October 1997 • Volume 14, Number 4

SPACE TELESCOPE SCIENCE INSTITUTE

Newsletter

Highlights of this issue:

The Formation and Evolution of Rich Star Clusters in the Large Magellanic Cloud

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One of the largest current GO programs uses 95 hours of Hubble Space Telescope time in Cycle 7 to obtain deep images of a carefully selected sample of rich star clusters in the Large Magellanic Cloud. Program 7307, led by Rebecca Elson and Gerry Gilmore, will use all of WFPC2, STIS (imaging mode) and NICMOS in parallel to obtain accurate multicolor photometry for stars, from near the young main-sequence turnoff down to the faintest cluster members, in eight Large Magellanic Cloud clusters with masses ~10^4 to 10^5 $M_\odot$ and ages ~10^7, 10^8 10^9 and 10^{10} years. These observations will provide a sequence of views of rich star clusters at all stages of evolution, over a wide range in radius, to be compared with state-of-the-art N-body models, also developed at the Institute of Astronomy.

These rich star clusters are interesting targets for several reasons: for understanding the detailed evolution of self-gravitating systems; for investigating such fundamental questions about the star formation process as the universality of the initial mass function; for quantifying the conditions required for rich clusters to form in the early stages of galaxy evolution, or later, during mergers; and to quantify the extent to which clusters are subsequently vulnerable to disruption from both internal and external forces.

The Large Magellanic Cloud clusters provide a unique laboratory for studying the processes through which star clusters form and evolve. Unlike the globular clusters in our own Galaxy, they span a wide range of ages, and unlike the open clusters in the disk of our Galaxy, which are much sparser, neither field star contamination nor small number statistics pose

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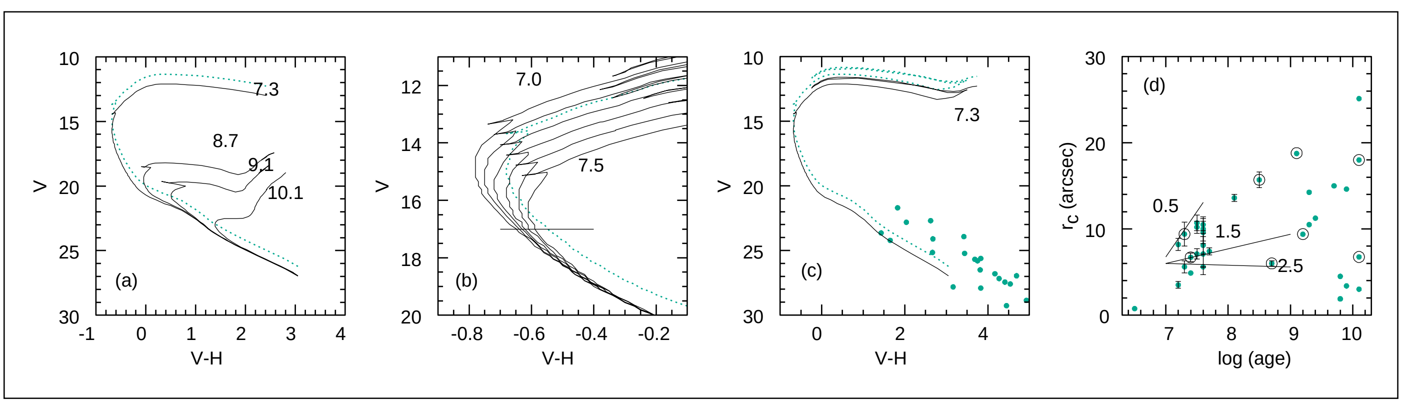

Figure 1. (a) Isochrones for [Fe/H]=-0.4, for ages corresponding to the cluster pairs in our sample. Our errors will be δ (V-H) ≲ 0.05 at V=17 and δ (V-H) ≲ 0.1 at V=25. The dashed curve is the 7.3 Gyr isochrone shifted brightwards by 0.75 mag, to represent a sequence of equal-mass binaries. (b) Isochrones for young clusters illustrating possible age spreads detectable near the top of the main-sequence. The dashed curve is as in (a). (c) Isochrone for a young cluster; filled circles are pre-main-sequence stars in the Chameleon nebula, transposed to the distance of the LMC. The dashed curve is as in (a). (d) Core radius vs age for LMC clusters. The objects in our sample are indicated with open circles. Theoretical predictions for three different IMF slopes are shown. (The Salpeter IMF has slope 1.35).

Director's Perspective

Bob Williams

The second servicing mission (SM2) verification of *HST* has now essentially been completed, and we are once again finding the weekly telescope schedule to be given over almost entirely to science observations. We are striving to construct schedules in accordance with the recommendation of the Independent Science Review, which considered appropriate actions in light of the shortened cryogen lifetime for NICMOS. They recommended that 40 to 50% of the observing be devoted to NICMOS until its cryogen is depleted, and that 25% be devoted to STIS. We should soon be achieving these percentages on a monthly basis and at the same time maintaining the observing efficiency as high as possible.

A number of interesting new developments have taken place recently that will impact *HST* in the future. First, the possibility exists that a closed-cycle cooler might be installed on the telescope on the third servicing mission, SM3, in late 1999, connected to NICMOS to extend its useful lifetime. Design studies are presently being carried out, and a demonstration flight of the cooler on a shuttle flight in October 1998 has been reviewed and approved. It would clearly be a welcome addition to *HST* if the cryocooler could keep NICMOS operating in a productive manner, and we are working with the Project to try to achieve this without adverse impact on the telescope or other instruments.

