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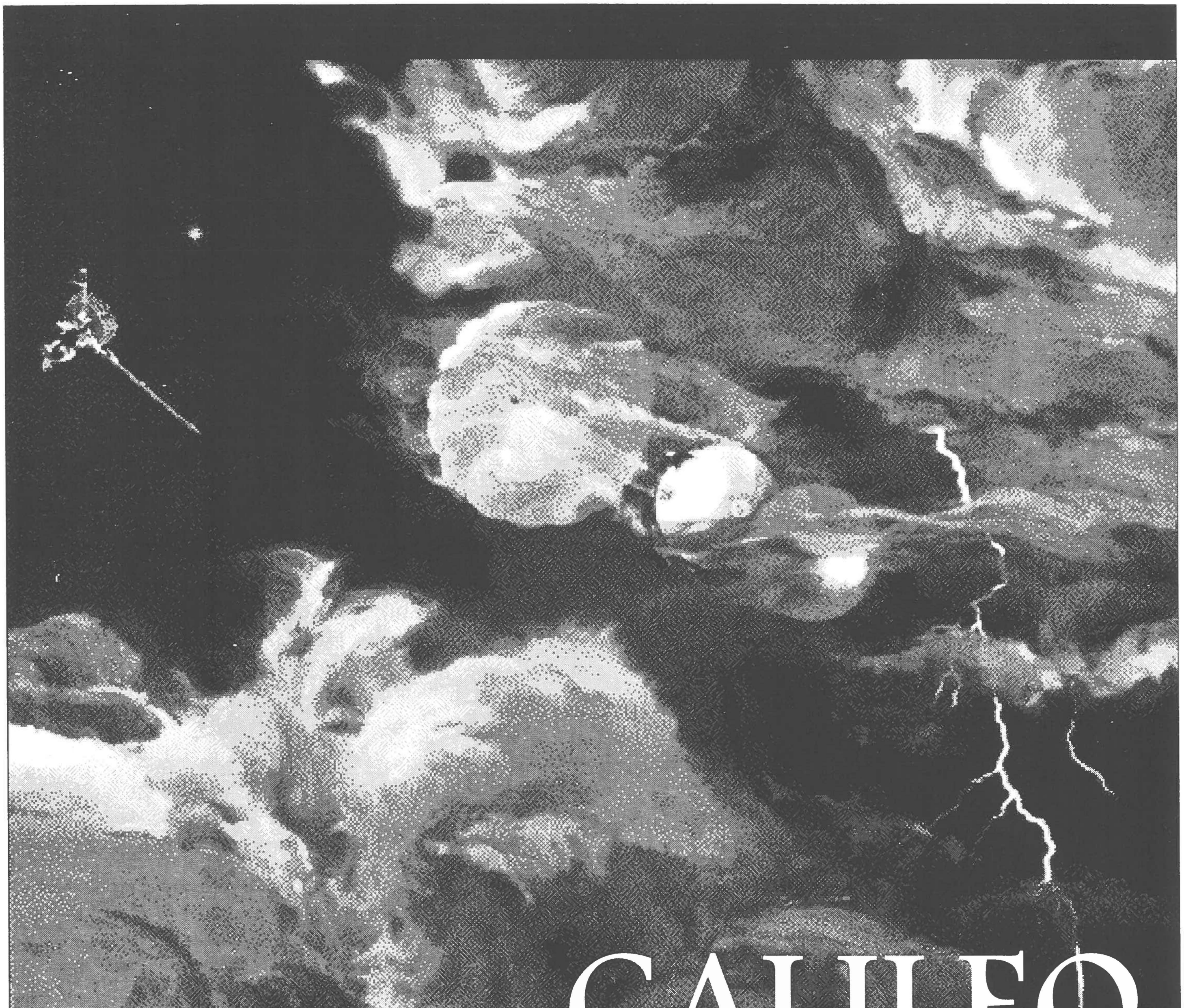
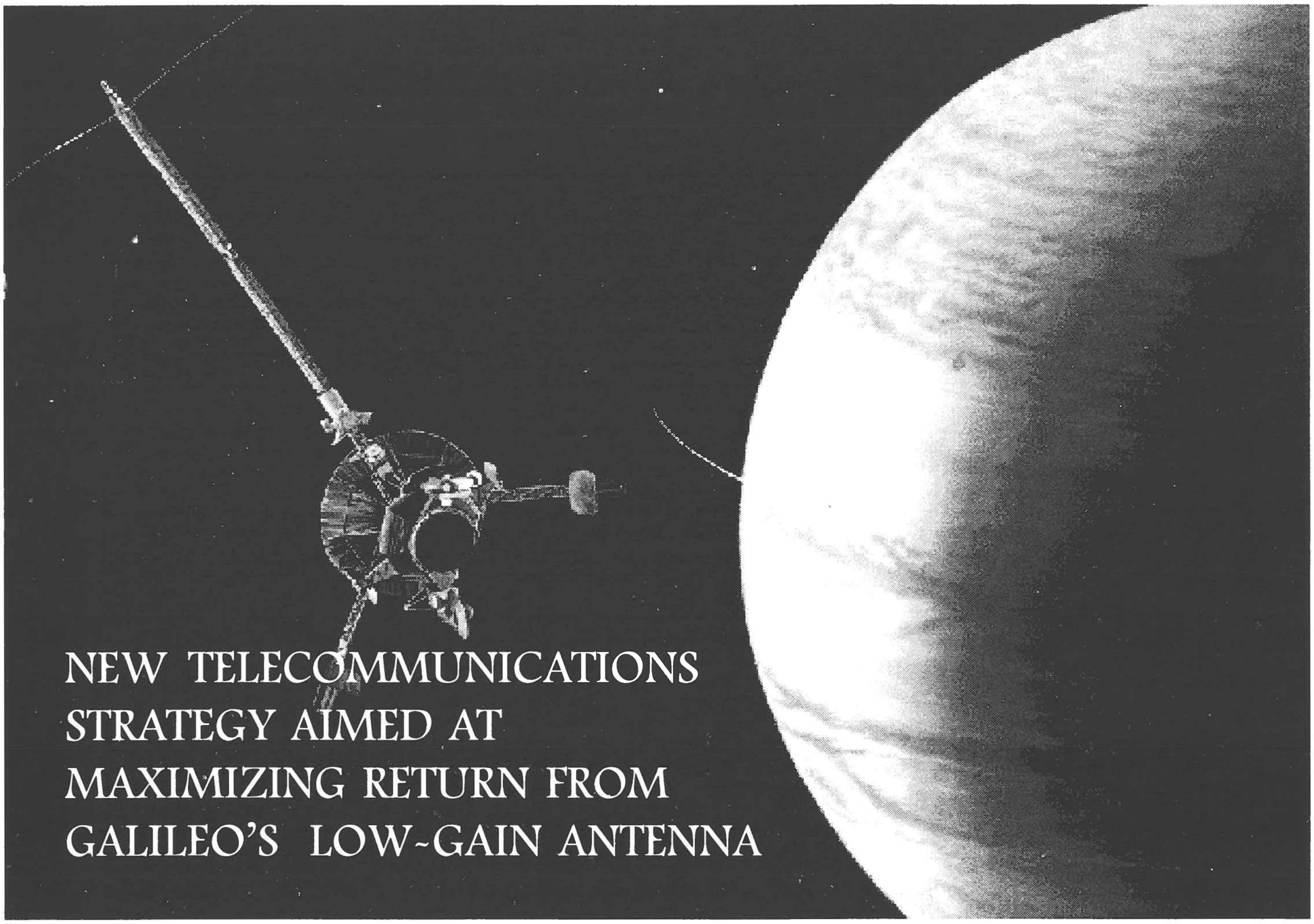


GALILEO NEARS JUPITER



NEW TELECOMMUNICATIONS STRATEGY AIMED AT MAXIMIZING RETURN FROM GALILEO'S LOW-GAIN ANTENNA

Engineers and scientists involved with the Galileo mission to Jupiter have devised several creative techniques to enable the spacecraft to achieve the majority of its scientific objectives despite the failure of its main communications antenna to open as commanded.

Upgrades to Galileo's onboard computer software along with modifications of its groundbased communications hardware have been developed and tested by the Jet Propulsion Laboratory (JPL) in response to the high-gain antenna problem, which could have caused a profound loss of data during the orbiter portion of the mission. (The spacecraft's Jupiter atmospheric probe mission can be accomplished without the new techniques, but the upgrades will enhance the orbiter's ability to reliably record and retransmit the data collected by the probe as it descends on a parachute.) The new telecommunications strategy hinges on more effective use of the low-gain antenna, which is limited to a very low data rate compared to the main, high-gain antenna.

