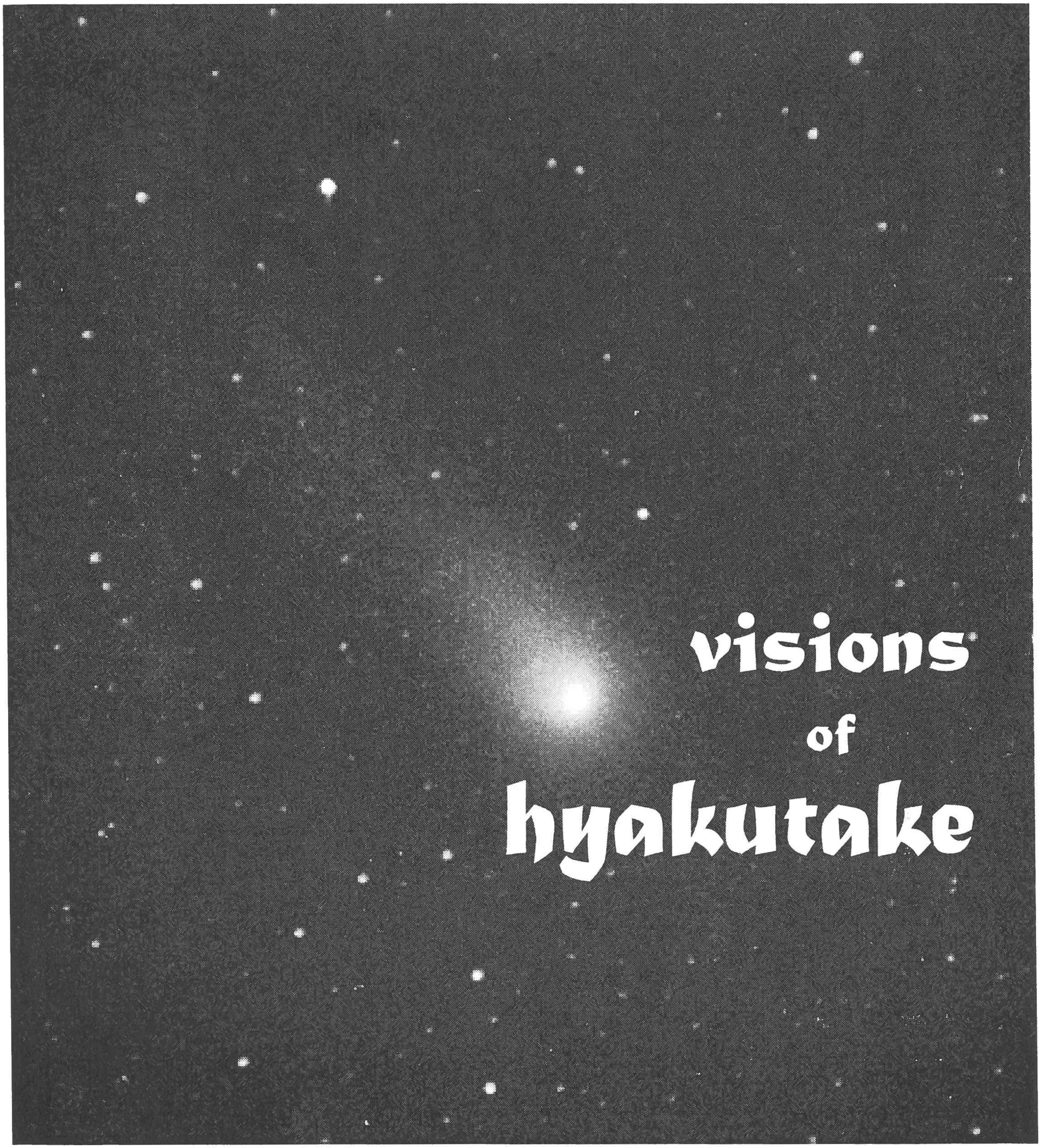
Lunar and Planetary Information
BULLETIN
SPRING 1996/NUMBER 79 • LUNAR AND PLANETARY INSTITUTE • UNIVERSITIES SPACE RESEARCH ASSOCIATION



THE FACE OF PLUTO— FIRST LOOK

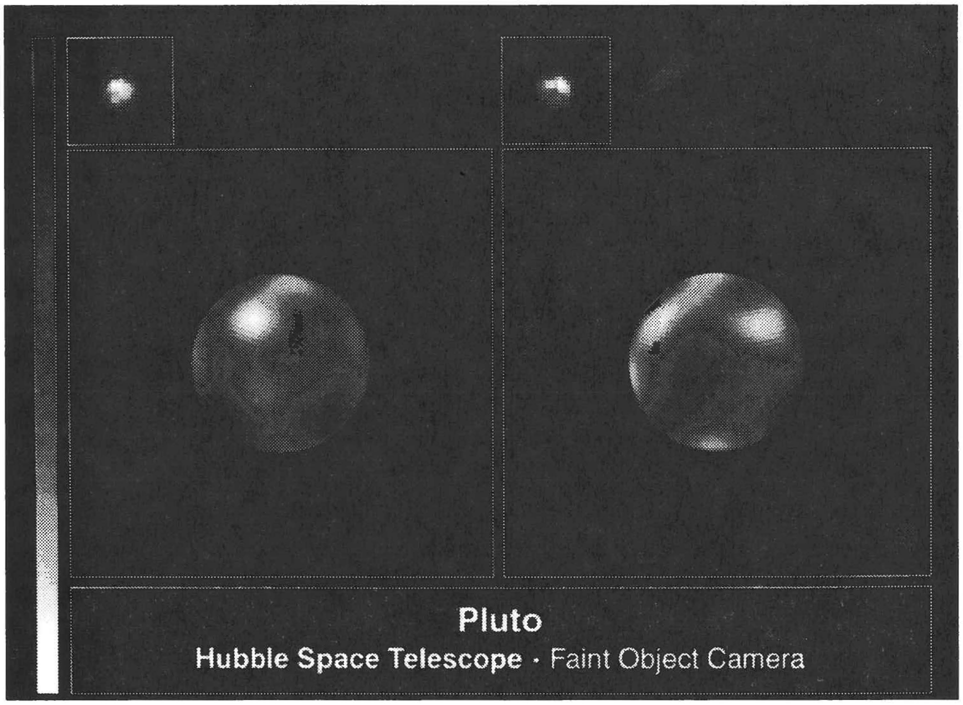


Photo: STScI-PRC96-09a
Credit: Alan Stern (Southwest Research Institute), Marc Buie (Lowell Observatory), NASA, and ESA

THE SURFACE OF PLUTO
Hubble imaged nearly the entire surface of Pluto, as it rotated through its 6.4-day period, in late June and early July 1994. These images, which were made in blue light, show an unexpectedly complex object. The two smaller inset pictures at the top are actual images from Hubble. North is up. Each square pixel is more than 100 miles across. At this resolution, Hubble discerns roughly 12 major regions of bright or dark surface. The larger images are from a global map constructed through computer image processing performed on the Hubble data. The tile pattern is an artifact of the image enhancement technique. Opposite hemispheres are seen in these two views.

Images from the Hubble Space telescope have given us the first-ever glimpse of Pluto's surface. Taken with the European Space Agency's Faint Object Camera, the images reveal almost a dozen distinctive albedo features, none of which have been seen before. They include a ragged northern polar cap bisected by a dark strip, a bright spot that appears to rotate with the planet, a cluster of dark spots, and a bright linear marking that is intriguing to the scientific team analyzing the images. The images confirm the presence of icy-bright polar cap features, which had been inferred from indirect evidence for surface markings in the 1980s.

"Hubble is providing the first, tantalizing glimpse of what Pluto will be like when we get there," said Alan Stern of Southwest Research Institute's Boulder, Colorado research office. Stern led the imaging team that includes Marc Buie, Lowell Observatory, and Laurence Trafton, University of Texas at Austin. They used the Faint Object Camera to obtain over a dozen high-quality visible and ultraviolet images of Pluto as the planet rotated through a 6.4-day period in mid 1994. These images have now been reduced and analyzed.

"These results and the maps we constructed from them are much better than I ever hoped for," said Buie. "It's fantastic. Hubble has brought Pluto from a fuzzy, distant dot of light to a world which we can begin to map and watch for surface changes. Hubble's view of tiny, distant Pluto is reminiscent of looking at Mars through a small telescope," said Stern.

Some of the sharp variations across Pluto's surface might be caused by topographic features such as basins and relatively fresh impact craters (as on Earth's Moon). However, most of the surface features are likely produced by the complex distribution of frosts that migrate across Pluto's surface with its orbital and seasonal cycles. "The light areas are as bright as fresh Colorado snow, and the darker areas are more reminiscent of the brightness of a dirty snow," said Stern. The darkest regions are probably hydrocarbon residues created by the interaction of ultraviolet sunlight and cosmic rays with the chemically varied surface ices.