Second, it has been determined by the Project that the new solar arrays to be installed during SM3 are smaller in size than the present ones, so that the decreased drag might not necessitate as large a boost of *HST* to a higher orbit as had been planned in order to survive the coming solar maximum. This impacts the amount of hardware that can be taken up to the telescope on SM3. The special Call for Proposals to augment existing Cycle 7 NICMOS programs resulted in 450 new proposals being submitted and reviewed by a TAC which evaluated them in early October and which recommended programs for the approximately 1000 orbits of additional NICMOS observations in Cycle 7 that we are confident we will be able to schedule before its cryogen depletes. We will accept an additional number later, based on the TAC rankings, at such time as it appears that the cryogen lifetime may extend into 1999. We are confident that these programs will accomplish much of the science that would have been executed with NICMOS had its cryogen life been 4-5 years, as expected before launch.

In August, NASA announced the award of a contract for the 2002 *HST* instrument to the University of Colorado for development of the Cosmic Origins Spectrograph (COS), whose PI is Dr. J. Green. Focusing on UV spectroscopy, COS will provide *HST* with unique ultraviolet capability that some in the community had been concerned might not exist in NASA missions foreseen for the coming decade.

The current agreement between NASA and ESA regarding ESA's participation in the *HST* mission expires in April 2001. That agreement guarantees ESA scientists a minimum of 15% of *HST* observing time (for the first seven Cycles they averaged 19% via the peer review process) in exchange for their contributions to the Project, which include 15 positions at the Institute, one of the initial instruments on *HST*, the FOC, and the solar arrays and drive electronics. Many of us feel that an essential component of the success of *HST* has been ESA's official participation in it, and we are determined to facilitate extension of the current Memorandum of Understanding. A working group is currently exploring ways in which this can be accomplished, a task now complicated by the fact that provision of additional hardware by ESA for future servicing missions is problematical because the 2002 instrument for the currently final scheduled servicing mission has been decided upon. Fortunately, NASA and ESA are both committed to continued collaboration on *HST*, and so I am encouraged that a means will be found to succeed in extending the MOU.

In this regard, it should be noted that recent statements from NASA headquarters have indicated their willingness to consider extending the operation of *HST* an additional five years past its present decommissioning date of 2005 if it can remain scientifically productive for substantially less cost than present, when servicing missions are no longer such significant cost drivers. Both the Project and the Institute believe that this should be feasible, and therefore we are thinking ahead to the operation of *HST* after its final servicing mission. What mode of operation would produce the most important discoveries with *HST* after the Advanced Camera for Surveys and COS are installed? How important would the simultaneous operation of both *HST* and NGST be? These and other questions will be the subject of a study which the Project is asking the Institute to conduct in the coming months. Given the importance of this topic, we expect to seek community involvement in the study in order to define the most productive modes for *HST* operation during its final years.

Clusters in the Magellanic Cloud *from page 1*

an observational problem. They are at an ideal distance: far enough away that the cluster cores fit into a single PC/NICMOS2 field and that the brightest stars can be observed with short exposures without saturation, and close enough that the faintest main sequence stars can be observed with STIS with reasonable signal-to-noise in a few thousand seconds.

In all the clusters we will use color spreads among main sequence stars to look for populations of close stellar binaries, both in the core and as a function of radius (Fig. 1a). We will thereby determine the fraction of primordial binaries, as well as how the binary fraction evolves as the clusters age. Binaries are believed to play an crucial dynamical role in the evolution of rich star clusters, particularly in inhibiting a runaway collapse of the core in old age.

Within the youngest clusters, our observations will allow us to identify age spreads by constructing color-magnitude diagrams and quantifying the spread in *V-H* color among stars near the main-sequence turnoffs at *V*~16 (Fig. 1b). Spreads in color at faint magnitudes (*V*~25) will be used to identify pre-main sequence stars (Fig. 1c). We will thus address the questions of whether the high or low mass stars form sequentially or together when a gas cloud collapses to form an approximately coeval cluster of stars, and whether the time scale for star formation is much shorter than, or comparable to, the dynamical crossing time.

We will determine deep luminosity functions in all the clusters both in the cores and further out. In the youngest clusters this will indicate whether there is primordial mass segregation with, for instance, the most massive stars forming preferentially in the deepest part of the protocluster's potential

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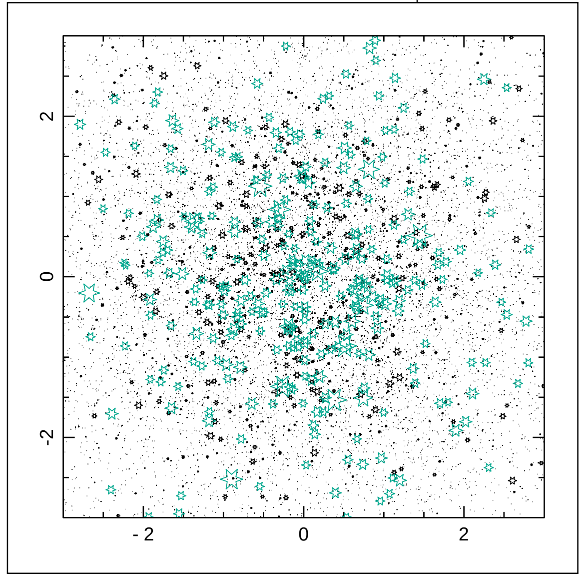

Figure 2. A snapshot of a cluster of 15,000 stars evolved in an N-body simulation to a turn-off mass of $3M_\odot$. For luminosities less than $2\ L_\odot$ the size of the star is proportional to its luminosity. For brighter stars (shown in green), the size of the star plotted is proportional to 2 + log $(L_\star / L_\odot)$. The cluster shown, has a core radius of 2pc, or equivalently 8 arcsec at the LMC, nicely matched to the capabilities of the current HST instruments.

The 1997 Calibration Workshop

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The 1997 *HST* Calibration Workshop took place at STScI on September 22-24, with the participation of about 140 scientists from around the world. The Workshop presented the status of all *HST* instruments operating since the first servicing mission, and provided an abundance of information to assist the calibration and analysis of both archival and new *HST* data.