The switch to the low-gain antenna and its lower data rate means that far fewer data bits will be returned from Jupiter. However, new software on the spacecraft will increase Galileo's ability to edit and compress the large quantity of data collected by the spacecraft and then transmit it to Earth in a shorthand form. On Earth, new technology is being used to greatly sharpen the hearing of the telecommunications equipment that will be receiving Galileo's whisper of a signal from Jupiter. Together, these efforts should enable Galileo to fulfill at least 70% of its original scientific objectives.

Background

The circuitous route Galileo has flown to reach Jupiter (one gravity-assist swingby of Venus and two of Earth) was necessitated by changes in U.S. space launch policy after the space shuttle Challenger accident in 1986. The powerful Centaur upper stage was to have been used to boost Galileo directly to Jupiter after its scheduled May 1986 launch onboard the shuttle. After the Challenger accident, the Centaur was deemed too hazardous to carry on a human space flight vehicle. A less volatile, but also less powerful, upper stage was substituted for the Centaur; this change delayed Galileo's launch until October 1989. The Inertial Upper Stage lacked the power to send Galileo on a direct course to Jupiter, but mission designers devised a flight path that used

For more information: http://www.jpl.nasa.gov/galileo/

the gravity fields of Venus and Earth to accelerate the spacecraft enough to reach Jupiter.

The High-Gain Antenna

The 4.8-meter (16-foot) wide, umbrella-like high-gain antenna is mounted at the top of the spacecraft. When unfurled, the antenna's hosiery-like wire mesh stretches over 18 umbrella ribs to form a large parabolic dish. Galileo was to have used this dish to radio its scientific data from Jupiter. This high-performance, X-band antenna was designed to transmit data back to Earth at rates of up to 134,400 bits per second (the equivalent of about one imaging frame each minute).

Galileo's original mission plan called for the high-gain antenna to open shortly after launch. For the Venus-Earth-Earth Gravity-Assist (VEEGA) trajectory mission, however, the heat-sensitive high-gain antenna had to be left closed and stowed behind a large Sun shade to protect it during the spacecraft's passage through the inner solar system. During this portion of the journey, two small, heat-tolerant low-gain antennas provided the spacecraft's link to Earth. One of these S-band antennas, mounted on a boom, was added to the spacecraft expressly to bolster Galileo's telecommunications during the flight to Venus. The other primary low-gain antenna mounted to the top of the high-gain was destined to become the only means through which Galileo will be able to accomplish its mission.

The Problem

On April 11, 1991, after Galileo had traveled far enough from the heat of the Sun, the spacecraft executed stored computer commands to unfurl the large high-gain antenna. But telemetry received minutes later at JPL showed that something went wrong. The motors had stalled and the antenna had only partially opened.

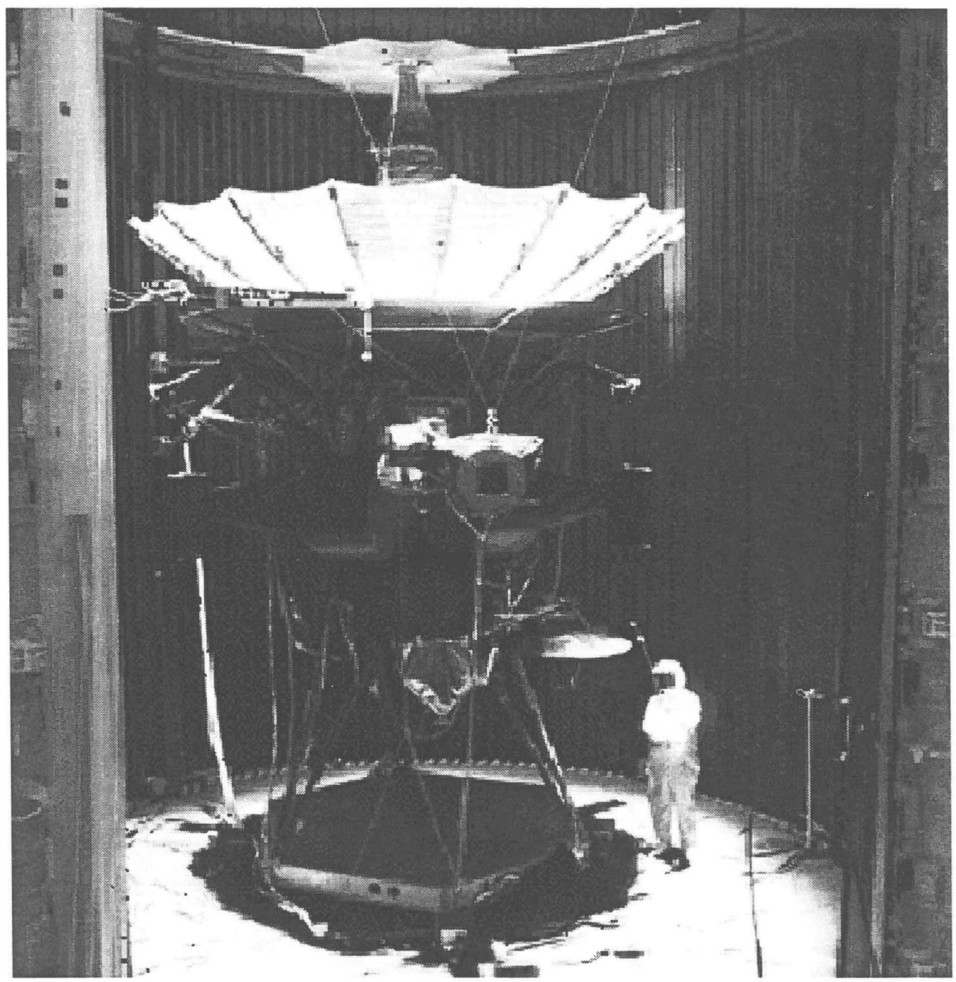
In a crash effort over the next several weeks, a team of more than 100 technical experts from JPL and industry analyzed Galileo's telemetry and conducted ground tests with an identical spare antenna. They deduced that the problem was most likely due to the sticking of a few antenna ribs, caused by friction between their standoff pins and sockets.

The excessive friction between the pins and sockets has been attributed to etching of the surfaces that occurred after the loss of a dry lubricant that had been bonded to the standoff pins during the antenna's manufacture in Florida. The antenna was originally shipped to JPL in Pasadena by truck in its own special shipping container. In December 1985, the antenna, again in its own shipping container, was sent by truck to Kennedy Space Center (KSC) in Florida to await launch. After the Challenger accident, Galileo and its antenna had to be shipped back to JPL in late 1986. Finally, they were reshipped to KSC for integration and launch in 1989. The loss of lubricant is believed to have occurred due to vibration the antenna experienced during those cross-country truck trips.

Extensive analysis has shown that, in any case, the problem existed at launch and went undetected; it is not believed to be a result of sending the spacecraft on the VEEGA trajectory, delaying antenna deployment.

Attempts to Free the Antenna

While diagnosis of the problem continued, the Galileo team sent the spacecraft a variety of commands intended to free the antenna. Most involved turning the spacecraft toward and away from the Sun, in the hope that warming and cooling the apparatus would free the stuck hardware through thermal expansion and contraction. None of these attempts succeeded in releasing the ribs. Further engineering analysis and testing suggested that



Before being launched from the shuttle, the Galileo orbiter was tested in a space simulation chamber. The test chamber, located at JPL, is designed to subject spacecraft to approximately the same environmental conditions that they will encounter in space. The high-gain antenna can be seen fully extended.

"hammering" the antenna deployment motors—turning them on and off repeatedly—might deliver enough force to free the stuck pins and open the antenna. After more than 13,000 hammerings between December 1992 and January 1993, engineering telemetry from the spacecraft showed that additional deployment force had been generated, but it had not freed the ribs. Other approaches were tried, such as spinning the spacecraft up to its fastest rotation rate of 10 rpm and hammering the motors again, but these efforts also failed.

Engineers now conclude there is no significant prospect of the antenna being fully deployed and used during the mission. Laboratory tests verified that holding ribs 9, 10, and 11 in the stowed position most nearly modeled the spacecraft telemetry. Nevertheless, one last attempt will be made in March 1996, after the orbiter's main engine is fired to raise Galileo's orbit around Jupiter. This "perijove raise maneuver" will deliver the largest acceleration the spacecraft will have experienced since launch, and it follows three other mildly jarring events: the release of the atmospheric probe, the orbiter deflection maneuver that follows probe release, and the Jupiter orbit insertion engine firing. It is possible, but extremely unlikely, that these shocks could jar the stuck ribs enough to free the antenna. This will be the last attempt to open the antenna before radioing the new software to the spacecraft to inaugurate the advanced data compression techniques designed specifically for use with the low-gain antenna.

