrees latitude the bands disappear, and the
Jovian atmosphere becomes turbulent and disorganized. It
appears to contain many small convection cells such as those
that create the belts and zones of the lower latitudes.

Radio astronomers found evidence for a magnetic field around
Jupiter during observations in the 1950s, when they discovered
radio-frequency emissions coming from the planet. The
emissions are confined to two regions of the spectrum -- with
wavelengths measured in tens of meters (decametric) and in
tenths of meters (decimetric). Another radio-noise contribution
comes from non-thermal mechanisms that depend on the planet's
magnetic field. This synchrotron radiation comes from
electrons that move near the speed of light.

The satellite Io appears to have some link with the decametric
radiation, since bursts of radio emissions seem to occur when
Io crosses the face of Jupiter. All radio emissions from
Jupiter are associated with rotation of the planet's magnetic
field.

While the Jovian magnetic field is essentially dipolar (north
and south, like Earth's), its direction is opposite Earth's
(the needle of a compass on Jupiter would point south). The
axis of the field is offset about 10.8 degrees from the
rotational axis, and the center of the axis is offset from the
center of the planet by about one-tenth of a Jupiter radius.
At the planet's cloud tops the field ranges between three and
14 gauss. Earth's magnetic field at the surface averages
about one-half gauss.

The shape of Jupiter's magnetic field is about the same as
Earth's with some significant differences. The movement of
energetic particles near the equator is intense, but at higher
latitudes falls off dramatically: there is apparently an
electric-current sheet along the magnetic equator that traps
and holds particles there.

The five inner satellites of Jupiter affect the distribution
of charged particles: as the satellites orbit Jupiter they
sweep particles out of their way and at the same time acquire
intense radioactivity.

Jupiter's outer magnetosphere is highly variable in size,
possibly due to changes in the solar-wind pressure; both
Pioneer spacecraft flew in and out of the magnetosphere
several times on their inbound legs. They first crossed the
magnetopause -- outer edge of the region -- at about 100 R_J
and crossed again as close as 50 R_J. Earth's magnetosphere
would shrink that much only in the event of the largest solar
magnetic storms.

High-energy electrons have also been observed in another
unexpected place: ahead of the bow shock wave in interplanetary
space. Scientists believe high-energy particles in Jupiter's
magnetosphere reach such velocity that they can escape.
Reexamination of records from Earth satellites turned up the
fact that these electrons had been observed for many years.
They were believed, however, to be of cosmic origin. Now
scientists think they spin down the solar magnetic-field lines
and intersect Earth, since their peaks occur every 13 months
when Earth and Jupiter are connected by the spiral lines of
the interplanetary magnetic field.

Jupiter's satellites fall into three groups -- the large
inner bodies, then a group of four that are small, and a
final group, also four in number, that are far distant and
have retrograde orbits.

The five inner satellites are Amalthea (the smallest; about
240 km (150 mi.) in diameter ; Io, larger than Mercury;
Europa, Ganymede and Callisto.

Io is about 3,636 km (2,260 mi.) in diameter. It displays
some of the most bizarre phenomena in the Solar System. Io
has red polar caps. For about 15 minutes after it emerges
from behind Jupiter it is several per cent brighter than usual.
The brightening occurs only about half the time. Scientists
believe it is caused by alteration of the colored material on
the surface while Io is behind Jupiter. Io has a layer of
ionized particles about 100 km (60 mi.) above the surface; the
satellite has a tenuous atmosphere. Measurements indicate the
the atmosphere is about one-billionth as dense as Earth's.
Io is surrounded by a yellow glow -- the emission lines of
sodium.

Europa, smaller than Io, has a diameter of 3,066 km (1,905 mi.)
Europa appears to be a rocky body like Io, and scientists say
this is probably because it heated early in its history, to a
temperature high enough to drive off the volatiles.

Ganymede is one of the largest satellites in the Solar System.
Its diameter is 5,216 km (3,241 mi.). Ganymede may be mostly
liquid water -- a planet-sized drop of water with a mud core
and a crust of ice.

Callisto has a diameter of 4,890 km (3,038 mi.). It is darker
than the other Galilean satellites, apparently because more
rocky material is exposed. It may have suffered the least
change of all the big satellites since formation 4.6 billion
years ago. Scientists believe it is probably half water, and
may contain so little rock that radioactive heating has not
melted or differentiated it.

All the outer satellites appear to be very different from the
inner group. They are probably asteroids captured by Jupiter's
gravity. Or they may be the remains of broken up satellites.
Their orbits are fairly highly inclined (25 to 28 degrees
from the equatorial plane), and the outermost four pursue
retrograde paths.

THE SATELLITES OF JUPITER

NAME		DIAMETER (km)	DISTANCE (km)	PERIOD
Amalthea	(V)	240	181,500	$11^h57^m22.7^s$
Io	(I)	3636	422,000	$1^d18^h27^m33.5^s$
Europa	(II)	3066	671,400	$3^d13^h13^m42^s$
Ganymede	(III)	5216	1,071,000	$7^d3^h42^m33^s$
Callisto	(IV)	4890	1,884,000	$16^d16^h32^m11.2^s$
Leda	(XIII)	7 (est.)	11,094,000	238.7^d
Himalia	(VI)	170	11,487,000	250.57^d
Elara	(VII)	80	11,747,000	259.65^d
Lysithea	(X)	14 (est.)	11,861,000	263.55^d
Ananke	(XII)	14 (est.)	21,250,000	631^d
Carme	(XI)	14 (est.)	22,540,000	692^d
Pasiphae	(VIII)	16 (est.)	23,510,000	739^d
Sinope	(IX)	14 (est.)	23,670,000	758^d

COMPARISON TABLE

	EARTH	JUPITER	SATURN
Radius (Equatorial)	6,378 km (3,963 mi)	71,400 km (44,366 mi)	59,800 km (37,158
Satellites	1	13	10 (?)
Year	1	11.86	29.46
Day	24^h	$9^h55^m33^s$	10h 26m
Mass	1	317.9	95
Gravity	1	2.61	0.9
Mean Distance From Sun	1 AU	5.203 AU	9.523

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