A full day was dedicated to the status and performance of the two new instruments aboard *HST*, STIS and NICMOS, after six months of operations. Both instruments are working well and, despite some quirks in their characteristics, producing new and exciting scientific results. Status reports were presented on WFPC2 and FOC, whose performance remains very good and has not been affected by the second Servicing Mission. The FGS also continues to work well, and the new element, the FGS1R, promises to provide astrometric performance better than FGS3. Closure reports were presented on the legacy instruments, FOS and GHRS, which provide a very rich set of data for archival research. Because of the many improvements in the calibration of both instruments over the years, archival researchers are strongly encouraged to recalibrate all the FOS and GHRS data they obtain from the Archive.

After discussion of software issues, Archive plans, and of dithering strategies for undersampled instruments, the meeting concluded with a look at the future *HST* instruments for the 1999 and 2002 servicing missions, the Advanced Camera for Surveys and the Cosmic Origins Spectrograph.
The presentations in the main session were complemented by nearly 50 posters. The meeting also included two-hour splinter sessions, arranged by instrument, which allowed for more detailed, interactive discussion among users of each instrument.

A list of talks and posters is available on the Calibration Workshop web page, at `http://www.stsci.edu/stsci/meetings/cal97`

The proceedings of the Calibration Workshop will be produced at STScI and will be distributed both on paper and electronically, via the STScI web pages. Availability of the proceedings is expected by the end of November.

Clusters in the Magellanic Cloud from page 3

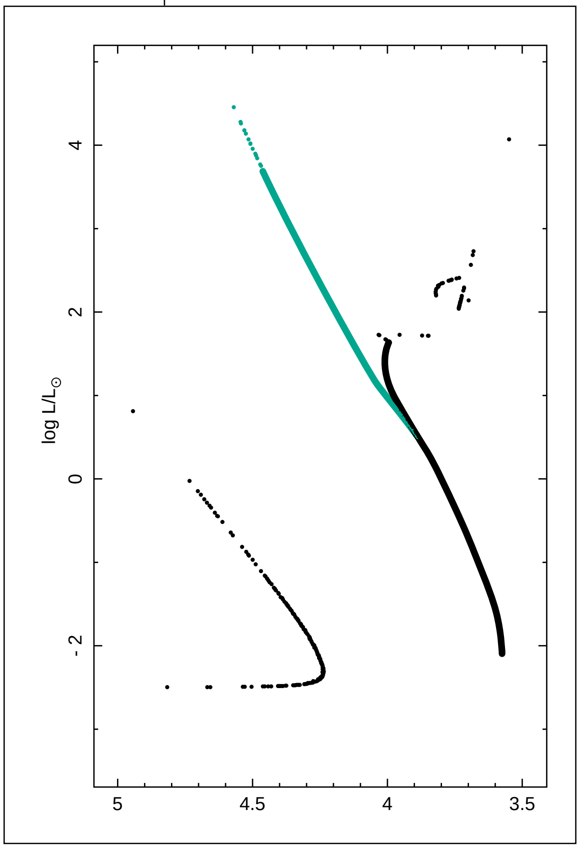

Figure 3. Synthetic HR diagram for a cluster of 10^4 Population II stars, generated as part of the dynamical modeling for this project. The locations of the evolved stars within the cluster are denoted in black at a time of 1 Gyr (left portion), and 2 Gyr (right portion). In both figures, the zero-age main sequence is illustrated in green.

well. In the older clusters this will enable us to trace the development of mass segregation, as the heaviest stars sink to the center.

Finally, since the stellar populations in the young and intermediate age clusters are essentially unaffected by dynamical selection, their luminosity functions may be translated straightforwardly into initial mass functions. We will therefore be able to address directly the all-important question of whether these clusters display a 'universal' initial mass function. The as yet unproved assumption that the initial mass function is universal underpins all attempts to interpret the integrated light of galaxies at cosmological distances.

There is some evidence that the initial mass function may vary among the clusters in our sample. In clusters with flat initial mass functions, mass loss from normal stellar evolution is dynamically significant, and will cause the core to expand rapidly. In clusters with steeper initial mass functions, this fractional mass loss and expansion is less dramatic. The three older pairs of clusters in our sample have very different core radii for clusters of essentially the same age (Fig. 1d). In the case of the oldest pair, this may indicate the onset of core collapse, but in the younger pairs it may indicate differences in initial mass function.

Modeling of the clusters is being performed using a special purpose 44 chip HARP computer, one of only three of its kind. The HARP allows extremely fast modeling of the mutual gravitational attraction of stars in a cluster, outperforming top of the line supercomputers for a fraction of the cost. The computational models include binary interactions, stellar collisions and full internal nuclear stellar evolution, for a range of metallicities, as well as the dynamical interactions of the ~10^4 stars in each cluster and the effect of the gravitational field of the Large Magellanic Cloud itself. Examples of such calculations are given in Figs 2 and 3. In Fig. 2 we show a snap-shot of an N-body simulation of a cluster of 15,000 stars evolved to a turn-off mass of $3M_\odot$. The brighter stars being given in red. In Fig. 3 we show synthetic HR diagrams for a similar cluster, at times of 1 Gyr and 2 Gyr.

Version 3.0 of the HST Data Handbook

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This fall we will be releasing Version 3.0 of the HST Data Handbook. The Handbook is a comprehensive guide to retrieving, reducing, and analyzing *HST* data. It covers the most common tasks in detail, at a level requiring little previous experience with *HST*, and points to many of the other more specialized resources that STScI offers where they are needed.

Version 3.0 contains new chapters on STIS and NICMOS data and completely revised versions of the FGS chapters. It also explains how to work with data in the new FITS format that will be standard for STIS and NICMOS data. Observers with these new instruments should find the Handbook very helpful.

Recognizing that our understanding of STIS and NICMOS is still changing rapidly, we have adopted a new modular format for the HST Data Handbook. It is now structured so that you will be able download individual updated chapters, replacing the older versions, without having to regenerate the entire Handbook. New chapters will be announced periodically on the STScI Web pages and in the STANs.

