REFINING THE HUBBLE CONSTANT
Refining the Hubble Constant with the Hubble Telescope

The Hubble Constant is the rate at which the universe is expanding, and its precise determination is essential for deducing the age and size of the universe. Named for Edwin Hubble, who in 1929 recognized that distant galaxies are rapidly receding from us, the constant can be measured by determining the velocity at which one galaxy is racing away from another and the distance between the two. Using the Hubble Space Telescope (HST), an international team of astronomers has taken a major first step in redetermining the constant by making more accurate measurements of the distances to galaxies farther away than ever before.

These results are being reported by Drs. F. Duccio Macchetto, Nino Panagia, and Abhijit Saha (Space Telescope Science Institute), Allan Sandage (Carnegie Institute of Washington), and Gustav Tammann (University of Basel) at the international workshop, Science with the Hubble Space Telescope, in Sardinia, Italy.

Using HST’s Wide Field and Planetary Camera (WFPC) the team found 27 Cepheid variable stars in a faint spiral galaxy called IC 4182, located 16 million light-years away in the northern sky constellation Canes Venatici. Only once before have Cepheids been found in a more distant galaxy (M101, located 23 million light years away). “The few Cepheids found in M101 with ground-based telescopes were unusually bright and required an enormous effort over many years,” says Macchetto. “Only Space Telescope can make these types of observations. Cepheids are too faint and the resolution too poor, as seen from ground-based telescopes, to separate the images in such a crowded region of a distant galaxy.”

Cepheid variable stars rhythmically change in brightness over intervals of days (the prototype is the fourth brightest star in the constellation Cepheus). Early in this century astronomers found a direct link between a Cepheid’s pulsation rate and its intrinsic brightness. Once a star’s true brightness is known, its distance can be calculated because luminosity drops off in proportion to the square of its distance from Earth. Though Cepheids are rare, they are very reliable “standard candles” for estimating intergalactic distances.

The galaxy IC 4182 was chosen for a Cepheid search because it is the site of a type Ia supernova explosion that occurred in 1937. Type Ia supernovae are thermonuclear explosions that may occur in systems containing a pair of white dwarf stars. Models predict that all supernovae of this type should reach approximately the same peak luminosity; thus, they, too, can be used as a yardstick for cosmic distance measurement. Because they are more luminous and can be detected 1000 times farther away than the Cepheids, they can help determine the Hubble Constant over much larger cosmic distances. But first, astronomers must accurately know their true intrinsic brightness. By determining the distance to IC 4182 using Cepheids, astronomers can calibrate the intrinsic brightness of the 1937 supernova. They can essentially now “link together” two rungs in the cosmological distance ladder.

The Hubble Constant is expressed in kilometers per second per megaparsec (3.26 million light-years). Previous estimates for the Hubble Constant vary by a factor of two (50 vs. 100 km/sec/Mpc). Using the absolute calibration of this single type of supernova in IC 4182, the researchers yield a range for the Hubble Constant of between 30 and 60 km/sec/Mpc. The most probable value is in the middle of this range, or about 45 km/sec/Mpc, which implies a minimum age for the universe of 15 billion years.

The astronomers plan to narrow this range next year by detecting Cepheid variable stars in other galaxies that have had recent type Ia supernovae as well. The ultimate goal is to use HST to refine the scale of the universe to within ten percent.
GOLDIN ANNOUNCES PLANS TO IMPLEMENT NEW INITIATIVES WITH RUSSIA

After several days of meetings with key space officials in Moscow, Goldin said significant progress was made in developing a plan to carry out a wide range of projects with Russia and Ukraine. They included:

- The creation of a Russian aerospace firm, NPO Energiya, to study the possible use of the Soyuz-TM as an emergency spacecraft for Space Station Freedom.
- The exchange of an American astronaut and a Russian cosmonaut.
- The exchange of scientific research, including biomedical and global change research.
- The exchange of Shuttle and Soyuz spacecraft.
- The exchange of Space Station Freedom and Space Station Mir components.
- The exchange of technical and scientific knowledge.

These initiatives were announced by Presidents Bush and Yeltsin on June 18, 1992, and ratified by a joint agreement on July 21, following a 7-day trip to Russia and Ukraine. NASA and the Russian Space Agency (RSA) have signed several important agreements, including:

- The agreement to develop a joint program for the International Space Station.
- The agreement to conduct joint research in biomedical and global change fields.
- The agreement to exchange Shuttle and Soyuz spacecraft.
- The agreement to exchange technical and scientific knowledge.

These initiatives will help advance cooperation between NASA and the Russian Space Agency in the field of space exploration and scientific research.
the Mir space station.

"In our relationship with Russia, we need to start slowly and deliberately to build a strong foundation of cooperation," Goldin said. "In this way we will ensure that what we do together will be successful, both technically and scientifically."

The interagency trip was jointly led by Goldin and National Space Council Executive Secretary Brian Dailey, and was supported by Vice President Quayle and President Yeltsin in a meeting last month. The U.S. participants included Assistant Secretary of the Air Force Martin Faga and representatives from the National Security Council, State Department, and Central Intelligence Agency.