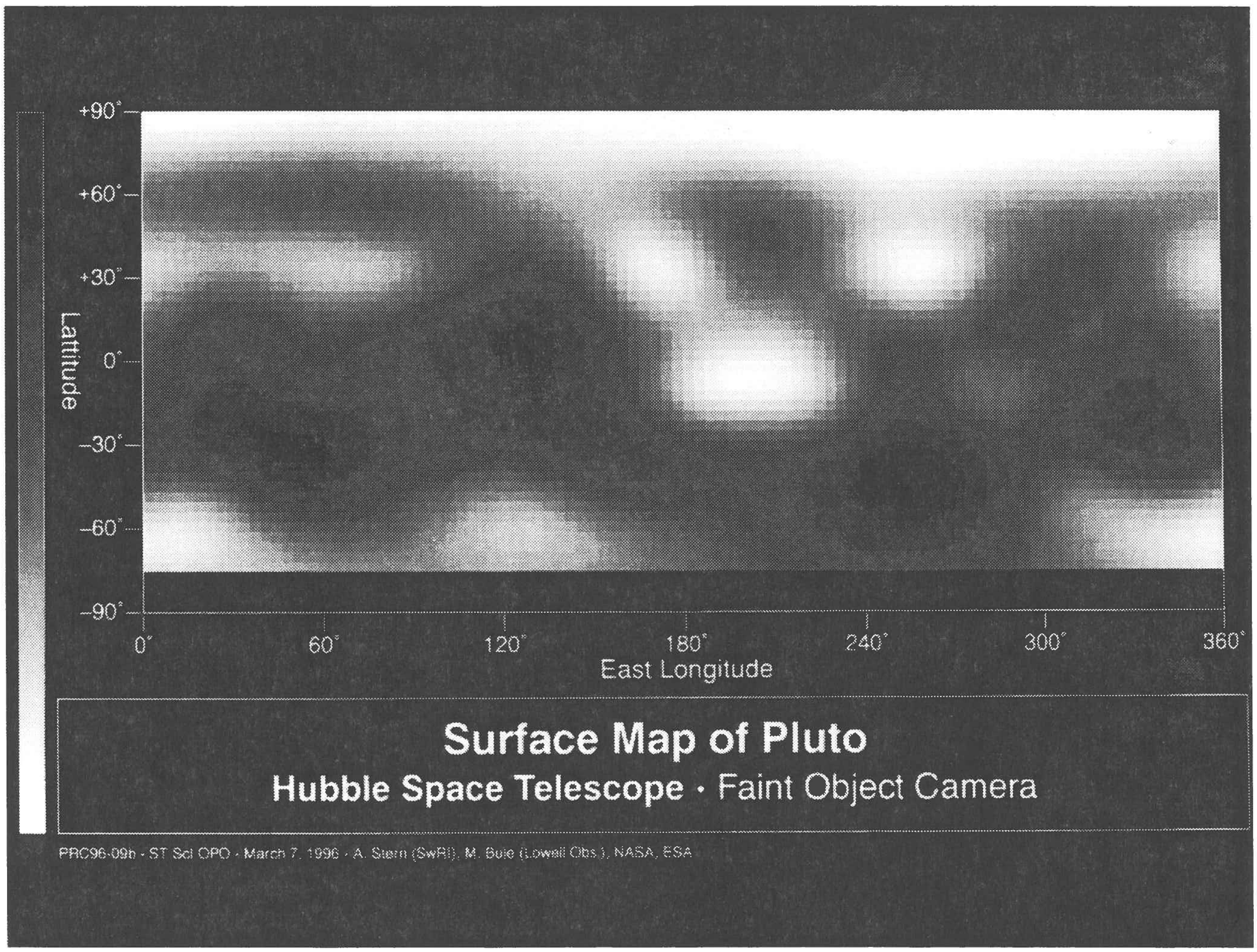
Despite its small size and immense distance from the Sun, Pluto experiences these dramatic seasonal changes because of its highly elliptical orbit, which carries it as close as 2.8 billion miles to the Sun (inside Neptune's orbit) and as far as 4.6 billion miles. As Pluto recedes from the Sun, much of its atmosphere of nitrogen, carbon monoxide, and methane freezes out onto its surface. This is thought to explain the abundance of bright ice on the surface. As Pluto warms when its orbit nears the Sun, the surface ices are sublimated into the atmosphere, thickening it and beginning the cycle again; thus the planet is apparently resurfaced with a new layer of ice each 248-year orbit.

Pluto passed its closest point to the Sun in late 1989. As a result, it presently enjoys a relatively balmy surface temperature near –350°F in the dark areas and a cooler –380°F in the bright areas. This difference may create large pressure differences at the surface, resulting in high winds in the thin atmosphere. For astronomers it's a rare and ideal time for viewing Pluto and studying these changes. The last time Pluto was this close to the Sun and the Earth, George Washington was a boy!

The Hubble images suggest much more surface variety on Pluto than on its so-called twin, Neptune's large moon Triton. According to team member Trafton, ". . . the HST images are confirming Pluto's individuality. It isn't a twin of Triton after all."

Pluto is two-thirds the size of Earth's Moon and 1200 times farther away with an apparent size in the sky of 0.1 arcseconds. Viewing such a remote and small body has been so difficult that Pluto's moon Charon wasn't detected until 1978, despite the fact that Pluto itself was discovered by Clyde Tombaugh in 1930. Shortly after its launch in 1990, the Hubble Space Telescope first peered at Pluto and clearly resolved the planet and its satellite (separated by only 1/3000th of a degree) as two distinct objects. However, a detailed look at Pluto's surface had to wait until Hubble's optics were repaired during the 1993 servicing mission.

The Advanced Camera, planned to be installed on Hubble in 1999, should yield slightly better images of Pluto. This will be our best view of the distant planet until space probes eventually make the long trek across the solar system. The images will help pave the way for a proposed Pluto flyby mission early in the next century. Pluto is the only solar system planet not yet visited by a spacecraft.



Credit: Alan Stern (Southwest Research Institute), Marc Buie (Lowell Observatory), NASA, and ESA

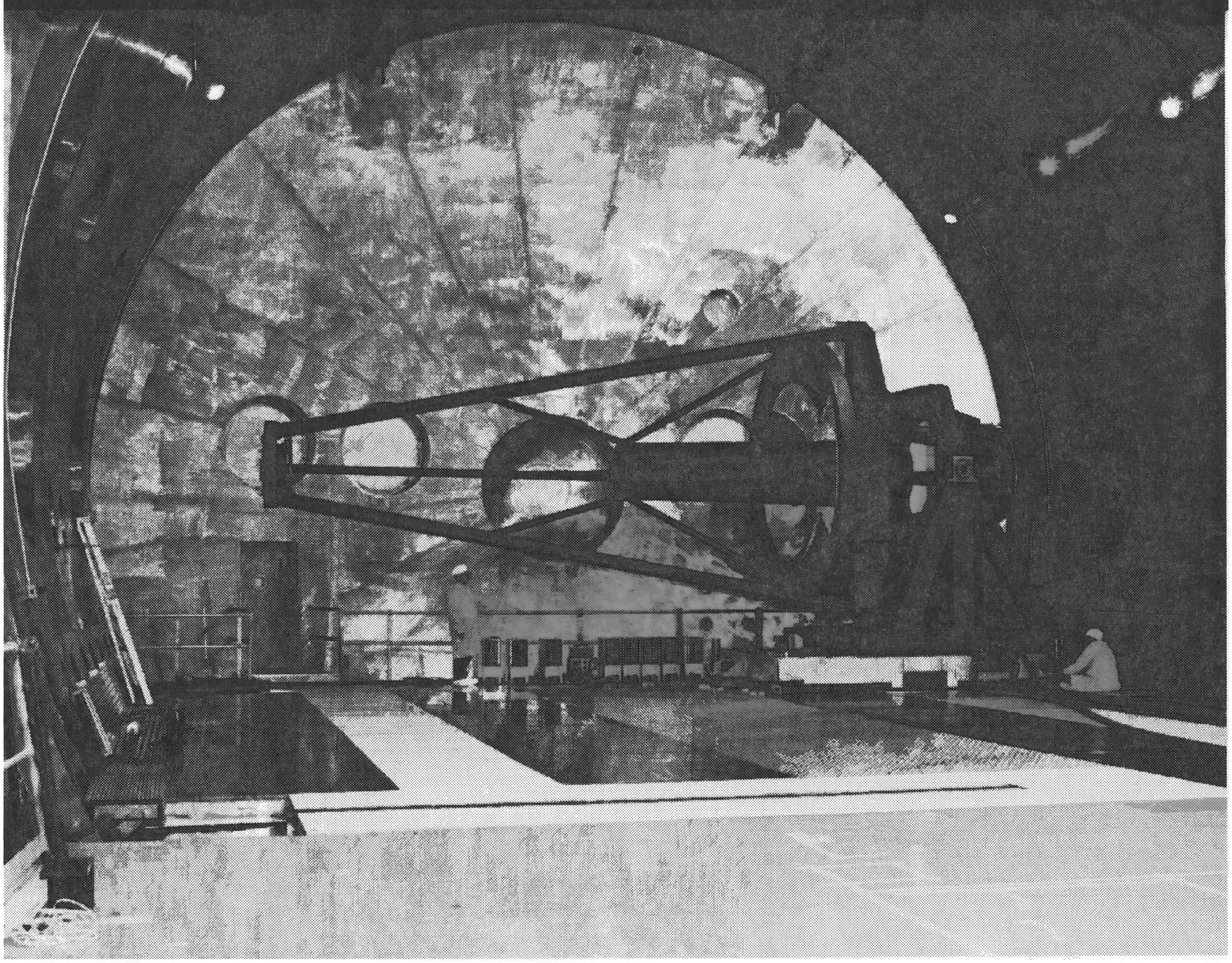
MAP OF PLUTO'S SURFACE

This is the first image-based surface map of the solar system's most remote planet. It was assembled by computer image processing four separate images taken with the Faint Object Camera. The map, which covers 85% of the planet's surface, confirms that Pluto has a dark equatorial belt and bright polar caps, as inferred from groundbased light curves obtained during the mutual eclipses between Pluto and its satellite Charon in the late 1980s.

Image reconstruction techniques smooth out the coarse pixels in the four raw images to reveal major regions where the surface is either bright or dark. The black strip across the bottom corresponds to the region surrounding Pluto's south pole, which was pointed away from Earth when the observations were made and could not be imaged.