The End of SMOV

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By the time this newsletter goes to press, the STIS proposal 7091, a test to measure pixel-to-pixel response stability, will have completed on Sep. 25th (knock on wood), thus marking the completion the Second Servicing Mission Observatory Verification period (SMOV2). This second SMOV officially began the instant that the refurbished *HST* was released from from the Shuttle orbiter on Feb. 19, following the end of *HST*'s Second Servicing Mission.

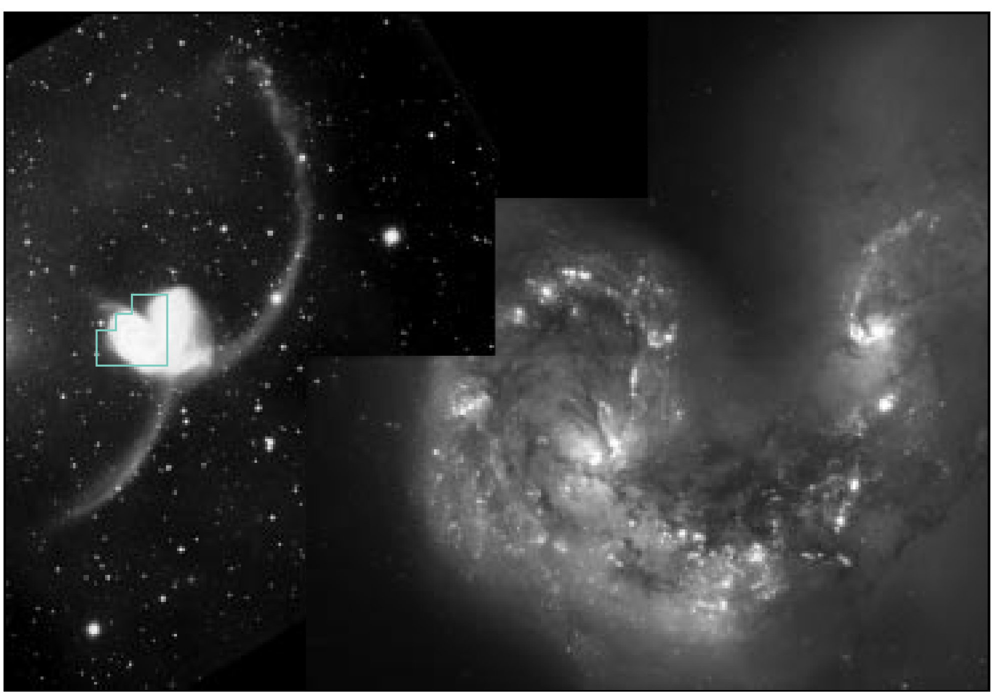
Over the course of the 218-day SMOV period, more than 130 SMOV proposals were executed and over 780 *HST* orbits of pointed observations, an average of about 3.6 orbits per day, were dedicated to the Observatory's recommissioning. Meanwhile, the other *HST* orbits were dedicated to science as the SMOV Program quickly re-enabled the WFPC2 and FOC for resumption of Cycle 6 observations, and enabled NICMOS and STIS, mode-by-mode, for the initiation of Cycle 7. At this point, STIS spectroscopy is being performed in all three detectors and NICMOS infrared astronomy is being carried out in Cameras 1 and 2.

This commissioning process did not occur without its own special brand of pitfalls. On February 24, barely 5 days after the Servicing Mission, the susceptibility of the MAMAs' electronics to charged particle impacts first appeared. Within a few more days, NICMOS displayed the same susceptibility. On March 4, the cooldown curve of the NICMOS dewar displayed an inflection which could only be interpreted as a thermal short that would lead to unexpected equilibrium temperatures for the detector and the filters as well as the possibility of a seriously shortened lifetime for the NICMOS instrument. By March 14, it became apparent that this thermal anomaly was causing dewar expansion such that the NICMOS Camera3 was no longer within the PAM range of focus. Later in SMOV, other STIS and NIMCOS anomalies caused delays and modifications to the original plans before the relevant science could be enabled.

I mention these problems only to highlight the fact that STIS and NICMOS science has experienced relatively little delay in its onset. With the exception of NICMOS Camera 3, all the detectors in both new science instruments are being used regularly for science.

This happy state of affairs is due to the dedication, talent, and sheer hard work on the part of the large contingent of people from the STScI, Goddard Space Flight Center, University of Arizona, Ball Aerospace, and elsewhere, who participated the planning and execution of the SMOV program.

People's responsiveness to these problems (and several others, including two safemode events unrelated to SMOV), at all levels of *HST* planning, scheduling, flight software development, and real-time operations, means that we have a functioning Observatory doing the type of new science that was hoped for following SM2. My personal thanks and congratulations to everyone who participated in the SMOV2 Program.



HST Recent Release: Hubble Reveals Stellar Fireworks Accompanying Galaxy Collision

Left
A ground-based telescopic view of the Antennae galaxies (known formally as NGC 4038/4039). The galaxies are located 63 million light-years away in the southern constellation Corvus.

Right
The respective cores of the twin galaxies are the blobs, left and right of image center, crisscrossed by filaments of dark dust. A wide band of chaotic dust, called the overlap region, stretches between the cores of the two galaxies. The sweeping spiral-like patterns, traced by bright star clusters, shows the result of a firestorm of star birth activity which was triggered by the collision.

HST News and Information Services: Continuously Bringing Hubble Science Down to Earth, to a Worldwide Audience

Ray Villard, STScI villard@stsci.edu

The year 1997 was unprecedented for engaging the public in the excitement and wonder of space astronomy. Hubble's servicing mission, not to mention NASA's Pathfinder landing on Mars and other space activity, was met with unprecedented enthusiasm by tens of millions of people around the world. During the servicing mission the STScI public information site had approximately 500,000 hits per day.

Following the servicing mission there have been hundreds of magazine and news articles reporting on Hubble results, in addition to ongoing internet traffic.