"The delegation had the opportunity to take a closer look at Soyuz-TM, the Russian docking system and at their human spaceflight operation," Goldin said. "We also learned a lot about the capabilities of the Mir space station and discussed ways to expand critical life science research and global change research."

Goldin said both the United States and Russia agreed to encourage private companies to expand their search for new commercial space business and agreed to facilitate appropriate contacts. Both countries also agreed that the docking mission planned in 1994 with Russia would highlight biomedical science.

NASA and the Russian Space Agency agreed—pending an appropriate review and approval of the governments of the two countries—to continue the activities of five working groups established by the 1987 joint agreement with the Russian Academy of Sciences. Additional initiatives will be undertaken by the Working Group of Space Biology and Medicine, which will now add life support systems to its concerns.

The two space agencies also agreed to:
- study the possible use of Mir for long lead-time life sciences research;
- establish a new working group to develop a plan to enhance cooperation on global change research (Mission to Planet Earth);
- recommend cooperative biomedical research projects for future missions, including those missions involving the exchange of a cosmonaut and an astronaut and the Space Shuttle/Mir rendezvous and docking mission;
- study the feasibility of further enhancing the biomedical capabilities on Mir using instruments from the U.S.; and
- study the possibility of closed-loop life support experiments with humans over different periods of time and to define requirements for long duration missions.

Goldin said he also discussed acquiring a small Russian lander to carry U.S. experiments that would be one of three landers flown on the Russian Mars '94 mission.

The Russian and Ukraine trip followed three months of technical meetings and negotiations between NASA and NPO Energia that preceded the summit meeting in June when Bush and Yeltsin signed the Joint Statement on Cooperation in Space.

NASA, NIH TO COOPERATE ON SPACE-RELATED BIOMEDICAL RESEARCH

On July 21, NASA Administrator Goldin and National Institutes of Health Director Bernadine Healy, M.D., signed an agreement that will enhance each agency's biomedical research capabilities.

At a signing ceremony held with Senator Barbara Mikulski, the agencies pledged to develop programs that apply NASA's unique expertise to practical medical needs on Earth and in space. "For decades, the rigors of space flight have pushed NASA to advance the bounds of medical knowledge for the protection of our astronauts' health," Goldin said. "In so doing, the space program has spawned a host of technological advancements. Walk into any hospital today and you see the work of NASA—programmable pacemakers, CAT scans, intensive care monitors, arthroscopic and laser surgery—all derived from the space program."

Barbara Mikulski said, "For the first time in history we are linking up the considerable talents of both our NIH and our NASA research teams, and we are saying to them 'work together on what needs to be done both on Earth and in space'. The joint NASA/NIH venture means that we will have twice the brainpower looking at diseases such as neurological disorders, arthritis, and even cancer."

Dr. Healy said, "This memorandum of understanding provides the National Institutes of Health and NASA with a welcome opportunity to combine the unique strengths of both agencies in conducting research on the frontiers of space and medicine. "NIH looks forward to what promises to be a productive exploration with NASA of the inner space of our bodies and cells and the outer space of our solar system and the universe," Dr. Healy said.

The agreement is intended to stimulate new opportunities in the biomedical and behavioral research community, as it provides for greater access to space as well as involvement by university-based research centers.

In general, the agreement calls for NIH to have the lead role in ground-based research activities and for NASA to have the lead role in space flight research activities.

Specifically addressed in the agreement are provisions for joint management and funding of programs that cover:
- focused, university-based biomedical and behavioral research;
- opportunities for space flight experiments to enable more biomedical and behavioral scientists to use the space environment for research;
- grants that allow NASA to fund awards to existing NIH research centers;
- program announcements, requests
for applications and requests for proposals to increase research tasks in selected areas of biomedical and behavioral research, and
• mutually sponsored workshops and symposia on specific biomedical research topics.

Initial research topics likely to be addressed under the agreement include the neurovestibular system (vestibular and balance disorders and sensory motor function) and the musculoskeletal system (bone, muscle, and related connective tissue).

Research performed by both agencies under the agreement would help us understand how these systems function in space crews and how mechanisms develop that lead to disease or dysfunction in patients on Earth.

NASA & DOE SIGN PACT ON ENERGY-RELATED SPACE ACTIVITIES

On July 12, NASA Administrator Goldin and Secretary of Energy James D. Watkins signed a cooperative agreement on energy-related civil space programs that provides “umbrella” principles that outline the responsibilities and authority of both NASA and the Department of Energy (DOE) in research and development, fundamental science, advanced technology development, and education efforts.

“This agreement is the latest step in a fruitful history of cooperation between NASA and the Department of Energy, which has existed since the beginnings of the U.S. space program,” said Goldin. “Combining the respective strengths of our agencies will make sure that our future space endeavors will succeed and pay off for the nation—even more effectively than they have in the past.”

In energy and energy-related research and development, the agencies will coordinate their efforts in renewable energy programs and will identify activities that address NASA’s civil power needs.

The agencies agreed to continue ongoing research in space nuclear power. DOE will design, build, and test space nuclear power and propulsion subsystems.