BEATING SWORDS INTO TELESCOPES?

—By Michael A'Hearn and David H. Smith



The recent images of stars forming on the tips of huge columns of interstellar gas and dust are just the latest in a string of spectacular discoveries made by the Hubble Space Telescope. The orbiting telescope has discovered new satellites around Saturn, has challenged cosmological orthodoxy by hinting that the universe may be younger than its oldest stars, and has otherwise amazed astronomers and the public alike. Despite its early problems, Hubble's performance has amply vindicated the idea of locating telescopes in space.

But Hubble also has been very expensive — costing more than a billion dollars to build and some $250 million a year to operate. If the space sciences are not to slip into a decline matching NASA's dwindling budget, researchers must find new and innovative ways to perform space missions.

Unfortunately, NASA's "smaller, faster, cheaper" approach is limited where certain spacecraft systems are constrained by the laws of physics and cannot be miniaturized. To collect the feeble light from distant objects, for example, space telescopes must contain very large mirrors.

In the 15 years since Hubble was built, scientists and engineers have made enormous advances in optical technology. Future space telescopes could be much larger and much cheaper to build and operate than Hubble. The use of very thin mirrors, for example, could significantly reduce the mass of the spacecraft, resulting in major cost savings. Placing future telescopes in higher orbits also could dramatically increase available observing time and greatly simplify operations — a major contributor to Hubble's high costs.

The problem is that each of these new concepts is risky. And neither NASA nor the astronomy community can afford another expensive and embarrassing failure like the spherical aberration built into Hubble's main mirror. Before they rush to embrace these new technologies, space scientists must have confidence that the technologies will work as advertised. Unfortunately, current budgets leave little room for missions devoted to demonstrating and validating new technologies.

But there is another way. With the relaxation of tensions among the superpowers, military technologies that were once secret are now available for civilian use. A recent study by the National Research Council (NRC) points out that some of this hardware could provide an answer to space astronomy's dilemma.

During the Cold War, the federal Ballistic Missile Defense Organization actively sponsored the development of spacebased laser weapons. As part of this program, more than $100 million was invested in developing the optics for an ultralightweight, 4-meter space telescope. Although the project was canceled, many of the telescope's components were constructed and are now available for civilian use.

The team of astronomers and optical experts convened by the NRC to analyze the Star Wars hardware found it capable of performing astronomy programs not possible with Hubble or any other facility in existence or in development. For example, astronomers could study the warm material at the edge of the universe that is just forming into galaxies. They could probe the many small bodies at the edges of our solar system to identify the source of comets.

In fact, putting Star Wars technologies to work will move spacebased astronomy in exactly the directions needed to undertake some of its most challenging missions. Astronomers could detect and characterize planets around other stars or study the earliest objects in the universe. And these technologies would be extremely cost effective, entailing expenditures in the hundreds of millions rather than billions of dollars.

Today much of the relevant hardware is gathering dust in warehouses and testing chambers. Yet this legacy of the Cold War could be crucial to NASA's ability to carry out major space astronomy missions. Astronomers need to become directly involved in the continued study, development, and eventual flight testing of this hardware. They also may find that these technologies have scientific applications beyond those already considered.

The Cold War may be over, but the need for advanced technologies is becoming greater all the time. We need to look carefully at devices developed for war and ask how they can be used in peace.

(Michael A'Hearn, professor of astronomy at the University of Maryland, recently chaired a task group for the NRC that examined astronomical technologies produced by the Ballistic Missile Defense Organization. David H. Smith was the task group's study director.)

The NRC report referred to, *A Scientific Assessment of a New Technology Orbital Telescope,* is available from the Space Studies Board, HA-584, National Research Council, 2101 Constitution Ave. NW, Washington DC 20418.

The proposed 4-meter space telescope would reuse or replicate much of the "Star Wars" hardware developed for the so-called Advanced Large Optics Technologies (ALOT) telescope, visible here in a testing chamber at Itek Optical Systems. ALOT's 4-meter, segmented mirror would, however, be replaced by a monolithic, meniscus mirror of equal size developed as the central, annular segment of another "Star Wars" mirror program, Itek's 11-meter Large Optical Segment project.

Photo: Itek.

The *Lunar and Planetary Information Bulletin* is published quarterly by the Lunar and Planetary Institute, 3600 Bay Area Boulevard, Houston TX 77058-1113.

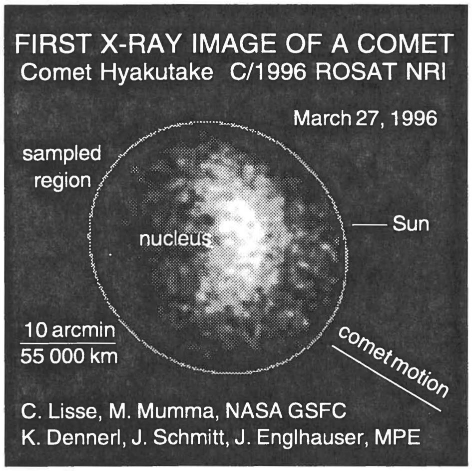
Pam Thompson, Editor

Editorial and production support are provided by the LPI Publications and Program Services Department. Copy deadline for the summer issue of the LPIB is August 12, 1996.

Please send articles or announcements to: P. Thompson, 3600 Bay Area Boulevard, Houston TX 77058-1113.

Phone: 713-486-2175, fax: 713-486-2162
E-mail: thompson@lpi.jsc.nasa.gov

NEWS FROM SPACE



ROSAT DETECTS X-RAYS FROM COMET HYAKUTAKE

A team of U.S. and German astrophysicists have made the first-ever detection of X-rays coming from a comet. The discovery of a strong radiation signal — some 100 times brighter than the most optimistic predictions — was made March 27, during observations of Comet Hyakutake using Germany's orbiting ROSAT satellite.

"It was a thrilling moment when the X-rays from the comet appeared on our screen at the ROSAT ground station," said Konrad Dennerl of the Max Planck Institute for Extraterrestrial Physics. Following the initial detection, the team reported repeated X-ray emissions from the comet over the next 24 hours. The comet was near its closest approach to Earth at a distance of less than 10 million miles when it was first detected by ROSAT.

The strength and rapid changes in intensity of the comet's X-ray emission both surprised and puzzled astronomers. "We had no clear expectation that comets shine in X-rays," said Michael J. Mumma of Goddard Space Flight Center. "Now we have our work cut out for us in explaining these data, but that's the kind of problem you love to have."

The comet was examined repeatedly during March 26 and 27 as it swept across the sky. The German scientists were able to correct satellite attitude for the comet's motion during each observation, and produce accurate images with the aid of a computer.

X-rays have never been observed from a comet before, and scientists had optimistically predicted an intensity that turned out to be about 100 times weaker than the radiation actually detected by ROSAT. Strong changes in the brightness of the X-rays were another surprise. There were pronounced changes in the X-ray brightness from one ROSAT observation to another, typically over a time difference of a few hours.

Still another puzzle is what generates the X-rays. The ROSAT image may contain clues: In the image, the X-rays seem to come from a crescent-shaped region on the Sunward side of Hyakutake.

Explaining the unexpected bright X-ray emission is the next major task for the science team. One preliminary theory is that X-rays from the Sun are absorbed by a cloud of water vapor surrounding the comet's nucleus and then reemitted by the water molecules in a process called fluorescence. According to this idea, the cloud is so thick that its Sunward side absorbs nearly all the incoming solar X-rays so that none reach the remainder of the cloud, which might explain why the X-ray emission source is crescent-shaped, rather than spherical around the comet's nucleus.

A second possible explanation is that the X-rays are produced from the violent collision between the cometary material and the supersonic solar wind of plasma and particles streaming away from the Sun.

"We always learn something new when we study an object at different wavelengths," commented Carey M. Lisse of Goddard, the leader of the X-ray investigation. "Now we have to determine why the comet is so bright in X-rays and see what we can learn about its structure and composition from these unique images."

ADVANCED LAND IMAGER PICKED FOR FIRST NEW MILLENNIUM EARTH SCIENCE FLIGHT

An advanced, lightweight scientific instrument designed to produce visible and short-wave infrared images of Earth's land surfaces has been selected for the first NASA New Millennium Program mission dedicated to Mission to Planet Earth. The Advanced Land Imager will serve multiple purposes, according to Dr. Charles Kennel, NASA Associate Administrator for Mission to Planet Earth.

The new instrument will demonstrate remote-sensing measurements of the Earth consistent with Landsat data collected since 1972 for resource monitoring and assessment. In addition, it will acquire data with finer spectral resolution, long sought by Earth observation data users, and it will lay technological groundwork for less costly, more compact land imaging instruments in the future.

"We looked at nearly a dozen different mission concepts in some detail, and a land surface imaging mission clearly was at the top of this year's priority list," Kennel said. "It will ultimately enable first-class science by validating breakthrough technology with clear potential capabilities, both commercially and to the future of NASA's Earth Observing System."

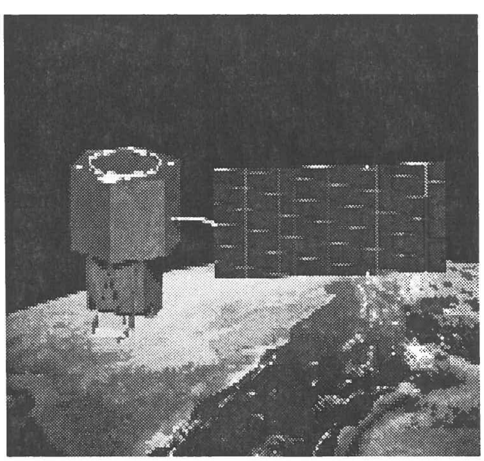
The Advanced Land Imager represents about a sevenfold decrease in mass and electrical power demands compared to the current Landsat 5 multispectral instrument. In addition, it extends existing measurement capabilities by incorporating an advanced high-resolution hyperspectral imaging spectrometer-on-a-chip. This novel, wide-field observing system requires no scan mirror. It is built around a lightweight, integrated silicon carbide structure and optical system with an innovative in-flight calibration system.