The Low-Gain Antenna

The difference between Galileo sending its data to Earth using the high-gain antenna and the low-gain is like the difference between the concentrated light from a spotlight versus the light emitted diffusely from a bare bulb. If unfurled, the high-gain would transmit data back to Deep Space Network (DSN) collecting antennas in a narrowly focused beam. The low-gain antenna transmits in a comparatively unfocused broadcast, and only a tiny fraction of the signal actually reaches DSN receivers. Because the received signal is 10,000 times fainter, data must be sent at a lower rate to ensure that the contents are clearly understood.

The Solutions

Forced to make do with the low-gain antenna, the Galileo project has developed solutions on the spacecraft and on the ground to harvest as much data as possible from the orbiter.

After arriving in orbit on December 7, 1995, Galileo will perform its tour of Jupiter as originally planned, including 10 close encounters with the giant gas planet's major moons over the 23-month orbital mission. The spacecraft will also return nearly uninterrupted streams of data about the complex charged particles and powerful magnetic field surrounding Jupiter. Galileo will return more than 1500 images of Jupiter and its moons. The technology innovations developed for the low-gain antenna operations will also expedite the return of 100% of the atmospheric probe data and provide a backup technique to guarantee the capture of the most important subset of data from the probe.

New Software on the Spacecraft

Key to the success of the mission are two sets of new flight software. The first set, Phase 1, began operating in March 1995 and was designed to partially back up and ensure receipt of the most important data collected from the atmospheric probe. Once the critical scientific data from the probe is returned to Earth, a second set of new software will be radioed and loaded onto the spacecraft in March 1996.

This Phase 2 software will provide programs to shrink the voluminous science data the Galileo orbiter will collect during its two-year mission, while retaining the scientifically important information, and to return that data at the lower data rate. The first use of the Phase 2 software will be to return data collected during the orbiter's final approach and arrival at Jupiter, including the close encounters with Europa and Io, observations of the atmospheric probe's Jupiter entry site prior to entry, and detailed profiles of the planet's inner magnetosphere.

Without enhancements, the low-gain antenna's data transmission rate at Jupiter would be limited to only 8–16 bits per second (bps), compared to the high-gain's 134,400 bps. However, the innovative Phase 2 software changes, when coupled with hardware and software adaptations at Earth-based receiving stations, will increase the data rate from Jupiter by as much as 10 times, to 160 bps. The data compression methods will allow retention of the most interesting and scientifically valuable information, while minimizing or eliminating less valuable data (such as the dark background of space) before transmission. Two different methods of data compression will be used. In both methods, the data are compressed onboard the spacecraft before being transmitted to Earth.

The first method, called "lossless" compression, allows the data to be reformatted back to their original state once on the ground. This technique is routinely used in personal computer modems to increase their effective transmission rates. The second compression method is called "lossy," a term used to describe the dissipation of electrical energy, but which in this case refers to the loss of some original data through mathematical approximations used to abbreviate the total amount of data to be sent to the ground. Lossy compression will be used to shrink imaging and plasma wave data down to as little as 1/80th of its original volume.

Customizing Receivers on Earth

S-band telecommunication was once the standard for space missions, and several S-band performance-enhancing capabilities were implemented at DSN tracking stations in the 1980s. For Galileo and its S-band low-gain antenna, these capabilities are being restored at the Canberra 70-meter antenna. Because Australia is in the southern hemisphere and Jupiter is in the southern sky during Galileo's tour, the Canberra complex will receive most of Galileo's data.

Another critical, ongoing DSN upgrade will be the addition of so-called Block V receivers at the tracking stations. These receivers, which are being installed for multimission use, will allow all Galileo's signal power to be dedicated to the data stream by suppressing the traditional carrier signal, thus allowing use of higher data rates.

Finally, starting early in the orbital tour, the 70-meter and two 34-meter DSN antennas at Canberra will be arrayed to receive Galileo's signal concurrently, with the received signals electronically combined. The arraying technique allows more of the spacecraft's weak signal to be captured, allowing a higher data rate to capture more data. Additional arrays are planned as well: the 64-meter Parkes Radio Telescope in Australia will be arrayed with the Canberra antennas, as will the 70-meter DSN antenna in Goldstone, California, when its view of Galileo overlaps with Canberra's.

Science Saved and Science Lost

Very few of Galileo's original measurement objectives have had to be completely abandoned as a result of the high-gain antenna problem. For the most part, science investigations on the spacecraft have adapted to the lower data rates using a variety of techniques, depending on the nature of the experiment. The new software and DSN receiver hardware will increase the information content of the data that will be returned by at least 100 times over the amount that was possible with the original low-gain configuration.

Onboard data processing made possible by the Phase 2 software will allow the spacecraft to store and transmit nearly continuous observations of the jovian magnetosphere and extensive spectral measurements of the planet and its satellites in the infrared, visible, and ultraviolet, including more than 1500 high-resolution images.

While tens of thousands of images would be required for large-scale movies of Jupiter's atmospheric dynamics, the hundreds of images allocated to atmospheric imaging will allow in-depth study of several individual features in the clouds of Jupiter. Cooperative observations with Hubble Space Telescope investigators and groundbased observers have long been planned as part of the Galileo mission to provide information on the global state of Jupiter's atmosphere.

Like a tourist allotted one roll of film per city, the Galileo team will select its observations carefully at each encounter to ensure the maximum amount of new and interesting scientific information is returned. The imaging campaign will focus on the planet and the four large Galilean moons, but it will also cover the four inner minor satellites and Jupiter's rings. Eleven close satellite encounters will be conducted: one Io flyby (on approach), three of Europa, three of Callisto, and four of Ganymede. Five additional midrange encounters (from closer than 80,000 kilometers, or about 50,000 miles) with these moons will also occur.

The Galileo orbiter mission, with its sophisticated instruments, close satellite flybys, and long duration in jovian orbit, was specifically designed to answer many of the questions that the Pioneer and Voyager spacecraft were unable to answer. Scientists expect that Galileo can still achieve this goal despite the fact that the total volume of data has been reduced. Thus, when Galileo examines a class of phenomena, fewer samples of that class can be studied, and the spectral or temporal resolution will often be reduced to lessen the total volume of data. The resulting information, however, should nevertheless provide unique insight into the Jupiter system.

Some specific impacts from the loss of the high-gain antenna include elimination of color global imaging of Jupiter once per orbit; elimination of global studies of Jupiter's atmospheric dynamics such as storms, clouds, and latitudinal bands (efforts to image atmospheric features, including the Great Red Spot, are still planned, however); a reduction in the spectral and spatial coverage of the moons, which would provide context for study of high-resolution observations of their key features; and reduction of much of the so-called fields and particles microphysics (requiring high temporal- and spectral-frequency sampling of the environment by all instruments) during the cruise portion of each orbit. Most of the fields and particles microphysics, however, will be retained during the satellite encounters.

Galileo has already returned a wealth of surprising new information from the targets of opportunity it has observed on the way to Jupiter. Two first-ever asteroid encounters yielded close-up images of the asteroids Gaspra and Ida, and the extraordinary discovery of a moon, Dactyl, orbiting Ida.

The spacecraft was in a unique position to observe the remarkable impact of Comet Shoemaker-Levy 9 as its fragments slammed into Jupiter in July 1994. The observations provided key information on the initial impact, the duration, size, and temperature of the fireball, and also of the splash-back phase, when the material flung into space by the impact fell back into the planet's atmosphere.

Important scientific observations were also made of Venus, Earth, and the Moon during those flybys. These events served as demonstrations of the orbiter's ability to make excellent scientific observations with all its instruments. The Ida/Dactyl and SL-9 observations were returned to Earth at data rates substantially lower than those that will be available with the new Phase 2 capabilities.

In the face of adversity, the Galileo project team has succeeded in developing an innovative strategy to maximize the science return from the mission. Beginning in May 1996, Galileo's newly streamlined data pipeline should be providing a constant flow of new information, including an average of two to three images per day, through the end of the mission. Galileo's scientific instruments represent the most capable payload of experiments ever sent to another planet. The data they will return promises to revolutionize our understanding of the jovian system and reveal important clues that it holds regarding the formation and evolution of our solar system.

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Pam Thompson, Editor

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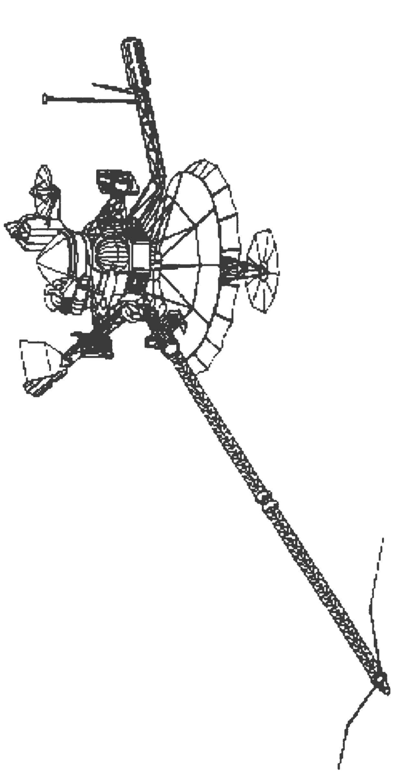
NEWS FROM SPACE



GALILEO ENCOUNTERS INTENSE DUST STORM

Galileo is plowing through the most intense interplanetary dust storm ever measured as it closes in on Jupiter after a six-year journey, scientists reported at the end of August. This is the latest and greatest of several large dust storms encountered since December 1994, when the spacecraft was still almost 110 million miles from Jupiter. The current storm has lasted more than three weeks. The spacecraft, launched in October 1989, is now about 39 million miles from Jupiter, which it will begin to orbit on December 7.