For NASA missions that require nuclear propulsion, NASA will be responsible for systems requirements and overall program management of space nuclear propulsion systems, system integration, and launch and continued on page 19

ASSOCIATE ADMINISTRATOR FOR RUSSIAN PROGRAMS APPOINTED

NASA Administrator Goldin announced the appointment of Samuel W. Keller as Associate Administrator for Russian Programs on July 7. The new function is being established within the Office of the Administrator and will focus on the many programs involving NASA and the former Soviet Union.

“NASA is actively pursuing opportunities for expanded cooperation in space activities with Russia. This area of international cooperation is critical and warrants creation of this new position. Sam Keller has the kind of experience necessary to ensure that our relationship with the Russian space program is beneficial to both sides. He will be responsible for overall coordination of the NASA program relating to cooperative endeavors with the Russian space program,” Goldin said.

Keller has served as Associate Deputy Administrator, NASA Headquarters, since May 1989. In that position he was the focal point for resolving institutional management and policy issues and provided agency leadership on US/Russian cooperative ventures carried out under agreements between the two governments.

Keller began his NASA career at the Goddard Space Flight Center in 1960. After holding various management positions, he was named the Director of Administration and Managent in 1972. In 1975, he transferred to NASA Headquarters and in 1981, was appointed Deputy Associate Administrator for the newly combined Office of Space Science and Applications. In that position he concentrated on the development of major space flight systems including the Hubble Space Telescope, Galileo, Magellan, the Gamma Ray Observatory, and the Cosmic Background Explorer.

Before joining NASA, Keller held positions at the Naval Research Laboratory, the Applied Physics Laboratory of the Johns Hopkins University, RCA Laboratories, and the Office of Naval Research. He served as a pilot in the U.S. Air Force from 1956 through 1959. He holds a Bachelor of Science degree in Electrical Engineering from the University of Maryland and a Bachelor of Laws degree from George Washington University.

Keller was awarded the NASA Exceptional Service Medal in 1969, the Presidential Rank of Meritorious Executive in 1983 and 1990 and both the Presidential Rank of Distinguished Executive and the NASA Distinguished Service Medal in 1985.
HUBBLE CLOSES IN ON THE CAUSE OF SOLAR FLARES

A fleeting event on a tiny red star could help scientists explain the cause of flares that erupt on the sun and have pronounced effects on the Earth. “This is a case where observing another star can help us understand our own sun,” said Dr. Bruce E. Woodgate, who led the science team making the new finding. The stellar flare event was monitored by the Goddard High Resolution Spectrograph on Hubble Space Telescope on Sept. 3, 1991.

The Hubble observiers found evidence of a powerful beam of downward-streaming protons at the onset of a stellar flare. The telltale evidence of the proton beams was a brief but striking increase in the intensity of ultraviolet radiation at wavelengths slightly longer than the characteristic wavelength of Lyman-alpha, the principal radiation emission of hydrogen atoms. This radiation was caused by protons moving downward at high speed in the atmosphere of the observed star, AU Microscopium.

“As the protons move downward, they collide with hydrogen atoms and rob them of their electrons,” Woodgate explained. “That makes the rapidly descending protons become hydrogen atoms. The atoms emit their characteristic light of Lyman-alpha. But because the atoms are moving downward on the star and therefore, are moving away from us as we look at the star, the light is shifted to longer wavelengths by the Doppler effect,” said Woodgate.

To recognize the observed effect as corresponding to the predicted proton beams, the Hubble observers required that the phenomenon must occur at the onset of a stellar flare, in the so-called impulsive phase of the flare and that it be of very short duration. In fact, the increase of light that they found near the start of the flare on star AU Microscopium lasted only 3 seconds. No other such brightening was observed at any other time during two hours of monitoring with the Hubble telescope, leading the scientists to estimate that there is only one chance in 40,000 that they had recorded a coincidental effect not related to the stellar flare. Nevertheless, they are planning further observations with HST to verify their finding.

The occurrence of this phenomenon in flares on the sun was predicted in 1976 by American astronomers Frank Q. Orrall and Jack B. Zirker, but instruments on sun-watching satellites have not had the necessary capabilities to detect it. “We tried to find proton beams in solar eruptions using the Solar Max satellite,” explained Dr. Steve Maran, one of the authors contributing to this research, “but the spectrograph could not obtain measurements at a sufficiently rapid rate.” Woodgate and associates Drs. Kenneth G. Carpenter and Stephen P. Maran collaborated with Drs. Richard D. Robinson and Steven N. Shore, of Computer Sciences Corp.

COMPTON DETECTS GAMMA RAY AFTERGLOW ON THE SUN

Solar scientists are puzzling over an unexpected gamma ray afterglow discovered on the sun by NASA’s Compton Gamma Ray Observatory. The glow, a strong emanation of high-energy gamma rays, persisted for more than 5 hours after a solar flare explosion on June 11, 1991, reported Dr. James M. Ryan, University of New Hampshire. A similar phenomenon occurred four days later, this time lasting more than 90 minutes, he said.

One theory is that the glow resulted when protons, boosted to energies of tens and hundreds of millions of electron volts by magnetic processes in the explosion, were stored in a series of magnetic loops, Ryan explained. They apparently constituted a coronal arcade or so-called “magnetic slinky” in the sun’s outer atmosphere or corona, he said. Protons are subatomic particles resulting from a nuclear reaction.
If the theory is correct, Ryan said, the protons are stored at the sun much the same way as protons are stored in the Earth’s Van Allen radiation belts. However, on the sun, they slowly leak out to produce the gamma rays seen by the Compton Observatory. Thus, scientists can draw an analogy from the Earth environment and apply it to the sun’s environment, Ryan explained.