Under project management by Goddard, the Advanced Land Imager will be developed by a team of industry partners led by MIT's Lincoln Laboratory, which will provide open access to design and performance information to expedite transfer of this technology into the U.S. commercial sector.

The instrument will feature 10-meter ground resolution in the panchromatic band and 30-meter ground resolution in its other spectral bands, using a four-chip, multispectral focal plane array that covers seven of the eight bands of the current Landsat. Hyperspectral capabilities, which further split these bands into highly differentiated images, will be tested to show that they can be combined into traditional Landsat-equivalent datasets.

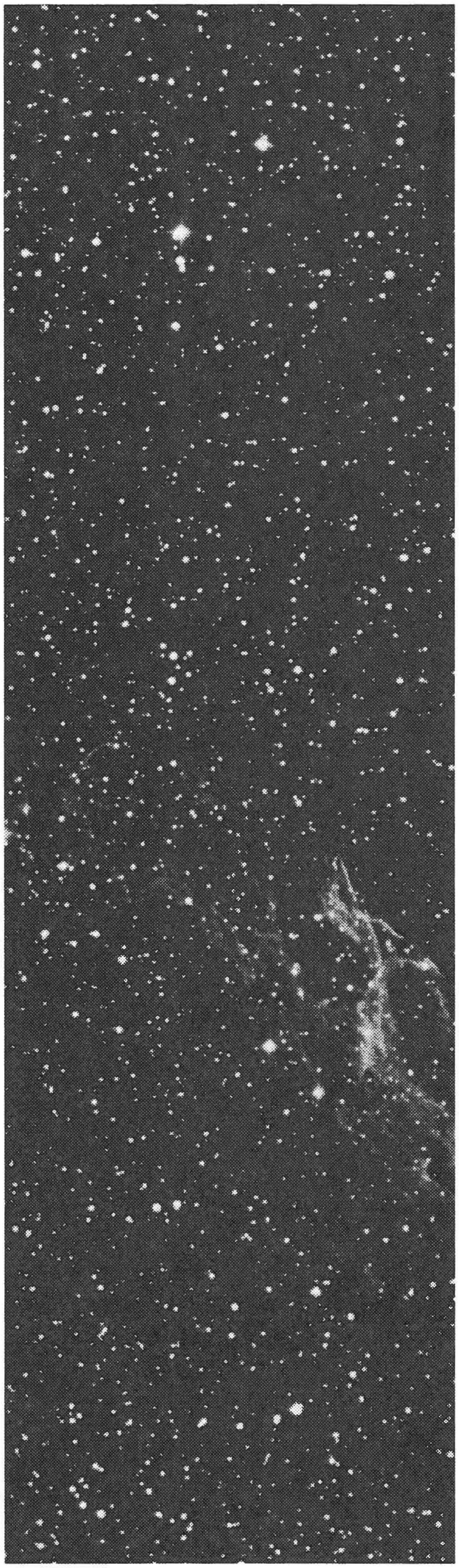
The spacecraft support structure, including advanced electrical power and data-handling subsystems, will be provided by Swales & Associates, Beltsville, Maryland, and Litton Industries, College Park, Maryland. Additional advanced spacecraft technologies will be made available through the New Millennium Integrated Product Development Teams.

The power and data subsystems will be provided through a Space Act cost-sharing agreement that calls for Litton to develop the hardware and integrate it into the New Millennium spacecraft, while providing the company with a two-year license to commercialize the technology. "This innovative arrangement, which includes a major commitment from Litton to integrate and deliver the hardware, represents an exciting new way of doing business for Goddard," said Center Director Joseph Rothenberg.



Further industry partnerships in the mission will be solicited in a workshop to be held during upcoming advanced definition studies. The total NASA cost of the first New Millennium Earth science mission, including its Small Expendable Launch Vehicle, has been capped at $90 million. Launch is planned for late 1998.

The current mission concept for the flight has the spacecraft flying autonomously several minutes ahead of the ground track flown by the planned Landsat 7 satellite to provide accurate paired-scene comparisons between new and traditional observing technologies. Evolutionary versions of the Advanced Land Imager would be candidates for flight on future generations of Earth Observing System missions, beginning with the AM-2 spacecraft.



"ONE-MAN BAND" OF AN OBJECT IN OUR GALAXY SURPRISES ASTRONOMERS

Astronomers have discovered an object toward the center of the Milky Way galaxy that exhibits a combination of behaviors never before seen in the 35-year history of gamma-ray astronomy. During the first day it was observed, the source produced over 140 powerful bursts of gamma-rays; since then, it has settled down to a daily rate of about 20 bursts, and it is currently the brightest source of hard X-rays and gamma-rays in the sky.

The discovery was described in a paper published on February 29 in *Nature* by scientists from Marshall Space Flight Center, the University of Alabama in Huntsville, Massachusetts Institute of Technology, and the University of Amsterdam. The unusual object in the southern sky was discovered in early December 1995 by researchers using the Burst and Transient Source Experiment on the Compton Gamma Ray Observatory. Since December 2, the new burster has produced more than 1000 hard X-ray bursts. "We're particularly excited about the discovery of a new X-ray source," said Marshall astrophysicist Gerald Fishman. "The object's strange behavior is one of the major discoveries in X-ray astronomy in the past decade."

The skies had more surprises in store. In mid December, the observers discovered an additional source of steady radiation from the same position as the burster. This new object further surprised scientists when it was observed to continuously emit pulses about twice per second — a pulsar. The question the observers faced was "What was the relation, if any, between the two objects?" said Chryssa Kouveliotou of the Universities Space Research Association at Marshall.

The answer was soon apparent — the burster and the pulsar had one and the same source.

"The properties of this X-ray source are unlike those of any we know," explained Kouveliotou. "The burst repetition rate makes this phenomenon very different from gamma-ray bursts that we have observed several thousand times from throughout the universe. Also, the longer duration and persistent bursting makes the object very different from so-called Soft Gamma Ray Repeaters, which have been observed to burst in short, isolated episodes separated by several years."

"What's unique about this object is that it does so many different things all at once," said Fred Lamb, an astrophysicist at the University of Illinois at Urbana-Champaign. "We've seen some sources that play the drums, some that crash cymbals, and a few that play the trumpet, but this source is a one-man band."

This bursting pulsar was later found by Mark Finger, Universities Space Research Association at Marshall, to be part of a binary system, performing one full revolution around its low-mass companion every 12 days. "The most likely explanation at this time is that the bursts of X-ray energy may result when the lighter of the pair of stars loses its material by gravitational or magnetic forces to the neutron star," said Kouveliotou. A neutron star is an exotic star with a mass greater than the Sun and a diameter of only about 10 miles. "The discovery of the new X-ray source may lead to a better understanding of how neutron stars form and evolve," Kouveliotou said.

The source was also observed by NASA's Rossi X-ray Timing Explorer (RXTE) spacecraft, which carries the largest collecting area of X-ray detectors ever flown in space. The two large instruments on the spacecraft, provided by teams led by Jean

Continued on page 14

PUBLICATIONS FROM LPI

QUANTITY	CODE	TITLE	PRICE	TOTAL

BOOKS

QUANTITY	CODE	TITLE	PRICE	TOTAL
	PRO-20	PROCEEDINGS OF THE TWENTIETH LUNAR AND PLANETARY SCIENCE CONFERENCE	$10.00	
	PRO-22	PROCEEDINGS OF THE LUNAR AND PLANETARY SCIENCE CONFERENCE, VOLUME 22	$10.00	
	B-ACM	ASTEROIDS, COMETS, METEORS 1991	$10.00	

SLIDE SETS

QUANTITY	CODE	TITLE	PRICE	TOTAL
	S-HAWAII	VOLCANIC FEATURES OF HAWAII AND OTHER WORLDS (40 SLIDES)	$22.00	
	S-RED	THE RED PLANET: A SURVEY OF MARS (40 SLIDES)	$22.00	
	S-IMPACT	TERRESTRIAL IMPACT CRATERS (26 SLIDES)	$20.00	
	S-WINDS	THE WINDS OF MARS: AEOLIAN ACTIVITY AND LANDFORMS (30 SLIDES)	$20.00	
	S-STONES	STONES, WIND, AND ICE: A GUIDE TO MARTIAN IMPACT CRATERS (30 SLIDES)	$20.00	
	S-VOLC	VOLCANOES ON MARS (20 SLIDES)	$18.00	
	S-APOLLO	APOLLO LANDING SITES (40 SLIDES)	$22.00	
	S-OCEANS	SHUTTLE VIEWS THE EARTH: THE OCEANS FROM SPACE (40 SLIDES)	$22.00	
	S-CLOUDS	SHUTTLE VIEWS THE EARTH: CLOUDS FROM SPACE (40 SLIDES)	$22.00	
	S-GEOL	SHUTTLE VIEWS THE EARTH: GEOLOGY FROM SPACE (40 SLIDES)	$22.00	
	S-CLEM	CLEMENTINE EXPLORES THE MOON (20 SLIDES)	$18.00	