During the current dust storm, Galileo has counted up to 20,000 dust particles per day, compared to the normal interplanetary rate of about one particle every three days, said Dr. Eberhard Grun, principal investigator on the spacecraft's dust detector experiment.

The particles are apparently emanating from somewhere in the jovian system, perhaps from volcanos on Io or from Jupiter's faint two-ring system. The dust particles, probably no larger than those found in cigarette smoke, may also be leftover material from Comet Shoemaker-Levy 9, which crashed into Jupiter last year.

Scientists believe the particles are electrically charged and accelerated by Jupiter's powerful magnetic field. They have calculated that the dust is speeding through interplanetary space at 90,000 to 450,000 miles per hour, depending on particle size. Even at these speeds, the tiny particles pose no danger to the Galileo spacecraft, scientists say.

Galileo's dust detector is about the size of a large kitchen colander. It counts particle impacts and observes their direction and energy allowing estimates of particle size and speed. Grun, of the Max Planck Institute for Nuclear Physics, also has dust detectors aboard Ulysses, which flew by Jupiter in 1992 on its way to study the Sun. His team first discovered dust emanating from Jupiter in 1992 using the Ulysses instrument. The Galileo instrument first observed dust coming from Jupiter in June 1994. Although both Ulysses and Galileo show that the storms seem to come from Jupiter, the intensity and timing of the recent storms differ from those detected by Ulysses.

With the onset of the current storm, Galileo flight engineers commanded the spacecraft to collect and transmit dust data as often as three times a day instead of only twice a week, according to Dr. Carol Polanskey, team chief for the dust instrument subsystem at the Jet Propulsion Laboratory. "This puts us in an excellent position to view the dust phenomena as Galileo moves toward Jupiter," she said. "We're looking forward to determining the source of the dust storms once we get into the Jovian system."

GALILEO'S ATMOSPHERIC PROBE SUCCESSFULLY RELEASED

Packed like an interplanetary paratrooper, the atmospheric probe onboard Galileo was successfully detached from the main spacecraft early on the morning of July 13 to began its five-month free fall toward Jupiter. Data from Galileo received shortly after 2:07 a.m. EDT confirmed that the probe release went as planned.

Its flight across the remaining 51 million miles to Jupiter will end abruptly on December 7 when it slams into the gas giant's atmosphere. After hitting the top of Jupiter's atmosphere at the highest impact speed (106,000 mph) ever experienced by a man-made object, the rugged probe will unfurl its main parachute and float downward.

Seven onboard instruments will make the first ever direct measurements of Jupiter's chemical make-up, winds, clouds, and lightning. The probe will radio its data to the Galileo spacecraft for up to 75 minutes.

The probe mission is likely to end when the main Galileo spacecraft passes beyond radio contact with the probe as the spacecraft enters Jupiter orbit. The ultimate fate of the probe may be determined by its battery lifetime, or it may first succumb to the immense pressure of Jupiter's atmosphere and be crushed. Galileo, meanwhile, will begin two years of close-up studies of Jupiter, its moons, rings, and powerful magnetic field.

ULYSSES DETECTS WAVE MOTIONS OF THE SUN

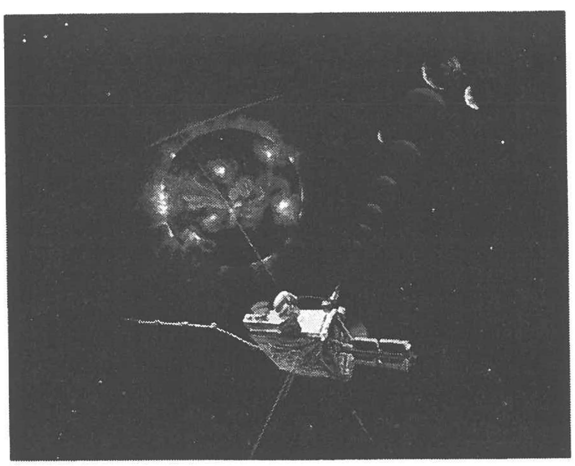
Periodic oscillations originating from deep within the Sun's interior have been detected for the first time in interplanetary space by particle detectors onboard the Ulysses spacecraft. The discovery was reported in the July 13 issue of *Nature* by Drs. Louis J. Lanzerotti, Carol G. Maclennan, and David J. Thomson of Bell Laboratories, Murray Hill, New Jersey.

In addition to finding that these signals affect energetic particles far from the Sun, the scientists reported that their experiment was able to identify oscillations, or wave motions, that have long been sought, but never detected, by Earth-based observers. "This is a breakthrough for studies of the Sun, the interplanetary medium, and the detrimental effects of energetic particles on terrestrial systems," said Lanzerotti, principal investigator of the Ulysses particle detector experiment.

The Sun vibrates to produce a number of discrete waves simultaneously, which travel through the Sun and arrive at its surface, much like seismic waves caused by earthquakes, which propagate through the Earth to the planet's surface. At the surface of the Sun, these waves appear as weak inward and outward motions, said Dr. Edward J. Smith, Ulysses Project Scientist for the U.S. portion of the mission, Jet Propulsion Laboratory.

Much of scientists' knowledge of the Earth's interior comes from studying these waves (seismology). The discovery of solar oscillations about 20 years ago provided a way of probing the Sun's interior (helioseismology). Scientists believe that such wave motions must occur on other stars and are actively searching for stellar oscillations.

The Ulysses scientists analyzed energetic particle measurements in search of narrow bandwidth waves. Using a sophisticated method of analysis, they found a large number corresponding with observations using other techniques. They cluster around wave periods of about five minutes, Thomson said. Each five-minute period represents the time it takes for the Sun's motion to change from moving outward to moving inward and then back outward again. These waves are equivalent to normal sound waves traveling through the Earth's atmosphere, but the periods are too long for the human ear to hear.



Lanzerotti and his co-investigators said their signals are probably the result of the effects of the solar motions on the magnetic fields that originate in the Sun's interior and are stretched outward into space by the solar wind. "As the magnetic lines of force oscillate in response to the passage of the waves, their motion is communicated to the energetic particles traveling along them," Lanzerotti said. Confirming their particle results, the investigators also found corresponding waves in the magnetic field data.

An even more surprising result was discovery of oscillations with longer periods of about three hours. Waves with these periods have been sought since theorists first predicted them. They can be used to probe even more deeply into the solar interior. "Observations of these oscillations in the energetic particle data are truly astounding," Smith said.

In late October, Ulysses will complete its pass over the northern pole and begin to journey back out to the orbit of Jupiter, not returning to the Sun until September 2000.

HUBBLE DATA SUGGEST GALAXIES HAVE GIANT HALOS

New Hubble Telescope observations may have helped solve a two-decade-old cosmic mystery by showing that mysterious clouds of hydrogen in space may actually be vast halos of gas surrounding galaxies. "This conclusion runs contrary to the longstanding belief that these clouds occur in intergalactic space," says Ken Lanzetta of the State University of New York at Stony Brook. The existence of such vast halos, which extend 20 times farther than the diameter of a galaxy, might provide new insights into the evolution of galaxies and the nature of dark matter—an apparently invisible form of matter that surrounds galaxies.

The possibility of galaxy halos was first proposed in 1969 by John Bahcall and Lyman Spitzer of the Institute for Advanced Study at Princeton. Previous observations with groundbased telescopes, the International Ultraviolet Explorer satellite, and Hubble have suggested that these clouds might be galaxy halos. However, the latest results are the most definitive finding yet, says Lanzetta, because they come from a large sample of 46 galaxies.

For the past two decades, observations with groundbased telescopes have shown that the light from distant quasars is affected by intervening gas clouds. These clouds are invisible, but betray their presence by absorbing certain frequencies of a quasar's light. Across a spectrum, the missing wavelengths appear as a complex "thicket" of absorption features. Groundbased observations also showed that the number of these clouds rapidly rises out to greater distances. One possible explanation was that these were primordial clumps of gas that dissipated over time.

However, in 1991, independent observations made with Hubble's Faint Object Spectrograph and the Goddard High Resolution Spectrograph detected more than a dozen hydrogen clouds within less than a billion light-years of our galaxy. These clouds could not be detected previously because they are only visible in the ultraviolet, which cannot be seen through Earth's atmosphere. This gave astronomers a powerful opportunity to further test the halo theory by imaging nearby galaxies and attempting to match them with nearby clouds.