Some highlights:

- National Geographic Magazine's March 1997 photo essay on Hubble's research was their most popular in six months, based on an informal pole by the NGS staff.
- USA Weekend Sunday supplement magazine, reaching 42 million Americans weekly, considers Hubble so popular among the public that it will feature Hubble results on a regular basis.
- The research of Hubble scientists was featured in several PBS documentaries including "Mysteries of Deep Space," and "The Hunt for Alien Worlds."
- The program highlighting Hubble images was the most popular in the Learning Channel series "Solar Empire."
- We receive 300,000 Internet queries for every news release. People complain if they don't see a new Hubble result on the Web at least once every two weeks.

Engaging the Public

A recent opinion survey reported that when taxpayers were asked to name two or three of the most important successes of the federal government over the past 30 years, a whopping 85 percent cited "promoting space exploration."

But we cannot rest on our laurels says NASA's Director of the Origins Program, Ed Weiler: "Hubble is an expensive and high profile mission. We have generated a great deal of public support for *HST* through our continuing efforts to get the science out to the taxpayers. Scientists using *HST* must realize that it is a publicly-funded facility and we owe it to the public to get the science to them expediently."

In his book, "The Demon Haunted World," the late Carl Sagan best described the challenge of science communication when he reflected on the lack of public support for the now canceled Supercolliding Super-Conductor: "If physicists are asking for 10 or 15 billion dollars to build a machine that has no practical value, at the very least they should make an extremely serious effort, with dazzling graphics, metaphors, and capable use of the English language, to justify their proposal."

The Informational Needs of the Public

In meeting the informational needs of the public, all news stories - science related or not - must provide information succinctly and in a limited amount of space. News reports are predominantly made up of factual statements presented with little technical detail or background, and without ambiguity. News media lack the time and space, and their readership lack the background and interest, to be plunged into the details and qualifiers.

This is supported by surveys showing that the public would like even more space science information. However the same surveys show that people quickly lose interest if the information is too technical or esoteric. Hence, all science writers strive for "appropriate simplification." Sometimes this is misinterpreted by scientists as "hype" or "shallow" reporting.

The reality is the news must be interesting, exciting, and compelling. People are flooded with information daily, and science articles must compete with other, often more dramatic and relevant issues: health, the environment, the economy, etc. Hence most reports tend to focus on the results of science - new discoveries - rather than the processes of research.

This is especially true for television, from which half of the American public gets their news exclusively. Some of the most basic science can be too complex and removed from every day life to be explained. What's more, it doesn't matter how interesting the science, the scientist, or the process is, without good pictures a story simply doesn't sell to TV news editors.

Getting Your Message Out

STScI's Public Information Office has a staff of communications experts with the skill to serve the information needs of the news media and public.

A seasoned, professional team of artists, writers, computer animators, and video producers is available to help you present your research in an interesting, understandable, and accurate way through traditional news media, television journalism, and the Internet.

The STScI news program has set a critically-acclaimed new standard of how to explain clearly to taxpayers what their money has bought and why the research matters.

We need your help in continually providing the public with the latest news from Hubble. If you have scientific results that you believe might be of interest to the public, please contact us.

STScI News Services Provided: Science Communication

We translate scientific findings into accurate, understandable press releases and other informational material for the news media and public.

Image Processing

We enhance and lay out *HST* images for reproduction as photographic prints, slides and electronic files, that can be easily reproduced by news media and viewed on the Internet.

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News and Information Services *from page 6*

Science Visualization

We create science illustrations to help explain non-imaging Hubble results, and prepare simplified diagrams of Hubble data. State-of-art computer animation is used for showing astronomical concepts that involve temporal changes, spatial relationships or three-dimensional structure. Such animation is often needed by television media in presenting a Hubble story.

Video Production

We produce video news releases which include animation, diagrams and an interview with the principal investigator who summarizes the research. This product provides all the tools a small or large TV news office needs to prepare a report.

News Coordination

We will work with your home university press office to simultaneously issue newsworthy research. If your results are being announced at an AAS meeting or other science conference, we will prepare and provide all news materials for the conference press room. We can serve as the contact point for filtering and coordinating media requests for interviews, so that you are not swamped with queries.

A Wide News Distribution Network:

Press releases reach several hundred news reporters and science journalists internationally, through direct mail, Internet listserver and automated FAX.

Video news releases are mailed directly to major networks for editing into televised reports

Outside of traditional news reporting channels, millions of people can directly access Hubble images, animation and text posted on our World Wide Web home page

Information and images are incorporated into a variety of educational products including slide sets, posters, color newsletters, educational videos, teacher lesson plans and CD-ROMs. This material is available to educators, planetariums and science museums.

Is your Research Newsworthy?

The Public's interest in research is often but not exclusively pegged to a major new discovery, other factors include relevance, novelty, esthetic appeal. As a general guide, your work has news value/potential if your results:

1. Represent a major discovery of a new phenomena or class of object
2. Decisively help settle an area of puzzlement or controversy in astronomy.
3. Present an unexpected new detail or new level of complexity in a known phenomena.
4. Represents an incremental but important step forward in knowledge in a given research area
5. Sets a new astronomical record or benchmark (i.e. the farthest known galaxy, hottest known star, etc.
6. Deals with unpredicted, transient events (nearby comets, a nova, changing weather on a planet)
7. Provides new insights into the following popular astronomical topics: cosmology, extra-solar planets, black holes, dark matter, solar system objects, distant galaxies, Earth's evolution, the search for extraterrestrial life.