TECHNICAL REPORTS AND CONTRIBUTIONS

AVAILABLE FOR THE COST OF SHIPPING AND HANDLING

QUANTITY	CODE	TITLE	PRICE	TOTAL
	93-07	ANTARCTIC METEORITE LOCATION AND MAPPING PROJECT, 2ND EDITION	$0.00	
	94-01	VENUS DATA ANALYSIS PROGRAM: DIRECTORY OF RESEARCH PROJECTS (1993–1994)	$0.00	
	94-05	WORKSHOP ON PARTICLE CAPTURE, RECOVERY, AND VELOCITY/TRAJECTORY MEASUREMENT TECHNOLOGIES	$0.00	
	95-01	MARS PATHFINDER LANDING SITE WORKSHOP II: CHARACTERISTICS OF THE ARES VALLIS REGION AND FIELD TRIPS IN THE CHANNELED SCABLAND, WASHINGTON	$0.00	
	95-02	WORKSHOP ON METEORITES FROM COLD AND HOT DESERTS	$0.00	
	95-03	WORKSHOP ON DISCOVERY LESSONS-LEARNED	$0.00	
	95-04	WORKSHOP ON MARS TELESCOPIC OBSERVATIONS	$0.00	
	95-05	PLANETARY SURFACE INSTRUMENTS WORKSHOP	$0.00	
	96-01	WORKSHOP ON EVOLUTION OF MARS VOLATILES	$0.00	

LPSC ABSTRACT VOLUMES

AVAILABLE FOR THE COST OF SHIPPING AND HANDLING

QUANTITY	CODE	TITLE	PRICE	TOTAL
	ABS-27	LPSC XXVI	$0.00	

PAGE TOTAL $ ____________

(OVER PLEASE)

BALANCE FROM PREVIOUS PAGE $ ________

Shipping and Handling Charges	U.S.	Canada Foreign Surface	Foreign Air Europe/S. Am.	Foreign Air Pacific Ocean
Each Book	$7.00	$7.00	$35.00	$35.00
One Slide Set	$4.00	$4.00	$8.00	$8.00
Ea. Additional Set, add:	$1.00	$1.00	$2.00	$2.00
One Technical Report/Contrib.	$6.00	$6.00	$12.00	$12.00
Ea. Additional Report, add:	$1.00	$1.00	$2.00	$2.00
Each Abstract Set	$12.00	$18.00	$65.00	$85.00

SUBTOTAL $ ________

SHIPPING AND HANDLING $ ________
(SEE CHART AT LEFT)

ADD 7.25% SALES TAX $ ________
FOR TEXAS DELIVERY
(APPLY TAX TO SUBTOTAL AND SHIPPING)

TOTAL AMOUNT ENCLOSED $ ________

PRICES EFFECTIVE THROUGH 10/96

Method of Payment

☐ Check (in U.S. dollars drawn on U.S. bank) ☐ Money Order
☐ VISA
☐ MasterCard

Account Number

Expiration Date ________ Print exact name appearing on credit card ________

Signature ________

Phone ( ) ________ FAX ( ) ________

PLEASE INDICATE BUSINESS HOURS PHONE.

PLACE ALL ORDERS WITH:

Order Department
Lunar and Planetary Institute
3600 Bay Area Boulevard
Houston TX 77058-1113
PHONE: (713) 486-2172
FAX: (713) 486-2186

MAKE CHECKS PAYABLE TO:
UNIVERSITIES SPACE RESEARCH ASSOCIATION
(USRA)

FOREIGN ORDERS MUST BE PREPAID

PURCHASE ORDERS WILL NOT BE ACCEPTED UNLESS THE TOTAL IS $20.00 OR MORE.

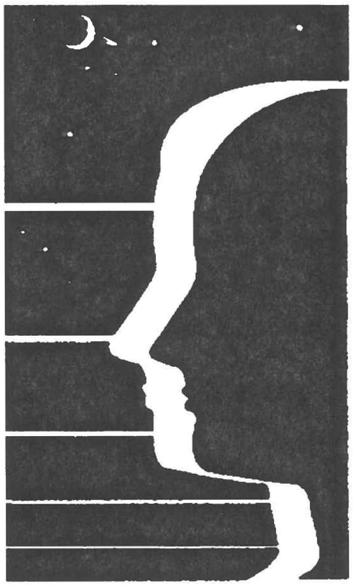
Ordered By

Organization ________
Name ________
Address ________
____
City ________
State ________ Zip ________ Country ________
Phone ( ) ________ (required to process order)
PLEASE INDICATE BUSINESS HOURS PHONE.

Ship To All domestic orders must ship to a street address only.

Organization ________
Name ________
Address ________
____
City ________
State ________ Zip ________ Country ________
Phone ( ) ________ (required to process order)
PLEASE INDICATE BUSINESS HOURS PHONE.

SUMMER INTERN



PROGRAM 1996

For the twentieth season, the LPI Summer Intern Program offers selected undergraduate students the opportunity to participate in lunar and planetary science research at the Institute and the NASA Johnson Space Center. The 1996 program begins June 10 and ends August 16.

When the program was conceived 20 years ago, its objectives were "to provide bright undergraduates with interests in lunar and planetary science with opportunities to experience full-time research in the field of their choice, to present the results in written and oral form, to meet active researchers who can help them assess the future of the research field, and to evaluate research as a career choice."

Through 1996, 256 students representing 159 universities across the United States and abroad have participated in the program, and many have chosen careers in planetary science. In 1995 alone, 35 former interns gave presentations at the annual Lunar and Planetary Science Conference.

For more information or to apply for internship next year, contact LPI Summer Intern Program, 3600 Bay Area Boulevard, Houston TX 77058-1113. Information can also be found on the World-Wide Web at URL: http://cass.lpi.jsc.nasa.gov/lpi.html.

This summer's interns will work on the following projects under the guidance of their advisors at LPI and JSC.

KATHERINE HERRELL, University of Texas
Advisor: Graham Ryder, Lunar and Planetary Institute

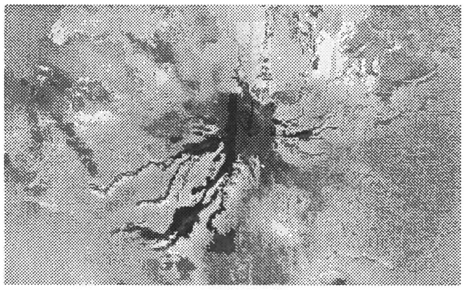
"Apollo 15 Mare Basalts." In this project the intern will classify olivine on the basis of shape and zoning and will make size measurements in a study aimed at clarifying the conditions of olivine crystallization. The study will be made on thin sections of about 20 Apollo 15 olivine-normative basalts in the advisor's possession using the microscope at the Lunar and Planetary Institute. The intern will first photograph the sections. Then she will classify the olivines according to shapes and other morphological features that provide information about crystallization conditions, including growth, reequilibration, and resorption. The size distribution of olivine crystals will be assessed, and comparisons within and among samples will be made. The intern will select some olivine crystals from several samples for microprobe analysis that will be made using facilities at the Johnson Space Center. These analyses of the variations in composition will provide further information about growth, reequilibration, and resorption. Some comparison will be made with data available for terrestrial basalts of known origin; if time permits, some microscope comparison with such basalts, e.g., samples from Hawaiian lava lakes, will be included in the study. Instruction will be provided by the advisor on all techniques and aims.

MARK JOHNSON, Bridgewater State College
Advisor: Carlton C. Allen, Johnson Space Center

"Lunar Dark Mantle Deposits." Violent volcanic eruptions on the Moon have produced large deposits of microscopic glass particles. Last year's intern analyzed laboratory spectra of three glass types, as well as representative lunar soils, to demonstrate how the glasses could be distinguished using data from the Clementine filter passbands. The 1996 intern will use Clementine images to create pseudocolor maps of several large volcanic deposits. He will then locate areas of relatively pure colored glass within the larger deposits and characterize these areas using Apollo orbital photography. Most importantly, the intern will attempt to correlate the colors measured by Clementine with laboratory spectra of lunar samples and analogs in order to estimate chemical composition.

KEVIN JONES, College of William and Mary
Advisor: Paul Schenk, Lunar and Planetary Institute

"Topography on Io." Io is the most volcanically active object in the solar system, yet we know little about even the gross composition of the lavas that cover the vast majority of



the surface. The intern will, with guidance, be responsible for selection of areas to be examined in detail, based on geologic significance and data availability. Landform types will be classified prior to data analysis. Stereo images will be produced and utilized where available to determine heights and slopes as a function of location on the surface and feature type. Experience in image processing techniques will be gained, using methods already tested and assisting in the further development of recently acquired methods. These data will then be useful for later integration into lava flow models and the physical volcanology of Io. A database will be developed that will complement, and not be superseded, by Galileo. Hoped-for compositional constraints from Galileo will ultimately permit detailed physical volcanology to be used together with these data to understand Io's volcanic history and nature.

KENTARO KANEDA, University of Tokyo
Advisor: Gordon McKay, Johnson Space Center

"Zoning in Nakhla Pyroxenes." This project will be a detailed elemental mapping study of Nakhla cumulus pyroxenes and of pyroxenes from crystallization experiments on proposed Nakhla parent compositions. Elemental maps will be collected using the Cameca SX-100 electron microprobe and will be studied using various image processing techniques to enhance and quantify the zoning patterns. Crystals in the proper orientation to reveal sector zoning will be located and zoning patterns will be studied. Results will provide important constraints on the origin of the Al variations in Nakhla pyroxenes and, ultimately, on the composition of the melt from which those pyroxenes crystallized.

PETER LETH, Pomona College
Advisor: Allan H. Treiman, Lunar and Planetary Institute

"Mars Valley Geology." Much of the geology of Mars is inferred from surface landforms, as imaged from the Viking Orbiter spacecraft. Canyon walls provide one of the few possible places to view the geology beneath the landforms. Reull Vallis is such a canyon and affords a unique view beneath martian highlands. Using spacecraft imagery, we will map part of the Reull Vallis area, emphasizing geological deposits and structures exposed in the Vallis walls. From stereo images, we will construct topographic profiles across and along Reull Vallis (and possibly a digital topographic map) to determine elevations, slopes, and thickness of deposits. Integrating these data, we will try to understand what rock types are exposed in Reull Vallis. Finally, we will compare our results with regional and global outlines of the geology of the martian highlands.