Lanzetta, David Bowen of the Space Telescope Science Institute, David Tyler of the University of California at San Diego, and John Webb of the University of New South Wales, Australia, attempted to match galaxies and clouds by first collecting Hubble archival data on six quasars. Next, using telescopes at the National Optical Astronomy Observatory, the Anglo Australian Observatory, the Lick Observatory, and the Isaac Newton Telescope, they identified galaxies near the clouds and measured distances. In the majority of cases they found galaxies within about 500,000 light-years of the clouds.

"These results are a surprise. We have never seen these halos in the local universe," said Bowen. The results explain why so many clouds are seen at greater distances: The light from distant quasars was more likely to pass through a galaxy's halo because the halo is so large. These results appeared in the April 1, 1995, issue of the *Astrophysical Journal.* The researchers plan to extend their research to a larger sample of galaxy/cloud pairs.

PIONEER II MISSION ENDS BUT THE SPACECRAFT SAILS ON

After nearly 22 years of exploration out to the farthest reaches of the solar system, one of the most durable and productive space missions in history will end. More than four billion miles from Earth, NASA's Pioneer 11 spacecraft is heading out into interstellar space. Because the spacecraft's power is too low to operate its instruments and transmit data, on September 30 NASA will cease daily communications with the spacecraft. The faint signals from Pioneer 11 now take more than six hours to reach Earth.

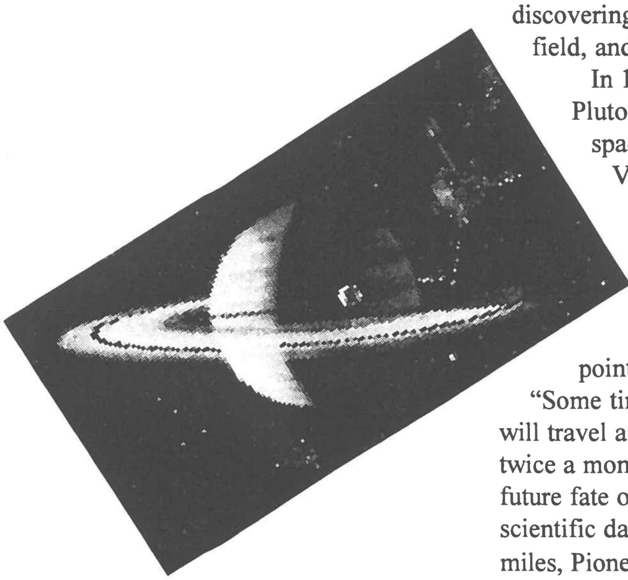
The spacecraft will continue speeding out into interstellar space toward the center of the Milky Way, taking an engraved gold plaque bearing a message about Earth to other civilizations. It will pass near the star Lambda Aquila in almost four million years.

"Pioneer 11 has had a spectacular life," said project manager Fred Wirth of Ames Research Center. "It was the second spacecraft to visit Jupiter, roaring through the heart of the planet's huge radiation belts at 107,373 mph, by far the fastest speed ever traveled by a human-made object."

Launched in April 1973, Pioneer 11 reached Jupiter in December 1974, following Pioneer 10, which flew by the planet a year earlier. It came in under the giant planet's south pole and skimmed within 26,600 miles of its cloud tops. The flyby was so close—the closest pass yet made—that the spacecraft received heavy bombardment from Jupiter's radiation belts, which are 40,000 times more intense than Earth's. Only Pioneer's speedy passage saved its electronics from severe damage.

The gravity assist from the close flyby threw the craft 100 million miles above the plane of the ecliptic and 1.5 billion miles across the inner solar system to Saturn. Pioneer flew high enough above the Sun's equatorial plane (17 degrees) to characterize the solar magnetic field for the first time.

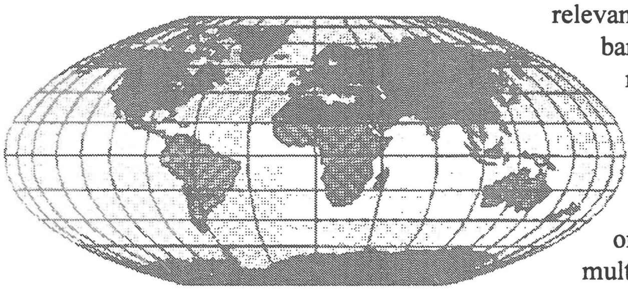
In 1979, Pioneer 11 made the first flyby of Saturn, passing within 13,000 miles and discovering two new moonlets, a new ring, and charting the magnetosphere, magnetic field, and general structure of Saturn's interior.



In 1990 Pioneer 11 became the fourth spacecraft to journey beyond the orbit of Pluto, heading in the same direction that the Sun moves through interstellar space. Pioneer 10 is traveling in the opposite direction, and with the two Voyagers, will continue to return information about the Sun's influence deep in space.

Although running out of power, most systems onboard the remarkably durable Pioneer 11 spacecraft are still healthy. For many years the spacecraft has been sending back limited data on the solar wind, magnetic field, and cosmic rays, but it can no longer be maneuvered to point its antenna accurately at the Earth.

"Some time in late 1996, its transmitter will fall silent altogether, and Pioneer 11 will travel as a ghost ship in our galaxy," Wirth said. "We plan to listen to it once or twice a month to learn about the fade-down process. This will help us understand the future fate of its sister craft, Pioneer 10," he said. Pioneer 10 continues to return scientific data and may have enough power to last until 1999. At almost six billion miles, Pioneer 10 is the most distant object built by humans.



INPUT SOUGHT FOR NEW CODATA STUDY ON THE TRANSBORDER FLOW OF SCIENTIFIC DATA

—by R. Stephen Berry and Paul F. Uhlir

Scientists commonly encounter barriers in gaining access to data relevant to their research. These barriers, both technical and nontechnical, have been a topic of increasing concern in recent years. Sheer volume has been one factor, but by no means the only one. Integration of multidisciplinary data on an international basis to address problems such as global environmental degradation or disease epidemics raises new kinds of challenges.

The National Research Council has organized a study, chaired by R. Stephen Berry of the University of Chicago, to investigate the barriers and other issues in the transborder flow of scientific data. The study's goal is to help improve access to scientific data and services internationally. The primary focus is on data in electronic forms, a topic of increasing complexity and importance in scientific research and international collaboration. The study is outlining the needs for data in the major research areas of current interest in the natural sciences. The legal, economic, policy, cultural, and technical factors and trends that have an influence—positive or negative—on access to data by the scientific community are being characterized. The study also is identifying and analyzing barriers to international access to scientific data that are expected to have the most adverse impact in the natural sciences, with emphasis those common to all disciplines. The study will recommend to the federal government and the scientific community approaches that could help overcome these barriers to international access.

The study is being performed under the auspices of the U.S. National Committee for CODATA (USNC/CODATA), a standing committee organized under the National Research Council. The Council is the principal advisory body to the federal government on scientific and technical matters. The USNC/CODATA serves as a bridge between the scientific and technical community in the United States and the international CODATA on data issues in the natural sciences.

CODATA—the Committee on Data for Science and Technology—is an interdisciplinary committee organized under the International Council of Scientific Unions, a nongovernmental organization created in 1931 to promote international scientific activity in the different branches of science and their applications to humanity. According to CODATA's charter, the committee is concerned with all types of quantitative data resulting from experimental measurements or observations in the physical, biological, geological, and astronomical sciences. CODATA's general objectives include improvement of the quality and accessibility of data, as well as the methods by which data are acquired, managed, and analyzed. It aims to facilitate international cooperation among those collecting, organizing, and using data, and to promote increased awareness in the scientific and technical community of the importance of these activities.

To obtain broad input from users and suppliers of scientific data, the study committee has developed an "Inquiry to Interested Parties" requesting information on barriers to data access, pricing of data, protection of intellectual property, problems of less-developed countries, scientific data for global problems, the use of electronic networks, and other technical issues. Anyone interested in providing views to the study committee is invited to respond to this public inquiry, which is posted on CODATA's World-WideWeb home page (http://www.cisti.nrc.ca/codata/welcome.html).

Information about the study and CODATA activities generally may be obtained from Paul F. Uhlir, Director, USNC/CODATA, National Research Council, 2101 Constitution Avenue, N.W., Washington DC 20418; e-mail: puhlir@nas.edu.

(R. Stephen Berry is Chairman of the new CODATA study; Paul F. Uhlir is Director of the U.S. National Committee for CODATA, National Academy of Sciences/National Research Council.)