Pathway to a News Release

1. Call Ray Villard (Public Information Manager) at (410) 338- 4514 to discuss the results, or send e-mail to `villard@stsci.edu`, along with a brief abstract or summary. Generally we prefer that you already have an accepted paper for publication before contacting us. Following a telephone interview, a review and assessment of newsworthiness will be made. a draft news release will be prepared for your review and approval.
2. If you have imaging data send it, preferably as a TIFF file, to Zoltan Levay (`levay@stsci.edu`). A photo caption, and sample image will be sent to you via Internet for final review and approval. We will work with you to develop support graphics where needed, such as diagrams and charts that further explain and clarify your results.
3. We will coordinate with you and your home university Public Information Office to set a date for the release. Typically, two to three weeks is required to prepare a press kit depending on our news schedule and the materials required, so its important that we be contacted well in advance of a publication or conference deadline. The press release date will usually coincide with acceptance of your research for publication in a science journal. If results are particularly significant you might be asked to participate in a televised press conference broadcast from NASA Headquarters, Washington D.C.
4. Following the release we can provide you with a bibliography of newspaper articles and TV reports which carried the story.

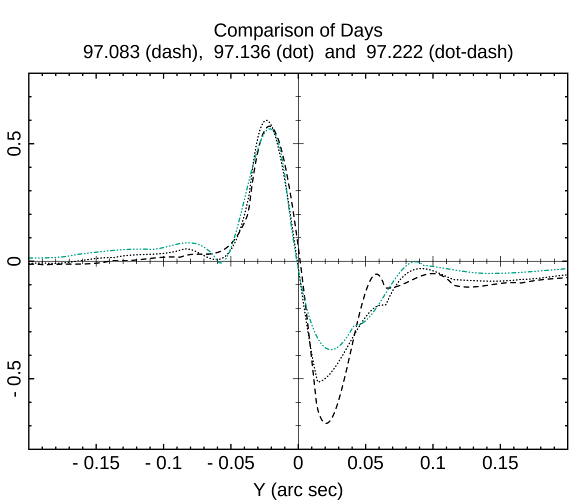
Instrument News

FGS

All three of *HST*'s FGSs continue to be used to success fully guide the telescope. This of course includes FGS1R, the refurbished FGS which was installed in *HST* during the second Servicing Mission.

FGS3, *HST*'s interferometric astrometer, continues to perform well as science instrument in both POSITION mode and TRANSFER mode. Several of the Cycle 7 calibration programs have been executed, including observations in TRANSFER mode of single stars of different stellar colors.

In late March 1997, FGS1R's articulating fold flat mirror was set to optimize its S-curves. Since then TRANSFER mode observations of a standard star have been made on several occasions to monitor FGS1R's performance and to assess its stability. As expected, the S-curves have degraded somewhat as the instrument outgasses water vapor from its graphite-epoxy components. Specifically, the tilt axis of the wavefront at the face of the Koesters prisms has shifted from the center of the prism by a small but measurable amounts, 0.10 mm on the *x*-channel, 0.25 mm on the *y*-channel. This is of no concern for FGS1R's ability to be used to guide the telescope, but it does confirm that it is not yet ready for calibration as a science instrument. The accompanying figure shows the *y*-axis S-curves measured on three occasions, March 23, May 15, and Aug 9. As a side note, it should be pointed out that if the telescope did not suffer from spherical aberration, a misalignment of 0.25 mm in the FGS would not be noticeable. In fact, the misalignment would need to be about ten times larger to have the same degrading effect on the Aug 9 S-curve shown in the figure.



FGS1R will continued to be monitored over the course of the next year. Once stability has been achieved, the articulating fold flat mirror can be adjusted to restore the S-curves to near ideal. FGS1R will then be assessed as a science instrument.

Faint Object Spectrograph

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Although the FOS instrument has now passed into inactive status, all contact scientist support for active FOS GO programs will continue with no change of responsibilities or personnel through the end of the normal proprietary periods. Continuing support for FOS archive researchers will be available from help@stsci.edu

In the past few months the FOS team has compiled the FOS Closeout Calibration analysis. New calibrations have been installed that improve FOS fluxes, flatfields, and wavelengths at virtually all observing epochs. Additionally, post-COSTAR polarimetry calibrations will now be possible with CALFOS. Although the quantitative change in the accuracy of the FOS calibration depends on the date of observation, a simple rule pertains to any FOS dataset:

All FOS data should be re-calibrated with the reference files from the FOS Closeout Calibration.

A thorough discussion of the methods of calibrating and analyzing FOS data, as well as the associated limitations and error sources in the calibrations, can be found in the 1997 edition of the HST Data Handbook. An entire volume of this handbook is devoted to the "heritage" *HST* instruments (FOS, GHRS, HSP, and WF/PC that are no longer installed in the telescope. This expanded handbook is intended to be the definitive document for calibration and analysis of FOS data. It includes a technical instrument overview, summaries of the results of important Instrument Science Reports, methods of FOS data quality assessment, and a thorough discussion of the closeout calibration accuracies.

ll important FOS publications, including closeout summaries and Instrument Science Reports, as well as the HST Data Handbook, are available from our web page and from help@stsci.edu.

In closing, I wish to call to your attention, and to thank most sincerely. the many, many individuals from the FOS Investigation Definition Team, GSFC, STScI, and elsewhere who have contributed their time and talent to the Faint Object Spectrograph program. More than 25,000 science spectra in the HST Archive are their shining legacy.

Instrument News

Goddard High Resolution Spectrograph

David Soderblom, STScI soderblom@stsci.edu

This will be the last report about the GHRS. Over the past few months the GHRS Group at STScI has diminished as Instrument Scientists and Data Analysts have gone to work with STIS or NICMOS. Lisa Sherbert, Jennifer Mack, and I have been finishing several projects that are intended to make archival research with GHRS spectra self-supporting.

The most important of these is completion of our portions of the Data Handbook, which should be available to users in November. The DH has been entirely rewritten, and we have taken special care to ensure that relevant portions of Instrument Science Reports and the Instrument Handbooks have been incorporated, so that the DH is a stand-alone document to the greatest extent possible.