CELINDA MARSH, University of Texas
Advisor: Robert R. Herrick, Lunar and Planetary Institute

"Venus Volcanos." Kunhild (18°N, 91°E) and Ereshkigal (21°N, 85°E) coronae on Venus are two volcanic structures that superficially have morphologic and topographic signatures similar to other large shield volcanos on Venus, particularly those of Central Eistla Regio and Bell Regio. However, unlike those volcanos and almost all other large volcanos on Venus, Kunhild and Ereshkigal have negligible signatures in the global gravity field. One possible explanation is that these are rare examples of extinct volcanos on Venus. If these are relatively old, dormant volcanos it would contradict the notion that large shield volcanos are a very recent phenomenon indicative of a thickening global lithosphere. The intern will perform a detailed study of the surface morphology to learn about the region's geologic history and possible causes of its unique geoid signature. She will do morphologic mapping to determine the sequence of emplacement of various surface features. The two volcanos are located in a region with radar stereo coverage, which will be used to develop a topographic model with 1-km horizontal resolution to

aid the analysis. In particular, the topography can be used to determine whether any post-emplacement tectonic tilting has occurred for various lava flow units.

PIMOL MOTH, University of California at Berkeley
Advisor: Deborah Domingue, Lunar and Planetary Institute

"Galilean Satellite Spectra." The three icy satellites of Jupiter are in a dynamic environment. They reside within the large magnetic field of Jupiter, which rotates more quickly than the satellites orbit the planet. Thus their trailing hemispheres are exposed to ion bombardment that their leading hemispheres do not experience. Sulfur ions from the magnetosphere are hypothesized to have been implanted in Europa's water as crust. Ultraviolet observations by Lane et al. (1980) have detected the presence of SO_2, which may be the by-product of this implantation. More recently, Calvin et al. (1995) and Noll et al. (1992) have detected possible oxygen implantation products on Ganymede. This April an observation will be made of the icy Galilean satellites with the International Ultraviolet Explorer (IUE) in an effort to examine their UV spectra for evidence of additional ion implantation products. A comparison will be made of our spectra with decade-old IUE spectra to look for temporal changes in the surfaces of these satellites. This project will involve reducing the IUE spectra obtained and examining them for implantation product signatures in addition to comparing them with the decade old dataset for temporal changes.

KIEKO NAKAMURA, Kobe University
Advisor: Michael E. Zolensky, Johnson Space Center

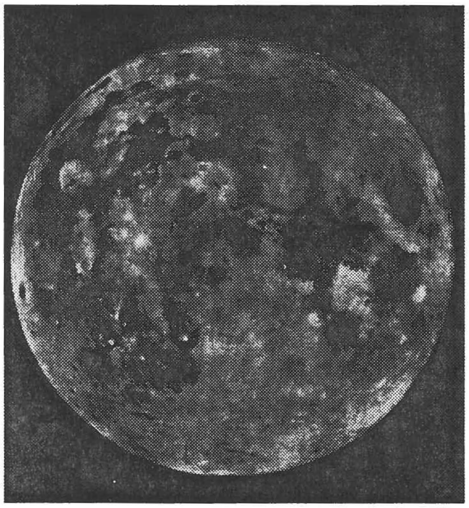
"Dark Inclusions in CV3 Chondrites." Using optical microscopy, scanning electron microscopy (SEM), and transmitted electron microscopy (TEM), the intern, with assistance, will produce detailed mineralogical characterizations of dark inclusions from CV3 chondrites. This work will shed additional light on geological processes that occurred on the parent asteroids.

CRAIG PAMPLIN, University College of the Cariboo
Advisor: Richard V. Morris, Johnson Space Center

"Acid-Sulfate Weathering." A detailed chemical analysis for sulfur in Mauna Kea tephra will be carried out. This data will better define the mineralogy of sulfur-bearing phases and define the origin of the sulfur, which is important for defining the jarosite formation processes on Mauna Kea and, by inference, on Mars. The sulfur could come from either magmatic gases or sulfide minerals. The project will involve analysis of approximately 100 samples and synthesis of the results with other data to give a model for acid-sulfate weathering processes on Mauna Kea.

PATRICK RUSSELL, Williams College
Advisor: Gary E. Lofgren, Johnson Space Center

"Relict Chrondrules." The study of recycling of chondrule material during chondrule formation is an important new area of interest. Recent studies have shown that relicts of early chondrule-forming events are more common in chondrules than previously thought. An extensive experimental study of the kinetics of recycling material to place new constraints on the formation process has been started. The intern will gain hands-on experience with conducting the experiments and examining the results; the most important factors to be determined by experiment are the rate of destruction of relict materials during the heating event and the overall time constraints that can be placed on the duration of the chondrule-forming event. In addition, the intern will examine thin sections from the meteorite collection to find examples of relict materials in chondrules for comparison with the experimentally produced relict textures.



AMER SMAILBEGOVIC, College of Charleston
Advisors: Donald A. Morrison, Johnson Space Center and Paul D. Spudis, Lunar and Planetary Institute

"Lunar Far Side Basins." The Clementine mission has provided us with multicolor images and topographic data for the Moon. In this project, the intern will collect and process color image data for the ejecta blankets of large impact basins on the Moon. These data will permit the mapping of compositional differences within and among ejecta for a variety of basin sizes and ages. Topography from the laser altimeter will allow crater and basin volumes to be estimated. By examining the composition of ejecta and using estimates of basin volumes and excavation models, we can reconstruct the targets of the basins and examine the compositional and petrologic structure of the ancient lunar crust. The intern will learn the techniques of image processing and photogeological mapping and will integrate lunar sample and geophysical information into a refined model of the structure and evolution of the Moon's crust.

ANNE TAUNTON, University of Arkansas
Advisor: David S. McKay, Johnson Space Center

"SEM Studies of Microbes." A major goal of the exploration of Mars is to determine whether life has developed there. To help understand how potential martian life may have evolved and whether such life might still exist in extreme environments on Mars, we will study selected samples from extreme environments on Earth. Samples of microbes are known to grow in rocks in Antarctica, in hot springs, in highly saline evaporate lakes, in arid deserts on rock surfaces, and deep in the Earth in rocks at depths of 10 kilometers or more. The intern will study representative samples of each of these materials with the scanning electron microscope (possibly supplemented by TEM studies of selected samples) to characterize the morphology and chemistry of the microbes, document the microbe-mineral interactions, and determine the types of fossil preservation, if any. Using published data and papers, the intern will also make a parallel evaluation of Mars environments in terms of their potential to sustain microbial life.

NEWS FROM SPACE

continued from page 8

Swank, Goddard Space Flight Center, and Richard Rothschild, University of California at San Diego, quickly found the source to be very bright across the X-ray band from 2 to 60 keV, with strong persistent emission as well as numerous bursts.

"First, matter is accelerated to half the speed of light because of the neutron star's enormous gravitational force. Then, it crashes into the surface of the neutron star and is heated to nearly one billion degrees," Lamb explained. "Because it is so hot, it radiates almost entirely in X-rays rather than visible light, in this case with a power comparable to 1 million times the power of the Sun originating from an area about the size of the National Mall in Washington, D.C."

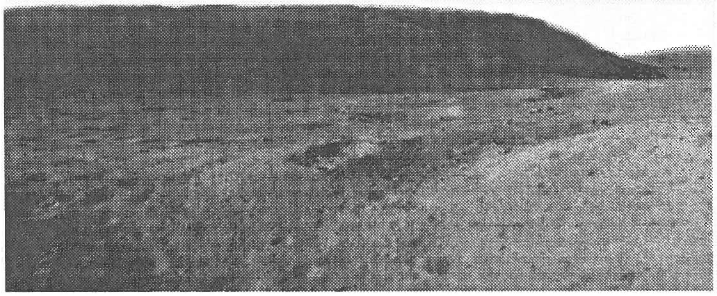
RXTE made repeated scans across the source to determine its position accurately, allowing observers to identify a radio source and a very faint visible star in the direction of the X-ray source. Since the bursting pulsar is a transient X-ray star that is expected to die out within a few months, scientists are working feverishly to try to unravel its mysteries while it still shines.

NEWS FROM

COMPLEX:

THE COMMITTEE ON PLANETARY AND LUNAR EXPLORATION

Since the beginning of the Space Age, NASA has been able to draw upon the expert assistance of a small group of leading planetary scientists on demand. Sometimes the need is for advice on setting long-term goals or the initiation of new programs; other times the tasks are far more difficult, especially when they involve the descoping of missions and programs. This advice comes from within the advisory framework of the National Academy of Sciences and its operating arm, the National Research Council (NRC).



The National Academy of Sciences was chartered by Congress in 1863. The mandates of the original charter led to the creation of a Space Science Board (SSB) in 1958, following a joint request for assistance from the National Science Foundation, the National Advisory Committee for Aeronautics (now NASA), and the Defense Advanced Research Projects Agency. When it was created, the SSB was charged "to stimulate needed research; to promote necessary coordination of scientific effort; and to provide such advice and recommendations to appropriate individuals and agencies with regard to space science as may be. . . desirable."

Within a year of its creation, the SSB had, at NASA's request, launched studies into, among other topics, "the problems of interplanetary probes and space stations, [and] their objectives, Venus and Mars. . . ." Throughout the 1960s, the SSB issued a series of reports (see bibliography listing in Web version of this Bulletin) outlining major issues in the planetary sciences that were later explored, in part, by NASA's Pioneer and Mariner series of spacecraft.