PUBLICATIONS FROM LPI

QUANTITY	CODE	TITLE	PRICE	TOTAL
		BOOKS		
	B-ACM	ASTEROIDS, COMETS, METEORS 1991	$50.00	
	PRO-20	PROCEEDINGS OF THE TWENTIETH LUNAR AND PLANETARY SCIENCE CONFERENCE	$25.00	
	PRO-22	PROCEEDINGS OF THE LUNAR AND PLANETARY SCIENCE CONFERENCE, VOLUME 22	$25.00	
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	S-WINDS	THE WINDS OF MARS: AEOLIAN ACTIVITY AND LANDFORMS (30 SLIDES)	$18.00	
	S-STONES	STONES, WIND, AND ICE: A GUIDE TO MARTIAN IMPACT CRATERS (30 SLIDES)	$18.00	
	S-VOLC	VOLCANOES ON MARS (20 SLIDES)	$15.00	
	S-APOLLO	APOLLO LANDING SITES (40 SLIDES)	$20.00	
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	S-GEOL	SHUTTLE VIEWS THE EARTH: GEOLOGY FROM SPACE (40 SLIDES)	$20.00	
	S-CLEM	CLEMENTINE EXPLORES THE MOON (20 SLIDES) ★NEW★	$15.00	
		TECHNICAL REPORTS AND CONTRIBUTIONS (AVAILABLE FOR THE COST OF SHIPPING AND HANDLING)		
	92-08	WORKSHOP ON THE POLAR REGIONS OF MARS: GEOLOGY, GLACIOLOGY, AND CLIMATE HISTORY	$0.00	
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Helene M. Thorson Retires from LPI After 24 Years

Helene M. Thorson, Assistant Director for Administration at the Lunar and Planetary Institute, retired after 24 years at the Institute at the end of August, 1995. Since joining the Lunar Science Institute staff on June 28, 1971, she has worked with seven of the eight Directors and witnessed the transition from lunar sample studies to solar system research as LSI became LPI in the early 1980s.

The present LPI Director, David Black, said of her retirement, "It is natural when coming to the close of a career to ask whether you have made a difference. The answer in Helene's case is a ringing 'yes!' Throughout the nearly quarter-century that she has worked at the Institute, she has served as mother-confessor for many of the staff, chief advisor and sounding board for Directors, and a repository of knowledge and wisdom for the entire USRA family.

"Her actions and dedication to her work, to the people with whom she works, to the Institute, and to the planetary science community is a model for others to emulate. It is, however, a standard that will be difficult to attain. Few will ever really know the many ways in which Helene's career has touched their lives in a positive way. I only hope that she realizes as she prepares to embark on the next phase of her life that she has indeed made a difference."

Thorson's career spans 37 years of technical and administrative work at LPI and other research institutions, first at Yerkes Observatory and the Departments of Astronomy and Geophysical Sciences at the University of Chicago, and later at the Planetary Sciences Division of the Kitt Peak National Observatory. The route she followed was not an obvious one, however, for Helene has led something of a double life.

From elementary school through her high school years in Williams Bay, Wisconsin, she was known for her musical talent, both as a trumpeter in the band, and especially as a state champion vocalist who was much in demand for concerts and recitals. "All of my family was musical. We could just about have our own band or chorus at home," she recalls.

It surprised no one when she chose to attend Bradley University in Peoria, known for its Opera Workshop in which students participate in all aspects of opera production, from set design and construction to performance. Majoring in music with a minor in English, Thorson intended to make music her career.

After college, she was drawn to New York city, the magnet for serious musicians, where she continued to study voice. Later, after experiencing firsthand the rat race and comparing notes with friends at Juilliard on the compromises required to pursue a professional singing career, Thorson decided to return to the Midwest, and there began the second thread of her double life.

She took a job working for Dr. Joseph W. Chamberlain at the Yerkes Observatory and became involved in assisting in a research project on the aurora borealis. "Learning to value these things—like looking at stars—was a learning curve for me. I came from a background where all the family worked at 'real' jobs from an early age. But working on the aurora archives, I became fascinated. Then I realized what it

continued on page 16

NEW IN PRINT

These publications are available from the publisher listed or may be ordered through local bookstores.

NEW FROM LGI

A new technical report, "Trafficability of Lunar Microrovers (Part 2)," TR95-01, is available free from the Lunar Geotechnical Institute. Order from LGI, P.O. Box 5056, Lakeland FL 33807-5056. Phone: 813-646-1842; fax: 813-644-5920.

NEW FROM THE ASTRONOMICAL SOCIETY OF THE PACIFIC

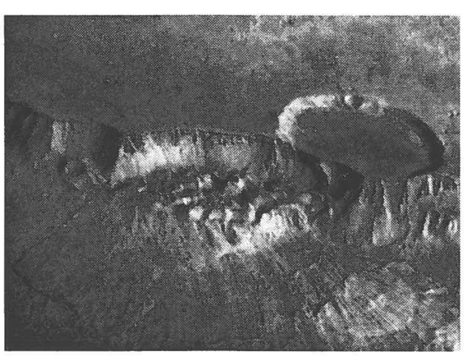
ASTRONOMY ACTIVITY AND RESOURCE NOTEBOOK

The Universe at Your Fingertips, an 813-page astronomy activity and resource notebook for teachers in grades 3–12 (and astronomers who work with them) has been published by the nonprofit A.S.P. The loose-leaf collection includes 90 hands-on activities selected from a wide range of sources that allow students to investigate many different areas of astronomy. Also included are an annotated resources list, including reading materials, audiovisual aids, software, support organizations, and national astronomy education projects. The notebook also has articles on astronomy basics and fitting astronomy into the science curriculum at different grade levels. Created by the National Science Foundation's Project ASTRO, the contents have been thoroughly field tested and reviewed by teachers and astronomers. $24.95, plus $6.00 shipping and handling to U.S. addresses, from A.S.P., Notebook Order Department, 390 Ashton Avenue, San Francisco CA 94112. Phone: 1-800-335-2624.

1995 MAIL ORDER CATALOG

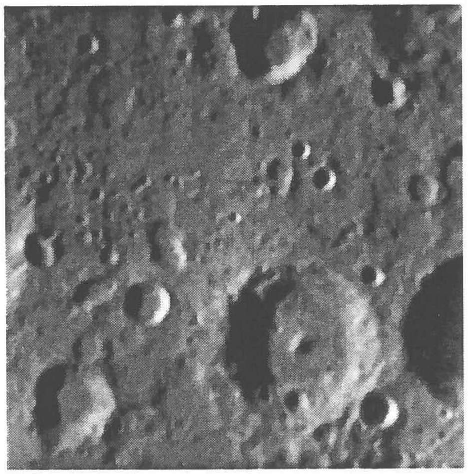
The 1995 mail order catalog, illustrated in color, includes a wide variety of materials for the teaching and enjoyment of astronomy. New items include *The Universe at Your Fingertips* activity and resource notebook; *NOVA* videotapes on eclipses, supernovae, and the infrared universe; a 25-slide set on the Shoemaker-Levy 9 impact with Jupiter; the new third edition of the *Cambridge Atlas of Astronomy; Jupiter Impact* CD-ROM of images and QuickTime movies from observatories around the world; Apollo 11 25th anniversary commemorative videotapes; Stephen Hawking's *A Brief History of Time* on CD-ROM for Macintosh and Windows; and CD-ROMs of high-resolution deep space and solar system images. Free, from A.S.P., Catalog Requests Department, 390 Ashton Avenue, San Francisco CA 94112. Phone: 415-337-1100; fax: 415-337-5205. E-mail: asp@stars.sfsu.edu

NEW FROM LPI



MARS SLIDE SET

The Red Planet: A Survey of Mars is a 40-slide set that illustrates many different kinds of geologic features, including tectonic structures, volcanos, impact craters, landslides, and features formed or modified by ice and water. Although humans have not yet sampled them *in situ,* scientists believe that rocks from Mars have arrived on Earth. These rocks, known as the SNC meteorites, are also featured, as are the two small moons, Phobos and Deimos. Compiled by Walter S. Kiefer, Allan H. Treiman, and Stephen M. Clifford, the set includes a booklet with an introduction and overview, a locater map, captions for each slide, suggested further reading, and a glossary. $20.00 from LPI; see Order Form in this *Bulletin.*



CLEMENTINE RAW IMAGES ON CD-ROM AVAILABLE AT NSSDC

The first 45 CD-ROM volumes of the 88-volume Clementine Raw Image Archive Collection are now available at NSSDC. The CDs contain all imaging data from the five imaging sensors onboard the Clementine spacecraft, arranged by orbit number. More information on these CD-ROMs, including ordering information, is available on the World-Wide Web at:

http://nssdc.gsfc.nasa.gov/planetary/clemcd.html

Additional information on the Clementine mission is available at:

http://nssdc.gsfc.nasa.gov/planetary/clementine.html

Contact: National Space Science Data Center, NASA Goddard Space Flight Center, Greenbelt MD 20771. Phone: 301-286-4136; fax: 301-286-1771.
Internet: towheed@nssdca.gsfc.nasa.gov
WWW: http://nssdc.gsfc.nasa.gov/

REVIEW

PLANETS OF THE SUN

Videotape in the "Nature Series" (1992) Diamond Entertainment Corporation 30 minutes. Includes the title film narrated by Leonard Nimoy and the film Flight to the Planets.