Speaking of Instrument Science Reports, these recent ones are the last that will be written about the GHRS:

- GHRS-ISR083, "The Far Wings of the GHRS PSF"
- GHRS-ISR086, "GHRS Cycle 5 Calibration Close-Out"
- GHRS-ISR087, "GHRS Cycle 6 Calibration Close-Out"
- GHRS-ISR088, "Redetermination of Sensitivity for Echelle-A and G140M"
- GHRS-ISR089, "Summary of the Post-COSTAR Side 2 Sensitivity Monitors for GHRS"
- GHRS-ISR090, "Redetermination of Sensitivity for Echelle-B"
- GHRS-ISR091, "Summary of GHRS Documentation at STScI and a GHRS Bibliography"

Copies of these may be requested by email to help@stsci.edu.

By now you may know that NASA has selected the Cosmic Origins Spectrograph for insertion into *HST* in 2002. COS will include some parts from the GHRS (the optical bench and some others), and when COS is installed those parts will be the only ones left from the original five science instruments. The GHRS owes much to IUE and gave much to STIS, mainly in the form of scientists and others who designed and constructed those instruments. With COS, the GHRS will just give a little more.

As with the FOS, Contact Scientist support for active GHRS GO programs will continue with no change of responsibilities or personnel through the end of the normal proprietary periods. Continuing support for GHRS archive researchers will be available from help@stsci.edu.

Near-Infrared Camera and Multi-Object Spectrometer

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The NICMOS Cycle 7 science program that began last June continues to deliver excellent images using NIC1 and NIC2 cameras. Over the past few weeks, a stable state in the scheduling of NICMOS proposals has been reached with 40% to 50% of the available *HST* observing time being used by NICMOS.

The NICMOS calibration pipeline continues to evolve. A new version of CALNICA handling the non-zero zeroth-read correction for bright sources is undergoing tests and is expected to be delivered early in October.

Cycle 7 calibration programs continue to take data. On-orbit darks for all 16 available MULTIACCUM sequences were initially obtained during June and July. An empirical model of the various components contributing to NICMOS dark current has been developed. These synthesized darks reproduced the on-orbit darks except for the dark current pedestal. A flight software modification, basically leaving NICMOS amplifiers on at all times, was developed to remove the pedestal and was installed August 22. Tests done after that date indicate that the fix removed the pedestal by typically a factor of four. At the time of writing (September 1997) new on-orbit darks for all the available MULTIACCUM sequences are being taken and new synthesized darks being generated. Observers with observations after the software fix went into operation will need to recalibrate their data with these new darks.

On-orbit flats for all NIC1 and NIC2 medium- and broad-band filters have already been taken and analysis and preparation of the corresponding reference files is in progress. Absolute spectrophotometric standards were observed in August with all NIC1 and NIC2 filters. These data are under analysis and a new photometric table with updated photometric zeropoints will be generated. Part of the data needed to characterize NIC1 and NIC2 polarizers have been taken while the rest of the program will be executed in December. The photometric stability of all three cameras is now being monitored once a month and preliminary analysis indicate that all three cameras are stable within the uncertainties of the measurements (2 to 5%). Coronagraph-related tests have been finished, and software to locate the target into the coronagraph hole in real time is being developed. It is expected that observations with the coronagraph will start late in the year but the exact date is not yet known. We continue to monitor changes in focus in all the cameras. Measurements in recent weeks indicate that NIC3 has reached a stable position at about -13 mm in PAM space.

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Instrument News

Camera and Spectrometer *from page 9*

The NICMOS observer community is reminded that we are continuing to characterize NICMOS as rapidly as possible. We will continue to post new results on our Web site. This should be checked regularly by those who need the latest information of the status of NICMOS and our understanding of optimum observing and data analysis strategies.

There will be a NIC3 campaign, however the exact dates are not known yet. Calibration plans to support this upcoming campaign are well advanced. The use of the Field Offset Mirror to reduce the vignetting of the NIC3 camera is being explored with on-orbit tests. Preliminary results look good and more analysis is underway. NIC3-specific calibration programs are being prepared. These programs, which will be executed before and during the campaign, allow a full characterization of NIC3 including darks, flats, plate scale, photometric zeropoints and grisms.

The 1997 HST calibration workshop was held at STScI September 22-24. Several talks and posters summarizing our current understanding of NICMOS detectors and their performance were presented by members of the NICMOS team. Postscript versions of the oral presentations and posters can be found on the NICMOS Web page.

The deadline for NICMOS delta Cycle 7 call for proposals was September 5th. A total of about 450 proposals were received. The Time Allocation Committee will meet October 6-10 and the community will be notified of the results soon thereafter.

Space Telescope Imaging Spectrograph

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With the successful completion of SMOV2 on 25 September 1997, all major modes of STIS for science observations have now been activated. The STIS flight software update performed in August, 1997 was highly successful, and target acquisitions and Doppler modes are now performing extremely robustly. Early indications from the SMOV, Cycle 7 calibration programs, the early EROs, and the first GO observations suggest that STIS is performing exceptionally well across the board, with impressive science coming from long slit optical and UV spectroscopy, as well as echelle spectroscopy and CCD and UV imaging. Observations of planets, comets, AGN, galaxies, the interstellar medium, a brown dwarf and a proto-planetary disk have all been taken with STIS.

Physical Quantity	*Accuracy*
Relative Wavelength	0.2-1.0 pixels (based on the dispersion solution, quite mode dependent, see the STIS Data Handbook for more details)
Zero-point Wavelength (w/WAVECAL)	0.1-0.2 pixels
Zero-point Wavelength (w/o WAVECAL)	<= 8 pixels (due to MSM repeatability and thermal drifts)
Flux	+/- 50% (this is quite mode and aperture dependent)

Science with STIS promises to be very exciting indeed! We remind you that the ERO data for STIS became public in early October.