In the early 1970s, the SSB created a standing body dedicated exclusively to the planetary sciences, the Committee on Planetary and Lunar Exploration (COMPLEX). COMPLEX's first four chairs, Gerald Wasserburg (Caltech), Michael McElroy (Harvard University), Eugene Levy (University of Arizona), and Donald Hunten (University of Arizona), set the standard for the committee's future activities by completing individual research strategies for the inner planets, outer planets, and primitive solar system bodies.

COMPLEX acquired new responsibilities during the tenure of its fifth chair, Robert Pepin (University of Minnesota), in the late 1980s. In 1988, the Space Science Board was reorganized into today's Space Studies Board: The Committee on Planetary Biology and Chemical Evolution was disbanded and its responsibilities were assigned to COMPLEX. Besides acquiring responsibility for exobiology, the committee extended its purview outward to encompass the discovery and study of planetary systems around other stars with the publication of the report, *Strategy for the Detection and Study of Other Planetary Systems and Extrasolar Planetary Materials: 1990–2000.*

Updating and integrating the existing strategies for the solar system's various "geographical" regions has been COMPLEX's most important accomplishment in recent years. This task was conceived during Larry Esposito's (University of Colorado) tenure as COMPLEX's sixth chair and carried out during that of Joseph A. Burns (Cornell University). The resulting report, *An Integrated Strategy for the Planetary Sciences: 1995–2010,* was completed in 1994 and became one of the first NRC reports accessible via the Internet. Closely related to the Integrated Strategy was the report, *The Role of Small Missions in Planetary and Lunar Exploration,* which was issued in 1995 toward the end of Burns' tenure as chair.

CURRENT COMPLEX ACTIVITIES

COMPLEX's eighth chair, Ronald Greeley (Arizona State University), was appointed in 1995. Under his direction, the committee is currently finishing two reports — assessments of the Clementine mission and NASA's Mars exploration program.

Although Mars has been a primary target for space science missions over the last three decades, the record of success in the last few years has been poor. Indeed there has not been a completely successful Mars mission since Viking in the mid 1970s. The failure of NASA's most recent Mars mission, Mars Observer, was a particularly hard blow for the planetary science community because this spacecraft was scheduled to carry out many of the highest-priority investigations of the Red Planet. The imminent flights of Mars Pathfinder and Mars Global Surveyor (the inaugural mission of the Mars Surveyor program) have the potential to recover the science lost with the destruction of Mars Observer and to greatly expand our knowledge of the most Earthlike planet in the solar system.

Since the intensive study of Mars was a high priority in COMPLEX's Integrated Strategy, the SSB charged COMPLEX to assess the Mars Pathfinder mission and the Mars Surveyor program to see if they are responsive to the priorities outlined in the committee's past reports. This study is now in the final stages of review.

The Clementine mission was designed to space-qualify advanced, lightweight imaging sensors and component technologies and to demonstrate autonomous operation for use in the next generation of Department of Defense spacecraft. A secondary objective was to perform a two-month global mapping survey of the Moon and a flyby of a near-Earth asteroid. Given the trend toward smaller, focused planetary science missions, the SSB asked COMPLEX to evaluate the preliminary scientific return from Clementine and to determine the lessons the scientific community can learn from Clementine on a variety of issues including schedule, budget, management approach, mission operations, and data processing. This study is currently in final review.

The trans-Neptunian study involves a review of the current state of scientific understanding of the distant outer solar system. Its goal is to identify the most important scientific questions about this region that can be addressed by ground- and spacebased telescopic observations and spacecraft missions in the near future.

REPORT FROM THE FEBRUARY MEETING

COMPLEX's most recent meeting took place at the National Academy of Sciences' Arnold and Mabel Beckman Center on the campus of the University of California, Irvine, February 5–7, 1996. The main purpose of this meeting was to continue work on the trans-Neptunian study and to hear presentations on some of NASA's ongoing solar system exploration missions. In addition, COMPLEX chair Ronald Greeley reviewed NASA's Planetary Exploration "Road Map" development and the activities of two new SSB task groups — the Task Group on Issues in Mars Sample Return (concerned with planetary protection and, in particular, forward contamination by extraterrestrial samples returned to Earth) and the Task Group on Space Astronomy and Astrophysics (concerned with opportunities and priorities in the post-SIRTF era).

COMPLEX member Gene Shoemaker reported to the committee on the latest developments in the study of near-Earth asteroids. This presentation was complemented by a presentation by Steward Nozette (Phillips Laboratory) on the USAF's plans for the Clementine 2 multi-asteroid flyby mission scheduled for launch in May 1998.

Additional presentations were made by Andrew Ingersoll (Caltech), Christopher McKay (NASA Ames), and Michael Carr (USGS) on various aspects of the scientific rationale for mobility on and in planetary surfaces and atmospheres. This topic may become the subject of a formal COMPLEX study (subject to NRC approval) once some of the committee's current projects are completed.

Presentations on current NASA planetary missions were given by Arden Albee, Matthew Golombek, and Torrence Johnson, the project scientists for Mars Global Surveyor, Mars Pathfinder, and Galileo respectively. Presentations related to the trans-Neptunian study included one by Dale Cruikshank (NASA Ames) on groundbased observations of the Kuiper disk. Another was given by Michael A'Hearn (University of Maryland), who reviewed his experiences chairing a recent NRC study and the relevance of the resulting report, *A Scientific Assessment of a New Technology Orbital Telescope,* to studies of the outer solar system.

Shortly after the Irvine meeting, COMPLEX received a formal request from NASA to perform a fast turnaround assessment of the planetary exploration "Road Map" currently under development. This will occur at the committee's next meeting, which will take place in Irvine, California, on June 24–28, 1996.

CURRENT MEMBERSHIP AND WWW INFORMATION

Ronald Greeley, Chair (Arizona State University)
James Arnold (University of California, San Diego)
Fran Bagenal (University of Colorado)
Jeffrey Barnes (Oregon State University)
Philip Christensen (Arizona State University)
Russell Doolittle (University of California, San Diego)
Heidi Hammel (MIT)
George McGill (University of Massachussets, Amherst)
Harry McSween (University of Tennessee)
Ted Roush (San Francisco State University)
John Rummel (Marine Biological Laboratory)
Gerald Schubert (University of California, Los Angeles)
Eugene Shoemaker (Lowell Observatory)
Darrell Strobel (Johns Hopkins University)
Alan Tokunaga (University of Hawaii)
Roger Yelle (Boston University)
Maria Zuber (MIT)

Additional information about COMPLEX and its activities can be found on the COMPLEX Home Page (http://www.nas.edu/ssb/complex1.html) or by contacting its executive secretary, David H. Smith, The Space Studies Board, HA-584, National Academy of Sciences, 2101 Constitution Avenue NW, Washington DC 20418.

CALENDAR 1996

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 SE, Albuquerque NM 87123-5103. Phone: 505-298-2124; fax (by arrangement): 505-298-2124.
E-mail: StWJohnson@aol.com

2–5

Statistical Challenges in Modern Astronomy II, University Park, Pennsylvania. Contact: Gutti Jogesh Babu, Department of Statistics, The Pennsylvania State University, 319 Classroom Building, University Park PA 16802-2111. Phone: 814-863-2837; fax: 814-863-7114; e-mail: babu@stat.psu.edu. *Or:* Eric Feigelson, Department of Astronomy and Astrophysics, The Pennsylvania State University, 525 Davey Laboratory, University Park PA 16802-6305. Phone: 814-865-0162; fax: 814-863-3399.
E-mail: edf@astro.psu.edu
WWW: http://www.stat.psu.edu/astrostat/

7–8

Kuiper Belt Workshop, Toronto, Canada. Contact: Matthew J. Holman. Phone: 416-978-8784; fax: 416-978-3921.
E-mail: holman@cita.utoronto.ca
WWW: http://www.cita.utoronto.ca/~holman/kuiperpage.html

9–13

188th Annual Meeting of the American Astronomical Society, Madison, Wisconsin. Contact: Steve Maran. Phone: 301-286-5154.
E-mail: hrsmaran@eclair.gsfc.nasa.gov

16–18

Planetary Formation in the Binary Environment, Stony Brook, New York. Contact: Michal Simon, Astronomy Program, SUNY, Stony Brook NY 11794-2100. Phone: 516-632-8226 *or* Andrea Ghez: 310-206-0420.
E-mail: origins@sbast1.ess.sunysb.edu
msimon@sbast1.ess.sunysb.edu
ghez@urania.astro.ucla.edu

17–20

IAU Colloquium 159: Emission Lines in Active Galaxies: New Methods and Techniques, Shanghai, People's Republic of China. Contact: IAU Colloquium 159, Department of Astronomy, Ohio State University, 174 West 18th Avenue, Columbus OH 43210. Fax: 614-292-2928.
E-mail: iau159@payne.mps.ohio-state.edu
ftp bessel.mps.ohio-state.edu *or* ftp 128.146.37.206
WWW: http://www-astronomy.mps.ohio-state.edu/iau159.html

JUNE (CONTINUED)

18–21

ESO Workshop on Science with the VLT Interferometer, Garching bei München, Germany. Contact: F. Paresce or O. von der Lühe, European Southern Observatory, Karl-Schwarzschild-Str. 2, D-82748 Garching b. München, Germany. Fax: 89-320-2362.
E-mail: fparesce@eso.org
ovdluhe@eso.org