DANGER! WARNING! This video is not as advertised, and is (in my opinion) of minimal educational value for the target 6–12-year age group. Despite the 1992 copyright date on the video and the Voyager Saturn mosaic on the jacket, the two film cuts were individually copyrighted in 1974 and 1970! Even then, they were woefully out of date. Nor do the films contain ". . .outstanding nature footage. . ." as the jacket claims; they contain artists' conceptions rather than real images of the solar system.

The most obvious flaw in the films is the lack of current images of planets and the universe (despite the Voyager Saturn mosaic on the video jacket). Since the 1970 and 1974 publication dates, we have visible-light images of the universe from Mariner 10, Pioneer Saturn, Viking, Voyager 1 and 2, Magellan, Hubble, Clementine, and Galileo; we have had enormous strides in Earth-based telescopic observations; and we have incredible new data and imagery from other parts of the electromagnetic spectrum. None of these advances in knowledge are, or could be, seen in this video.

Even worse, the films in this video did not use images current in their publication years, 1970 and 1974! Instead of images, films rely on paintings of planetary and astronomical scenes, with some simple animations. Between them, the videos contain only one real photo or image of a planet, Earth as seen from Apollo 8. There are no real images of the Moon, neither telescopic from Earth nor spacecraft from Luna, Lunar Orbiter, Surveyor, or Apollo. Rather, the videos contain paintings of the Moon's disk and a crude, unrealistic model of the Moon's surface. Mars is shown in Bonestell-like paintings, ignoring the availability of excellent telescopic images of the disk and Mariner views of the surface. Jupiter and Saturn appear only as paintings (including a few from Bonestell). Given time lags in production, perhaps the first films can be forgiven the lack of using the Pioneer images of Jupiter (1973).

Nor was the script up to date, even in 1970 and 1974. It was amusing and pathetic to learn that soil on the Moon is very much like that on Earth, and to hear Mars described without mention of volcanos, the Valles Marineris, polar ice, or flood channels.

Many good, current videos and CDs are available with stunning, real images of planets and the universe. Buy one of them rather than this historical relic. (Even the music is historical—I caught a few riffs from The Who's *Teenage Wasteland.* A wasteland indeed!)

—Allan Treiman

(Dr. Treiman is a staff scientist at LPI and a contributor to education and outreach projects at the Institute.)

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was—it was like music—it was something that simply had to be done! And it's been science ever since."

The aurora work resulted in a publication with Chamberlain, and Helene found that she enjoyed editing papers and book galleys. Other jobs followed from the Yerkes experience. Today, Thorson says, "I never dreamed that I'd be a secretary and all the rest that followed from that. They used to say, 'Whatever you do, young women, get a background in business skills.' Well, I didn't. I've had to train myself for a business and technical career."

Of her years working with astronomers, geophysicists, geologists, and planetary scientists, she recalls mischieviously, "One of the things that was the most fun—I noticed that there were and continue to be distinct differences in the kinds of people in each field, even to their drinking habits! But I'm not going to reveal those particular habits!"

From time to time, Thorson explored jobs outside the research field to satisfy her curiosity and to try something different. She recalls a year spent working for a major Chicago patent law office that served the meatpacking industry, "Totally corrupt, really cutthroat! I saw a completely different side of life. I was happy to get back to the research environment." But she feels it's important to have a look outside one's familiar world from time to time. "I advise anyone to do so when feeling dissatisfied with one's job."

During the '70s, as she began the LPI phase of her career, Thorson continued to sing with the Bay Area Chorus, a well-known regional chorus in the Houston area. "I increasingly appreciate how mathematical music is," she says of the science and music threads that have been interwoven through her life.

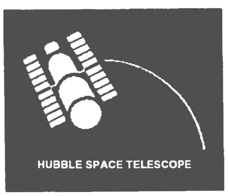
Of her decision to retire, she says, "It's time to stop and smell the gardenias. Music is still my life. I would rather listen to a symphony than eat. That's what retirement will be about."

ABSTRACT DEADLINE FOR 27th LPSC ANNOUNCED

The LPI Pulications and Program Services Department has set 5 p.m. CST, January 10, 1996 as the deadline for receipt of abstracts for the 27th Lunar and Planetary Science Conference. In a departure from tradition, the due date falls on a Wednesday, rather than Friday. Announcements and instructions for abstract preparation will be mailed to the community as usual during the fall of 1995 and will be accessible from the LPI Home Page (http://cass.jsc.nasa.gov/lpi.html) as they are published. LPSC itself will be March 18–22, 1996.

Left: Hubble Telescope image of the second ring plane crossing, August 10, 1995. Right: Images from the 256 × 256 IR camera on the European Southern Observatory 3.6-m telescope; top view shows, left to right, A ring, B ring, Janus, C ring; bottom view shows, left to right, C ring, B ring, A ring, Tethys and Mimas merged together. Brightening of the western extremity of the A ring is unexplained but could be caused by a newly discovered satellite or clumpy material in the F ring or Enke gap.

SATURN RING PLANE CROSSING YIELDS INTRIGUING IMAGES



A team of astronomers using the Wide Field Planetary Camera II on the Hubble Space Telescope may have discovered several orbiting clumps of icy rubble that could be the remnants of recently shattered moonlets orbiting near the outer edge of Saturn's ring system. They may have discovered a new class of ephemeral, transitional objects in the solar system that provides new clues to the evolution of the rings.

The observations were made during the ring plane crossing on August 10, which provided a rare opportunity to seek out faint satellites in and near the ring plane. "Ring plane crossings" are those moments when the Earth or Sun crosses the plane of Saturn's rings, allowing them to be seen (or illuminated) edge on. The usually bright rings are seen only as a faint, thin line, and Saturn's smaller satellites become visible. These events are rare, occurring in groups of two or four at intervals of about 14.5 years.

The latest pictures gave astronomers an opportunity to confirm the presence of two new satellites first observed in Hubble images taken during the May 22 ring plane crossing. Rather than solving the moon question, however, the August observations presented a new mystery: "We realized these moons are too bright to have gone undetected when the Voyager spacecraft flew by Saturn in 1980 and 1981," said Phil Nicholson of the Cornell University observing team.

A further complication is that the August pictures seem to show at least three new objects, and in different orbits from the two May objects. "They also appear to be very elongated or arc-like, unlike a satellite should be. One possibility is that they are large clouds of debris from small satellites shattered by impacts with chunks of space debris (possibly comets), sometime during the 14 years since the Voyager 2 flyby."

The discovery of objects in this transitional phase is not totally unexpected, says Nicholson, because one theory for the origin of Saturn's ring system is that it is made up of countless fragments from several pulverized moons. This idea is reinforced by the fact the new objects orbit Saturn near the narrow F ring, which is a dynamic transition zone between the main rings and the larger satellites. Moonlets in this region can be easily disrupted by Saturn's tidal pull if they are fractured by an impact, forming a cloud of debris. Eventually such a cloud would spread around the moon's orbit to form a new ring.

The dynamics of this "bumper car" zone are also evident in Hubble's observations of the satellite Prometheus. Although a third object seen in the May images was first suspected to be another new satellite because its location did not match the predicted position for any of the known satellites charted by Voyager, it now appears that this body is in fact Prometheus, which has slipped in its orbit by 20 degrees from the predicted position. Nicholson suggests that this may be a consequence of a collision of Prometheus with the F ring, which is believed to have occurred in early 1993 as the moon passed close enough to one of the denser, lumpy regions of the F ring to have its orbit changed.

The researchers plan to observe the moons and rings again during the third ring plane crossing in November.