The work was accomplished using the Energetic Gamma Ray Experiment Telescope and Imaging Compton Telescope instruments on the observatory by Drs. Gottfried Kanbach and Mark McConnell of the Max Planck Institute for Extraterrestrial Physics in Garching, Germany, and the University of New Hampshire, respectively.

**HST SKY SURVEY REVEALS EMBRYONIC GALAXIES**

A “serendipitous” survey of the heavens with NASA’s Hubble Space Telescope (HST) is revealing a variety of unusual shapes and structures in distant galaxies, which previously appeared as fuzzy blobs in ground-based sky surveys. These tantalizing early results, reported by Dr. Richard Griffiths (STScI) at the workshop, Science with the Hubble Space Telescope, in June, may lead to a much clearer understanding of galaxy formation and evolution.

Some of the remote galaxies, estimated to be between 3 and 10 billion light years away, do not have the familiar spiral and elliptical shapes characteristic of nearby galaxies. One cosmological model suggests that galaxies in the early universe interact dynamically and grow bigger by cannibalizing smaller regions of star formation. If so, the objects resolved by HST may be building blocks for today’s large galaxies. “We have seen several examples of what appear to be interacting or merging galaxies,” says Griffiths.

The HST’s Medium-Deep “Parallel” survey uses the Wide Field Camera to take pictures in a random field while another HST instrument conducts a “primary” observation of a different celestial target. These results may lead to a much clearer understanding of the origin and evolution of galaxies.
Russian Rover Tested In Death Valley

“Extraordinarily successful,” was the verdict of Viacheslav Linkin, Rover Chief Scientist, about the results of the May 23-26 rover tests in Death Valley. “For the first time all systems on the rover worked together: the sensors, navigation equipment, computers, and cameras.” The vehicle is a prototype of a rover to be launched on board the Mars 96 mission—the second launch of the Mars 94/96 project.

Test participants included rover team members from three Russian institutions, Hungary, France, and The Planetary Society; ISX Corporation; and Ball Aerospace. Also present were the media and observers, including Society members and employees of NASA, JPL, and the aerospace industry. Daniel Goldin, NASA Administrator, came to see the Russian rover in action on May 29, after it was returned to its Pasadena staging site to prepare for the trip back to Russia.

The first day of testing was at Dumont Dunes, north of Baker, to judge the rover’s mobility and navigation on steep dunes of loose sand. The remainder of the test period was spent at Mars Hill in Death Valley, testing the rover’s capabilities over a rocky terrain similar to that seen on Mars by the Viking landers.

These tests provided the first demonstration of autonomous surface navigation with a flight-prototype vehicle. Not only did the Russian team demonstrate the high mobility of their rover, but the test also showed their readiness to implement navigation and control algorithms that will permit extensive exploration of the surface of Mars.

The rover maneuvered in both teleoperated and autonomous modes. A Mars-Earth communications link was simulated by having the rover navigate the dunes and Mars Hill while its operators communicated with it from a control van approximately 100 yards away. Three radio telemetry links provided TV imaging and other data from the on-board sensors and computer. The sensors included inclinometers, a magnetometer, a 3-axis accelerometer, and electrical and torque information from the wheel motors.

Three different imaging system concepts were also investigated: a single camera system using an 8-mm “handy-cam,” provided by The Planetary Society and IKI; a stereo system using a pair of CCD cameras developed by France’s Centre National d’Etudes Spatiales (CNES) and their contractor LAS/Marseilles; and a panoramic camera system under development at Ball Aerospace Corporation in the U.S. The Russian team is studying the use of images from these types of systems for navigation and path selection on Mars.

ISX Corporation, a U.S.-based firm, provided two microrovers for a joint test with the Russian rover at Mars Hill. Attila, a small, six-legged robot, and Pebbles, a tracked rover, climbed a ramp to the Russian rover and crawled around the local terrain to demonstrate their mobility. Microrobots could be used in exploration as the mobile hands and eyes of larger rovers. If equipped with a TV camera, a microrobot could move ahead of the rover and look back, assisting it in its navigation, or it could return small soil samples to a larger vehicle.

The Russian Mars rover is being designed as part of the international space mission, Mars ’96, to launch in 1996. This robotic explorer will be deployed on the planet’s surface from the same descent module that will carry the Mars Balloon. The Planetary Society is also participating in developing the Mars Balloon in cooperation with the French and Russian space agencies. Three Russian organizations are contributing to Mars ’96. NPO Lavochkin will build the spacecraft to carry the rover from Earth to Mars and the descent module and landing system. IKI is responsible for the scientific payload and analysis of the results. VNIITransmash will design and build the rover itself. The rover tests were co-sponsored by The Planetary Society and three Russian organizations: Babakin Center of NPO Lavochkin, Khimki; the Institute for Space Research (IKI), Moscow; and the Mobile Vehicle Engineering Institute (VNIITransmash), St. Petersburg.
In early May, NASA delivered a report to the U.S. Senate outlining a shift in emphasis toward smaller, lower cost, and more frequent planetary missions. The Small Planetary Mission Plan, which was requested by the Senate Committee on Appropriations, Subcommittee on VA, HUD and Independent Agencies, chaired by Sen. Barbara Mikulski (D-Md.), describes two proposed missions that NASA has selected for preliminary studies leading to launches in 1996 and 1998.