20–27

Fourth International Conference on Nuclei in the Cosmos, Notre Dame, Indiana. Contact: Michael Wiescher, Department of Physics, University of Notre Dame, Notre Dame IN 46556. Phone: 219-631-6788; fax: 219-631-5952.
E-mail: NIC96@nd.edu
WWW: http://www.nd.edu/~nic96

21-26

108th Annual Meeting of the Astronomical Society of the Pacific, Santa Clara, California. Includes: **Universe '96: National Astronomy Festival (6/22–23); Project ASTRO Workshop for Astronomers (6/23–24); The Universe in the Classroom Teachers' Workshop (6/24–25).** Contact: Meeting Information, A.S.P., 390 Ashton Avenue, San Francisco CA 94112. Phone: 415-337-1100.
E-mail: lbaker@stars.sfsu.edu
WWW: http://www.physics.sfsu.edu/asp/asp.html

24–26

From Stardust to Planetesimals: A Scientific Symposium, Santa Clara, California. Contact: Yvonne Pendleton, M/S 245-3, NASA Ames Research Center, Moffett Field CA 94035-1000.
E-mail: stardust@galileo.arc.nasa.gov
WWW: http://www-space.arc.nasa.gov/~stardust

25–27

Missions to the Outer Solar System and Beyond: First IAA Symposium on Realistic Near-Term Advanced Scientific Space Missions, Turin, Italy. Contact: Giancarlo Genta, Dept. of Mechanics, Politecnico di Torino, Corso Duca degli Abruzzi 24, I-10129 Torino, Italy. Phone: 39-11-564-6922; fax: 39-11-564-6999.
E-mail: Genta@polito.it

JULY

1–5

IAU Colloquium 165: Dynamics and Astronomy of Natural and Artificial Celestial Bodies, Poznan, Poland. Contact: Agnieszka Kryszczynska, Astronomical Observatory of A. Mickiewicz University, ul. Sloneczna 36, PL-60-286 Poznan, Poland. Phone: 48-61-679670; fax: 48-61-536536.
E-mail: astro@phys.amu.edu.pl
WWW: http://www.astro.amu.edu.pl/IAU_Coll.html

CALENDAR 1996

JULY (CONTINUED)

1-5

IAU Colloquium No. 161: Astronomical and Biochemical Origins and the Search for Life in the Universe (5th International Bioastronomy Symposium), Capri, Italy. Contact: Cristiano Coxmovici, IFSI/CNR, Via Galilei, 00044 Frascati, Italy. Phone: 39-6-94186230-8; fax: 39-6-9426814.
Email: cosmo@hp.ifsi.fra.cnr.it

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.
E-mail: sl9jupiter@megasx.obspm.fr

8–12

ACM-96 : Sixth Asteroids, Comets, Meteors Conference, Versailles, France. Contact: ACM, Aeronomie CNRS, BP3, 91371, Verrieres, France. Fax: 33-1-69-20-29-99.
E-mail: aclr@aerov.jussieu.fr

8–12

IAU Symposium 162: New Trends in Astronomy Teaching, London, England. Contact: D. McNally, Univerisity of London Observatory, Mill Hill Park, London NW7 2QS. Phone: 44-0-181-0421; fax: 44-0-181-906-4161.
WWW: http://yan.open.ac.uk/~ajnorton/astro/iau/conf.html

15–17

International Workshop Tunguska96, University of Bologna, Bologna, Italy. Contact: Tunguska96, Department of Physics of the University, Via Irnerio 46, I-40126 Bologna, Italy. Fax: 39-51-244101 or 39-51-247244.
E-mail: Tunguska96@bo.infn.it
WWW: http://bohp03.bo.infn.it/tunguska96/

17–20

The Case for Mars VI, Boulder, Colorado. Contact: Tom Meyer, The Case for Mars, P.O. Box 4877, Boulder CO 80306. Phone: 303-494-8144; fax: 303-494-8446.
E-mail: meyertr@colorado.edu
E-mail: marscase@colorado.edu *(abstracts/papers)*
WWW: http://spot.colorado.edu/~marscase/home.html

9–19

The XVIII Congress of the International Society for Photogrammetry and Remote Sensing: Resource and Environmental Monitoring, Vienna, Austria. Contact: Lawrence W. Fritz, ISPRS Secretary, Martin Marietta Corporation, P.O. Box 8040-13A24, Philadelphia PA 19101. Phone: 215-531-3205; fax: 215-889-3296.

JULY (CONTINUED)

22–26

59th Annual Meteoritical Society Meeting, Berlin, Germany. Contact: Publications and Program Services Department, LPI, 3600 Bay Area Boulevard, Houston TX 77058-1113. Phone: 713-486-2166; fax: 713-486-2160.
E-mail: simmons@lpi.jsc.nasa.gov

AUGUST

4–14

30th International Geological Congress, Beijing, China. Contact: Zhao Xun, Deputy Secretary General, 30th IGC, P.O. Box 823, Beijing 100037 P.R. China. Phone: 86-10-8327772; fax: 86-10-8328928.
E-mail: zhaox@bepc2.ihep.ac.cn

26–Sept 6

International School of Space Science 1996 Course on Space Science from the Space Station, L'Aquila, Italy. Contact: International School of Space Science, c/o Dipartimento di Fisica, Università degli Studi dell'Aquila, Via Vetoio, Coppito, 67100 L'Aquila, Italy. Phone: 39-862-433016; fax: 39-862-433033.
E-mail: ssc@aquila.infn.it

SEPTEMBER

11–13

Space Microdynamics and Accurate Control Symposium (SMACS 2), Toulouse, France. Contact: Agnes Letraublon, CNES, 18, avenue Edouard Belin-BPI 2011, 31055 Toulouse Cedex, France. Phone: 33-61-27-36-26; fax: 33-61-28-13-27.

OCTOBER

7–10

Hypervelocity Impact Symposium, Freiburg, Germany. Contact: Susanne Deschoux, 1996 HVIS, Ernst-Mach-Institut, Fraunhofer-Institut fur Kurtzzeitdynamik, Eckerstr. 4, D-79104 Freibur I. BR, Germany. *Or:* Mark Boslough, MS 0821, Sandia National Laboratories, P.O. Box 5800, Albuquerque NM 87185-0821. Phone/fax: 505-845-8851.
E-mail: mbboslo@sandia.gov

16–18

Workshop on Evolution of Igneous Asteroids: Focus on Vesta and the HED Meteorites, 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.
E-mail: enticknap@lpi.jsc.nasa.gov

CALENDAR 1996–1997

OCTOBER (CONTINUED)

22–25

28th Annual Meeting of the Division for Planetary Sciences of the American Astronomical Society, Tucson, Arizona. Contact: Steve Larson, Lunar and Planetary Laboratory, University of Arizona, Tucson AZ 85721. Phone: 520-621-4973; fax: 520-621-4933.
E-mail: slarson@lpl.arizona.edu

28–31

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

NOVEMBER

4–7

IAA Symposium on Small Satellites for Earth Observation, Berlin, Germany. Contact: Bernd Kirchner, Symposium and Program Coordinator, DLR/WS. Phone: 49-30-69545-545; fax: 49-30-69545-532.
E-mail: iaa.symp@dlr.de

DECEMBER

2–5

Aerospace Technologies in Earth Sciences, Moscow, Russia. Contact: MIIGAIK, 103064, Gorochovskiy per., Moscow, Russia. Phone: 7-095-267-5436; fax: 7-095-267-4681. Or: Russian Aerosol Society, 103064, Vorontsovo pole str., 10, NIFHI, Moscow, Russia. Phone: 7-095-916-6389; fax: 7-095-147-4361.
E-mail: kirill@cc.nifhi.ac.ru

9–13

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

30–Jan 1

Astronomical Time Series (Wise Observatory 25th Anniversary Symposium), Tel- Aviv, Israel. Contact: Dan Maoz, School of Physics and Astronomy, Tel-Aviv University, Tel-Aviv 69978, Israel.
E-mail: dani@wise.tau.ac.il

1997

JANUARY

26–30

Space Technology and Applications International Forum (STAIF-97), Albuquerque, New Mexico. Includes: **14th Symposium on Space Nuclear Power and Propulsion; 2nd Conference on Commercial Development of Space; 2nd Conference on Next Generation Launch Systems; 1st Conference on Future Space and Earth Science Missions; 1st Conference on Synergistic Power and Propulsion Systems Technology; 1st Conference on Applications of Thermophysics in Microgravity.** 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.
E-mail: mjbragg@unm.edu

MARCH

17–21

28th 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.

JUNE

2–6

Seventh Annual V. M. Goldschmidt Conference, Tucson Arizona. Contact: Michael J. Drake, Department of Planetary Sciences, Lunar and Planetary Laboratory, The University of Arizona, Tucson AZ 85721. Phone: 520-621-6962; fax: 520-621-4933.
E-mail: goldconf@lpl.arizona.edu

JULY

17–19

Workshop on Parent Body and Nebular Modification of Chondritic Materials, Maui, Hawaii. Contact: Publications and Program Services Department, LPI, 3600 Bay Area Boulevard, Houston TX 77058-1113. Phone: 713-486-2166; fax: 713-486-2160.
E-mail: simmons@lpi.jsc.nasa.gov

AUGUST

30–Sept 5

Sudbury 1997: Large Meteorite Impacts and Planetary Evolution, Sudbury, Ontario. Contact: Burkhard Dressler, LPI, 3600 Bay Area Boulevard, Houston TX 77058-1113. Phone: 713-486-2112; fax: 713-486-2162.
E-mail: dressler@lpi.jsc.nasa.gov

INSIDE

SUMMER INTERN PROGRAM 1996

Universities Space Research Association USRA

LUNAR AND PLANETARY INSTITUTE
3600 Bay Area Boulevard
Houston TX 77058-1113

ADDRESS CORRECTION REQUESTED