CALENDAR 1995

SEPTEMBER

11–14

The Role of Dust in the Formation of Stars, Garching, Germany. Contact: Hans Ulrich Kaufl, European Southern Observatory. WWW: http://http.hq.eso.org/stardust.html

11–15

58th Annual Meteoritical Society Meeting, Washington, D. C. Contact: Glenn MacPherson, Department of Mineral Sciences, MRC-NHB 119, U.S. National Museum of Natural History, Smithsonian Institution, Washington DC 20560. Phone: 202-357-2260; fax: 202-357-2476.
Internet: mnhms044@sivm.si.edu

24–30

Mars Pathfinder Landing Site Workshop II: Characteristics of Ares Vallis Region, Spokane, Washington. **Field Trip I: Channeled Scablands (9/24–27); Field Trip II: Missoula Lake breakout (9/30),** Moses Lake area, Washington. Contact: Publications and Program Services Department, LPI, 3600 Bay Area Boulevard, Houston TX 77058-1113. Phone: 713-486-2166; fax: 713-486-2160.
Internet: simmons@lpi.jsc.nasa.gov

25–28

Land Satellite Information in the Next Decade, Vienna, Virginia. Contact: Chris Dyer. Phone: 301-493-0290 ext. 29; fax: 301-493-0208.
Internet: cdyer@asprs.org

OCTOBER

8–13

27th Annual Meeting of the Division for Planetary Sciences of the American Astronomical Society, Kona, Hawaii. Contact: Karen Meech, University of Hawaii, Institute of Astronomy, 2680 Woodlawn Drive, Honolulu HI 96822.
Internet: meech@pavo.ifa.hawaii.edu

Workshops in Conjunction with DPS Meeting, Kona, Hawaii:

8

Conference on Laboratory Measurements Related to Planetary Atmospheres. Contact: Kenneth Fox. Phone 301-314-9124; fax: 301-314-9121.
Internet: kf35@umail.umd.edu

8

Workshop on Thermal Remote Sensing of Volcanos on Io and Earth. Contact: Rosaly Lopes Gautier, Phone: 818-393-4584; Internet: rlopes@jpluvs.jpl.nasa.gov *or* David Rothery, Phone: 1908-652124; Internet: d.a.rothery@open.ac.uk.

OCTOBER(CONTINUED)

14

Educator's Workshop. Contact: Linda French. Phone: 617-734-5200. Internet: linda@annie.wellesley.edu

6–8

SPACE FRONTIERCON IV: "Space—Fiction or Frontier?", Los Angeles, California. Contact: Space Frontier Foundation, 16 First Avenue, Nyack NY 10960. Phone: 800-78S-PACE; fax: 212-387-8499 *or* 914-358-8415.
Internet: openfrontier@delphi.com

10–12

Artificial Intelligence & Knowledge Based Systems for Space: 5th Workshop, Noordwijk, The Netherlands. Contact: ESTEC Conference Bureau, P.O. Box 299, 220 AG Noordwijk, The Netherlands. Phone: 31 1719 85005; fax: 31 1719 85658.
Internet: confburo@estec.esa.nl
WWW: http://www.estec.esa.nl/aikbs.html

25–27

3rd Huntsville Symposium on Gamma-Ray Bursts, Huntsville, Alabama. Contact: Susan Benefield.
Internet: workshop@batse.msfc.nasa.gov
WWW: http://cossc.gsfc.nasa.gov/grb3.html

NOVEMBER

6–9

Annual Meeting of the Geological Society of America, New Orleans, Louisiana. Contact: Vanessa George, 3300 Penrose Place, Boulder CO 80301. Phone: 303-447-2020; fax: 303-447-1133.

26–Dec 1

International Symposium on Spectral Sensing Research (ISSSR) 1995, Melbourne, Australia. Contact: Judy Cole, Science and Technology Corporation, 101 Research Drive, Hampton VA 23666-1340. Phone: 804-865-7604; fax: 804-865-8721.
Internet: cole@stcnet.com

DECEMBER

4–8

Science with the Hubble Space Telescope II, Paris, France. Contact:
Internet: hst2@eso.org
WWW: http://http.hq.eso.org/hst2.html

CALENDAR 1995

DECEMBER (CONTINUED)

11–15

American Geophysical Union Fall Meeting, San Francisco, California. Contact: AGU Meetings, 2000 Florida Avenue N.W., Washington DC 20009. Phone: 202-462-6900; fax: 202-328-0566.

JANUARY 1996

7–11

Space Technology and Applications International Forum (STAIF-96), Albuquerque, New Mexico. Includes: **1st Conference on Commercial Development of Space; 1st Conference on Next Generation Launch Systems; 1st Conference on Remote Sensing for Commercial, Civil, and Science Applications; 2nd Spacecraft Thermal Control Symposium; 13th Symposium on Space Nuclear Power and Propulsion.** Contact: Mohamed S. El-Genk, Technical and Publications Chair or Mary Bragg, Institute for Space & Nuclear Power Studies, University of New Mexico, School of Engineering, Albuquerque NM 87131-1341. Phone: 505-277-4950; fax: 505-277-2814.
Internet: mjbragg@unm.edu

22–26

New Extragalactic Perspectives in the New South Africa: Changing Perceptions of the Morphology, Dust Content, and Dust-Gas Ratios in Galaxies, Johannesburg, South Africa. Contact: David L. Block, Department of Computational & Applied Mathematics, Witwatersrand University, P.O. Box 60, WITS 2050, South Africa. Phone: 27-11-339-7965; fax: 27-11-716-3761.

29–Feb 2

OSETI II: The Search for Extraterrestrial Intelligence (SETI) in the Optical Spectrum, San Jose, California. Contact: Stuart A. Kingsley, The Columbus Optical SETI Observatory, 545 Northview Drive, Columbus OH 43209-1051. Phone: 614-258-7402; fax: 614-258-7459. Optical SETI BBS: 614-258-1710.

FEBRUARY

5–7

First ISU Symposium—Space of Service to Humanity: Preserving Earth and Improving Life, Strasbourg, France. Contact: Emma Moyen, International Space University, Parc d'Innovation, Boulevard Gonthier d'Andernach, 67400 Illkirch, France. Fax: 33 88 65 54 47.
Internet: moyen@isu.isunet.edu

12–14

Workshop on Evolution of Martian Volatiles, Houston, Texas. Contact: Publications and Program Services Department, LPI, 3600 Bay

FEBRUARY (CONTINUED)

Area Boulevard, Houston TX 77058-1113. Phone: 713-486-2166; fax: 713-486-2160.
Internet: simmons@lpi.jsc.nasa.gov

MARCH

11–14

Infrared Space Interferometry Workshop, Toledo, Spain. Contact: Margie Guitart, Secretary LOC, L.A.E.F.F., Apdo. 50727, 28080 Madrid, Spain. Phone: 34-1-813-1161; fax: 34-1-813-1160.
Internet: irinter@laeff.esa.es

18–22

27th Annual Lunar and Planetary Science Conference, Houston, Texas. Contact: Publications and Program Services Department, LPI, 3600 Bay Area Boulevard, Houston TX 77058-1113. Phone: 713-486-2166; fax: 713-486-2160.
Internet: simmons@lpi.jsc.nasa.gov

JUNE

1–6

Space 96: The Fifth International Conference and Exposition on Engineering, Construction, and Operations in Space *and* **RCE II: The Second Conference on Robotics for Challenging Environments,** Albuquerque, New Mexico. Contact: Dr. Stewart W. Johnson, Chair, Space and Robotics Conferences, Johnson and Associates, 820 Rio Arriba, S.E., Albuquerque NM 87123-5103. Phone: 505-298-2124; fax (by arrangement): 505-298-2124.
Internet: StWJohnson@aol.com

JULY

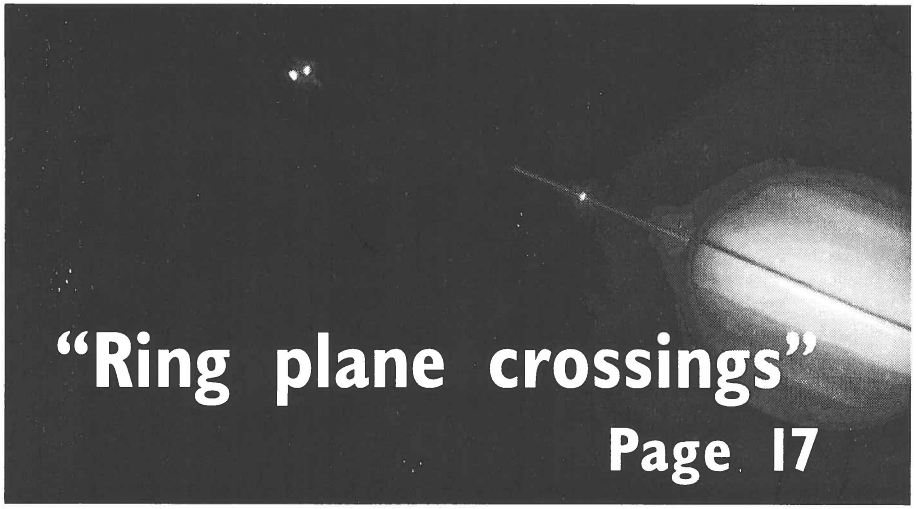
3–5

International Conference on the SL9–Jupiter Collision, Meudon, France. Contact: Agnes Fave, Conference SL9-Jupiter, DESPA, Observatoire de Paris, F-92195 Meudon Cedex, France. Fax: 33 1 45 07 28 06.
Internet: sl9jupiter@megasx.obspm.fr

8–12

Asteroids, Comets, Meteors, Versailles, France. Contact: ACM, Aeronomie CNRS, BP3, 91371 Verrieres, France.

INSIDE



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