The two missions, part of the Discovery program, are the Mars Environmental Survey (MESUR) Pathfinder, planned for launch in 1996, and the Near Earth Asteroid Rendezvous (NEAR), planned for a 1998 launch. Phase A studies of the MESUR Pathfinder mission have been awarded to NASA's Jet Propulsion Laboratory, Pasadena, Calif. The Applied Physics Laboratory of Johns Hopkins University, Baltimore, Md., has been awarded Phase A studies of the NEAR mission.

"We're very excited about this plan," said Wes Huntress, Director of NASA's Solar System Exploration Division. "It will enable more opportunities for planetary exploration without a large budget impact. It will allow us to more effectively take advantage of emerging technology and to quickly—and relatively cheaply—undertake new missions of discovery. A significant benefit will be increased student involvement because the shorter project timeframes fit nicely with most academic degree programs."

The plans emphasize a recent change in the character of NASA's Solar System Exploration Division's programs. Most planetary missions of the past two decades have involved relatively large spacecraft with broad science goals. There have been only a few missions per decade. The new, less expensive projects can be launched more often, affording timely new opportunities to many investigators and institutions. They can also fill in gaps in the planetary exploration program and revitalize educational interest in planetary science.

Small planetary missions, described in the report as the centerpiece of NASA's new planetary programs for the 1990's, are designed to proceed from definition to flight in less than 3 years, combining well-defined objectives, proven instruments and flight systems, strict cost limits, and acceptance of a greater level of risk. Most will be implemented by teams including substantial academic representation.

The Discovery missions will be modeled on existing Explorer and Earth Probe programs, with each mission costing no more than $150 million. The first Discovery mission, MESUR Pathfinder, is envisioned as a technical demonstration and validation flight for the MESUR program, scheduled to begin in 1999. The MESUR program would build a network of about 16 small, automated, widely spaced surface stations on Mars to study the planet's internal structure, meteorology, and local surface properties.

NASA is studying the possibility of including a prototype Mars microrover on the MESUR Pathfinder lander. The microrover, currently under joint development by the Solar System Exploration Division and NASA's Office of Aeronautics and Space Technology, would carry a camera and one or two additional scientific instruments. The lander could also include instruments provided by NASA's Office of Exploration to search for subsurface ice and measure soil toxicity.

NEAR, the second concept under study, would spend up to a year station-keeping with a near-Earth asteroid. The NEAR spacecraft, probably carrying only three instruments, would assess the asteroid's mass, size, density, and spin rate, map its surface topography and composition, determine its internal properties, and study its interaction with the interplanetary environment.

Other candidate Discovery missions listed in the report include a Venus atmospheric probe, Earth-orbiting planetary telescopes, multiple asteroid/comet flybys and comet reconnaissance missions, a Mars orbiter to study the planet's upper atmosphere and missions to Mars' moons.

Also included in the report to the Senate is the first phase of a program called Toward Other Planetary Systems (TOPS-0), that would use ground-based observations to identify and examine Jupiter-sized planets around other stars within 50 light years of Earth. The TOPS-0 plan includes development of a second 10-meter telescope at the Keck Observatory in Hawaii and enhanced instrumentation.

The Discovery and TOPS programs are managed by the Solar System Exploration Division of the Office of Space Science and Applications, at NASA Headquarters, Washington, D.C.
In April, NASA announced the selection of 33 participating scientists to take part in a wide range of investigations on the Mars Observer mission, planned for launch September 16, 1992. These scientists joined team leaders and interdisciplinary scientists selected in 1986 to increase the range of studies planned for the 2-year global mapping mission. "We are very glad to be able to provide this new scientific talent to the Mars Observer mission," said Dr. Wes Huntress, Director of NASA's Solar System Exploration Division. Mars Observer is the most complex mission we have ever flown to Mars, and it has a huge task to raise our understanding of Mars to a new level by obtaining long-term orbital data about the whole planet."

Mars Observer, America's first mission to Mars in more than 15 years, will be launched from the Kennedy Space Center by a Titan-III expendable launch vehicle built by Martin Marietta. The spacecraft itself will ride on the new Transfer Orbit Stage built by Orbital Sciences Corporation, which will send the spacecraft out of Earth orbit on its way to Mars. In August 1993, after an 11-month interplanetary cruise, the spacecraft will reach Mars where it will fire its onboard engines and enter a nearly polar orbit at an altitude of 240 miles. The spacecraft's seven instruments will record the global characteristics of Mars for slightly more than a full martian year (687 Earth days) to watch a full cycle of changes in the martian seasons. By early 1996, the spacecraft will have returned to Earth more than 600 billion bits of scientific data, more than has been collected by the nearly two dozen previous missions flown to Mars by the U.S. and the former U.S.S.R.

Besides representing U.S. universities and research centers, the newly-selected group of participating scientists includes four individuals from the United Kingdom, France, and Germany.

Six scientists from Austria, the United Kingdom, France, and Germany are already involved in the mission and a group of ten participating scientists from Russia will be added later this year.

Some of the 33 participating scientists will work with one of the seven instrument-related science teams. The instruments carried by Mars Observer are a gamma-ray detector to measure the chemical composition of the surface; a laser altimeter to measure the shape and topography of the surface; an infrared detector to measure surface mineral composition; a different infrared detector to measure the composition and behavior of the martian atmosphere; a magnetometer
to measure the planet's magnetic field; and a camera to photograph the landscape at resolutions ranging from a few kilometers to several meters. In addition, careful tracking of the spacecraft's radio signal will make it possible to map the gravity field of Mars and some features of its atmospheric structure.

Other participating scientists will work with one of six interdisciplinary science teams, which will combine data collected by several different instruments to probe general questions of Mars' geology, atmospheric behavior, surface weathering, the influence of the polar caps, and the migration of water and carbon dioxide between the atmosphere, the polar caps, and the martian surface layer.

The wide range of Mars Observer science investigations will focus on answering questions raised but not settled by earlier U.S. missions to Mars, such as whether or not the planet has a magnetic field, where the water has gone, and what the mineral and chemical composition of martian soil and bedrock is. The information gathered on the planet's gravitational field, atmospheric structure, and surface topography and properties will be crucial to future human exploration of Mars.

"Mars Observer's mission is to make the first-ever global scientific inventory of an entire planet," said Dr. Bevan M. French, NASA's Program Scientist for the mission. "Mars is a complex world. Parts of it are like the Moon, with ancient rocks that preserve a record of intense meteorite bombardment during the early years of the solar system. Other parts of Mars are younger and more dynamic, like the Earth. These places have volcanoes, great fractures in the crust, and large channels cut by running water a billion or two years ago."

"Mars also has polar ice caps, an atmosphere, clouds, frost, wind, and sand dunes," he continued. "We want to understand how Mars formed and changed over time, why parts of it are similar to Earth, and why other parts are utterly different."

Mars Observer also will support data collection by the Russian Mars-94 mission, which is planned to arrive at Mars in late 1995 and land small stations on the planet's surface. A communications relay on the Mars Observer spacecraft will relay data from the surface stations to Earth. Depending on the lifetime of the spacecraft, the same relay might be available later to send back data collected from Mars-96, a subsequent Russian mission that also will launch balloons into the martian atmosphere.

Some of the Mars Observer's participating scientist investigations will look beyond Mars and even beyond the solar system. These include studies to detect and make high-resolution measurements of the mysterious gamma ray "burster" events, studies of gamma rays produced by violent high-energy flares on the Sun, and the first deep-space search for gravity waves using the extraordinarily precise tracking data from the Mars Observer communication system. Gravity waves are a fundamental phenomenon predicted by Einstein's Theory of Relativity but have yet to be detected.
Chicxulub Collaboration Leads to Agreement Between UNAM and LPI

The Lunar and Planetary Institute and the Universidad Nacional Autonoma de Mexico (UNAM) recently signed a memorandum of understanding that will help them to maintain and promote channels of communication to further their common academic and research goals. Dr. Luis Esteva Maraboto, Dean of Scientific Research at UNAM and Dr. David Black, Director of LPI signed the agreement.

The arrangement grew out of collaboration between UNAM and LPI scientists in studying the Chicxulub impact crater, now thought to be the source of widespread extinctions at the Cretaceous/Tertiary boundary. In exploring the Chicxulub structure, Dr. Virgil Sharpton, Staff Scientist at LPI, and others worked with members of the Astrophysics and Space Geology Departments of UNAM as well as Pemex employees.

As the project progressed, Sharpton found a high level of interest in space science programs, such as Magellan, among professionals and students alike; the interest was stymied, however, by the lack of a conduit to NASA and NASA datasets. Under the new agreement, LPI can serve as a gateway to space science data and can offer experience and expertise in data analysis. Access to data and analytical tools will enhance education and space science in Mexico, a valuable investment for NASA as it seeks international commerce; for example, the need to improve telecommunication satellite microelectronics (that have obvious application in extraterrestrial exploration as well). Strong advocacy for this drilling activity has been provided by the Texas Space Commission and by Texas Governor Ann Richards.

Another objective is to study the post-K/T basin itself. Deposition of deepwater limestone including fossils and geochemical signatures provides a continuous record of climatic and paleontological change over 65 million years. In addition the impact event made accessible deep (~20 km) continental crustal rocks in the central uplift that can reveal a wealth of information about the composition, age, and tectonic history of the rather poorly understood Northern Yucatan region. A further goal is to develop interest and expertise in doing a careful and systematic search for other impact structures in Mexico.

The scientific exchange program envisioned by the memorandum will include short-term visits by students and professional to the Institute and an intern program that will seek to support six students for a six-week session each year. UNAM and LPI are also seeking funding for a proposal to conduct a series of workshops and an annual conference each year for a three-year period.  

Mexican researchers examine an exposure of the K/T boundary in Chiapas, Mexico, 550 km from the Chicxulub crater.
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A REVIEW
SATELLITES OF THE OUTER PLANETS: WORLDS IN THEIR OWN RIGHT
By David A. Rothery

The rogues' gallery of satellites orbiting the outer planets are finally getting some well deserved attention. Despite occasional contrary opinion, these bodies constitute, as the title of this book suggests, worlds in their own right. Each is distinctly different from the others. The largest of them display a startling geologic diversity just on their own surfaces. Mr. Rothery has brought them all together in a coherent, highly readable book that is both timely and, for the general scientific literature, relatively accurate regarding recent concepts and debates of satellite geology.

The text is written for an audience familiar with some of the basics of natural science but not necessarily active or versed in planetary or even geological sciences, yet it is rich in details of recent investigations of satellite geologists. This makes it a valuable introduction to the outer solar system for undergraduates and geologists alike, as well as being comprehensible to well educated laymen. (A glossary assists those less familiar with terminology that includes such terms as "clathrate" and "palimpsest.") The text is up to date (as of 1991) on the latest "facts" and conjectures about the flotsam and jetsam of the outer planets. For example, Mr. Rothery nicely describes the off-world version of "plate tectonics" observed on Europa and correctly points out that no such tectonic system occurs on Ganymede, both large satellites of Jupiter. More speculative suggestions of faulting on several smaller satellites are also presented. In most cases, speculations based on circumstantial evidence are wisely indicated as such. We are, after all, still rather ignorant on most aspects of planetary geology.

The coverage of geologic and geophysical issues and hypotheses is nearly complete. Cratering, volcanism, and tectonism are all covered in some detail, but gaps in other subdisciplines are present. The entire issue of photometry and exogenic surface modification is only briefly mentioned in a single paragraph. The text begins with a discussion of the various forces and materials that influence satellite evolution. Next we are led on a tour of the more interesting satellites, focusing first on those that are "dead" and progressing to those that are more active and interesting. This is a different approach from the usual organization into separate systems centered on the four large planets that the satellites orbit. A good selection of references is presented for those interested in pursuing ideas further. The list is not indexed to specific passages in the text, however, and it is a little more difficult to trace who is responsible for what outrageous hypothesis, except by scanning the reference list at the back. Overall, the text is entertaining and conveys some of the astonishing variety of these outer worlds that continues to amaze even those of us working in the field since before Voyager made its epochal tour. A bit of Mr. Rothery's humor emerges where the author compares images of Triton's cantaloupe terrain with a photo of an actual cantaloupe rind and suggests that the presence of methane and ammonia would doubtless give Triton an inferior flavor compared to a real melon. Enough said.

—Paul Schenk

(Dr. Schenk is a Staff Scientist at Lunar and Planetary Institute.)

continued on page 19
1992 is International Space Year

A host of activities, events, and meetings around the world will focus on space science and exploration with a special emphasis on education. The year-long celebration is coordinated by the national space agencies of 29 countries, the United Nations, 9 international organizations, and many other groups, large and small. Some of the highlights are included in the LPIB Calendar. For a more complete list, refer to the special ISY insert in the January/February issues of Ad Astra or Final Frontier or contact the US-ISY Association, 600 Maryland Avenue NW, Suite 600, Washington DC 20024; phone: 202-863-1734; FAX: 202-863-5240.

SEPTEMBER

10-12
MSATT Workshop on Chemical Weathering on Mars, Cape Canaveral/Orlando, Florida. Contact LPI-MSATT Chemical Weathering Workshop, LPI, 3600 Bay Area Boulevard, Houston TX 77058-1113. Phone: 713-486-2150; FAX: 713-486-2160

14-16
Planetesimal Dynamics, Santa Barbara, California. Contact: Glen Stewart, LASP, Campus Box 392, University of Colorado, Boulder CO 80309. Phone: 303-492-3737. GSTEWART@COLOLASP.bitnet

14-17
4th International Colloquium on Atomic Spectra and Oscillator Strengths for Astrophysical and Laboratory Plasmas, Gaithersburg, Maryland. Contact: Lori Phillips, National Institute of Standards and Technology, Gaithersburg MD 20899. Phone: 301-975-4513; FAX: 301-926-1630.

14-18

14-19

15-19
The Impact of Astrometry on Astrophysics and Geodynamics, Shanghai, China. Contact: Ivan I. Mueller, Department of Geodetic Science and Surveying, Ohio State University, Columbus OH 43210-1247. Phone: 614-292-2269; FAX: 614-292-2957.

SEPTEMBER (CONTINUED)

21-22
Third International Conference on Mechanical Systems, Tomsk, Russia. Contact: Gennadij Andreev, Astronomical Observatory of Tomsk State University, Box 1106, SU-634010, Tomsk, Russia. Phone: +3822 909721 or 909576 (UT 08-16 UT) and +212466 (17-06 UT).

21-25
International Symposium on Observational Cosmology, Milano, Italy. Contact: Secretariat, Osservatorio Astronomico, Via Brera 28, 20121 Milano, Italy. Phone: (02)72023751; FAX: (02)72001600. SPAN: 39216::OBS_COS Internet: OBS_COS@ASTMIB.INFN.IT PSI: PSI%23910085::OBS_COS

28-30

30-Oct 2
International Symposium on Artificial Intelligence, Robotics, and Automation in Space (I-SAIRAS), Toulouse-Labege, France. Contact: Groupe Europa -40, boulevard des Recollets, 31400 Toulouse, France. Phone: (33) 61 32 66 99; FAX: (33) 61 32 66 00.

OCTOBER

4-9
<table>
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<tr>
<th>OCTOBER (CONTINUED)</th>
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<tbody>
<tr>
<td>5-7</td>
<td>13-15</td>
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<tr>
<td>8-9</td>
<td>15-20</td>
</tr>
<tr>
<td>10-11</td>
<td>17-20</td>
</tr>
<tr>
<td>Fourth International Conference on Laboratory Research for Planetary Atmospheres, Munich, Germany. Contact: Program Services Department, LPI, 3600 Bay Area Boulevard, Houston TX 77058-1113. Phone: 713-486-2150; FAX: 713-486-2160.</td>
<td>Discovery Program Mission Concept Workshop, San Juan Capistrano, California. Contact: Doug Nash, San Juan Institute, 31872 Camino Capistrano, San Juan Capistrano CA 92675. Phone: 714-240-2010; FAX: 714-240-0482.</td>
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</tbody>
</table>

LPIB No. 64 • 17
space operations. Both agencies will ensure that their space
nuclear-related activities meet environmental, safety, and
security requirements.

For the U.S. Global Change Research Program, NASA will
lead the definition of the spacebased part of the program with
DOE support.

The agreement also covers fundamental science research.
DOE irradiation facilities, including particle accelerators, will
support NASA life sciences, space physics, and spacecraft
development activities designed to understand the radiation
effects of long-duration spaceflight for both humans and
hardware. The agencies also agreed to continue research in

space physics and astrophysics to support the nation's space
science program.

NASA and DOE will cooperate on advanced technology to
meet critical needs that will be defined and incorporated in
NASA's Integrated Technology Plan for the civil space program.
The agencies reaffirmed their commitment to programs that
improve U.S. science education and will attract more young
people to science, engineering, and mathematics careers.

Collaboration on specific projects will be detailed in subse-
quent agreements that will address the agencies' respective roles
and responsibilities, performance and schedule requirements and
funding. ☞
NEW TECHNICAL REPORTS FROM LGI

"The Investigation of the Physico-Mechanical Properties of Luna-20 Regolith in Helium and in Vacuum in the TOR-I Instrument," TR.92-04, and "The Results of Investigations of the Physical and Mechanical Properties of a Sample of Lunar Soil in a Nitrogen Medium," TR.92-05, are available from the Lunar Geotechnical Institute. They may be ordered free from LGI, P.O. Box 5056, Lakeland FL 33807-5056. Phone: 813-646-11842; FAX: 813-644-5920.

BEST GEOSCIENCE REFERENCE BOOK AWARD, 1992


Problems Connecting? Ask Some Key Questions

As more information becomes available on line from LPI, we field more questions from people having trouble connecting for the first time. LPI telecommunications specialist Lorraine Willett has these suggestions for the terminally confused.

Find your local computer system support person (if any). In a university setting this is usually not someone from the Computer Sciences Department, but an administrative person in your own department. Failing that, find a colleague or student down the hall who's computer literate.

Ask some key questions:

1. Do I have access to Internet or NSI DECNET (formerly SPAN)? If "yes," type the following at your computer's prompt:
   For Internet, type: telnet LPI.JSC.NASA.GOV
   (or telnet 192.101.147.11)
   For NSI DECNET, type: SET HOST LPI
   At the USERNAME: prompt, type LPI; follow the menu instructions from there.

2. If the answer to Question 1 is "no," ask: Do I have access to a modem or modem pool? If the answer is "no," you'll have to acquire a modem. If the answer is "yes," ask: What communications package do I have (if any)? Common ones are ProComm, SmarTerm, VersaTerm, and many more. Check the Settings or Defaults in the communications package: "VT100 emulation" MUST be selected. In addition, select "8 bit," "1 stop bit," "N parity," and either 1200 or 2400 baud where the package asks for these. Now you are ready to direct dial through the modem. Dial:
   713-244-2091 or
   713-244-2090 (this line also connects to 9600 baud).

   When connected, press return until LPI prompt USERNAME: appears. Type LPI and follow the menus.

3. E-mail—Currently, only users that have access to a network can interact with LPI staff via E-mail. The most comprehensive guide to syntax for E-mailing on a wide variety of networks is the NSI E-Mail Matrix. You can request this large chart from NASA Science Internet Project, MS 233-8, NASA Ames Research Center, Moffet Field CA 94035-1000.
   If you still encounter problems, please phone Lorraine at 713-486-2194. She will need the answers to the key questions outlined to help you solve the problem. ☺
<table>
<thead>
<tr>
<th>INSIDE</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 The Hubble Constant</td>
</tr>
<tr>
<td>3 New Agency Initiatives</td>
</tr>
<tr>
<td>6 News from Space</td>
</tr>
<tr>
<td>8 Russian Rover</td>
</tr>
<tr>
<td>10 Mars Observer</td>
</tr>
<tr>
<td>15 New In Print</td>
</tr>
<tr>
<td>16 Calendar</td>
</tr>
</tbody>
</table>

TESTING THE RUSSIAN ROVER, PAGE 8