The STIS Long Range Plan has been evolving and becoming more stable through the early fall, and almost all programs now have plan windows and scheduled observations. GOs receiving STIS data this fall should expect to receive flux- and wavelength-calibrated, cosmic-ray-rejected, flat-fielded and rectified two-dimensional spectra for long slit observations, and one-dimensional aperture-extracted spectra for echelle observations. By spring, one-dimensional spectra will also be extracted for first-order modes. We continue to work the aperture extraction algorithms and optimal sizes, and to evolve methods for correcting for scattered light and the cross dispersion profiles, in the echelle modes (particularly), and in the first order modes. As we have learned more about the behavior of STIS, we have evolved the calibration software, CALSTIS, to reflect our improved understanding and to correct bugs uncovered during data analysis. An in-depth discussion of the major tasks performed by the pipeline was presented in the July issue of the STScI Newsletter, and updates, software modifications, and new release information is regularly provided in the STIS STAN. The latest version of CALSTIS can be downloaded from the STSDAS page on the STScI WWW. A number of changes to the CALSTIS software have been made recently and will continue to be made and we encourage you to *always* check the WWW pages and

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download the most recent version of CALSTIS and associated tasks prior to beginning to work with your STIS data. We remind you that TABLES and STSDAS, versions 2.0. were released on Sep. 5, 1997. This version includes new code for accessing NICMOS and STIS datasets, as well as new tools for manipulating the data. Note that IRAF 2.11 is required to run TABLES/ STSDAS 2.0. The latest information on the release is available off the STScI home page by linking to STSDAS via the Science Resources and Software pages. More recent releases of the CALSTIS software will exist than that release and should be downloaded separately. See the WWW pages.

The following table summarizes how well the current set of reference files (as of October 1, 1997) and CALSTIS are doing in terms of calibration accuracy. We expect to continually update the accuracy levels as time goes on and the current accuracy levels will always be posted under the calibration button of the STIS Instrument WWW page. The accuracies given below are at slit center.

We expect the first major update to the on-orbit sensitivities to come around the turn of the year, bringing the sensitivity calibrations to ~+10-15% for all prime settings for observations at slit center in wide slits; the first-order low-resolution mode calibrations should be considerably more accurate than that around the same time. Look for updates in the STANs and on the STIS Instrument pages.

The STIS Pure Parallel Archival Program is well underway and is providing excellent results. More than 1300 datasets have been obtained to date. The current program is designed to obtain slitless spectroscopy with the G750L grism in a search for emission line galaxies at intermediate to high redshift. Short exposures with the 50CCD imaging mode are also being taken to provide the wavelength zero-point calibration, and to help determine the connection between galaxy morphology and spectral type as a function of redshift. At low Galactic latitude these data can be used to search for low mass stars and brown dwarfs. Initial images show many faint galaxies and possible clusters, and include some gravitational lens candidates. The depth of the images obtainable in a short time, and the potential of the spectroscopy to obtain redshifts in a spectral region where the atmospheric emission is bright (and variable), will undoubtedly prove to be a valuable feature of STIS. All datasets obtained as part of the pure parallel program are non-proprietary, and we encourage you to download the data, have a look, and get started. The Pure Parallels Working Group met at STScI in late September and made some recommendations for enhancements to the STIS Archival Pure Parallel Program which should take effect around January, 1998. The heart of the STIS Pure parallel program will not change substantially, however additional observations such as those aimed at deriving Color Magnitude Diagrams for the outskirts of nearby galaxies and globular clusters and deeper imaging for number counts and galaxy morphologies are likely to start being taken along with the G750L slitless spectra. Look for more information in the next STScI Newsletter.

The Cycle 7 calibration program has also begun in earnest. Programs which have fully or partially executed to date include the CCD and MAMA Sensitivity and Focus Monitors, HITM and LINE Lamp Flux Determinations, CCD and MAMA Geometric Distortion, CCD Spectroscopic Flats, CCD G230LB and G230MB Wavelength Calibrations, CCD Red Light PSF Halo, CCD Hot Pixel Annealing and the CCD Target Acquisition Workout. We are struggling to keep up with all the calibration data we are getting, and we ask you to be patient as we work to get the results quantified and in usable form for you and the pipeline. One of the things we have recently done is to provide an On-Orbit Performance page for STIS on our WWW pages. This includes information and graphics documenting on-board measurements of sensitivity for all the low-dispersion modes (as well as a few medium-dispersion modes), target acquisition accuracies, CCD and MAMA detector performance data including noise, flat fielding, geometric distortion and resolution characteristics and on-orbit PSF analyses. STIS thermal stability coronagraphic performance and line spread function data are also discussed. This provides you with a quick look at the to-date measured performance of STIS as we work to process the data and information into reference files and Instrument Science Reports and enhancements to the CALSTIS pipeline - all of which take time. Several 'foibles' with STIS are also noted in the On-orbit Performance pages. Included among these are the fringing for CCD spectroscopic observations at wavelengths longward of 750nm, CCD long-wavelength detector halos, hot pixels, large-scale pattern-noise for the CCD with GAIN=4, dust motes (shadows of specks of dust on the CCD faceplate), high NUV-MAMA dark current and spectroscopic-mode ghosts. Some of these items have also been discussed in depth in recent STIS STANs. Continuing in November and on, we will be posting more in-depth information on the STIS web pages describing on-orbit performance accuracies to date. Also due in November will be the release of the new Data Handbook providing information and instructions on the analysis of STIS data.

One early calibration result which will affect some observers who were using the STIS echelles to observe the brightest sources is the finding that the global rates seen for echelle mode

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observations are between roughly 1.5 and 2 times greater than originally predicted. This comes from a combination of a greater efficiency of the gratings than expected, some increased scattering out of the orders in some modes, and the fact that early predictions of the global count rates did not take into account that counts from beyond the nominal free spectral range of the orders do fall on the detector. We will update the ETC and will directly contact observers whose observations are now ‘too bright’ for STIS’s global screening limits. We expect to reissue magnitude screening limits for the STIS MAMAs based on all the on orbit measurements later this fall.

Two major outstanding issues for STIS which remained at launch were the signal-to-noise obtainable in the Near-IR (longward of ~8000 Å) where the CCD fringing and long wavelength halo become issues and in the UV, where the flat fielding properties of the MAMA were not well characterized. The early results from SMOV and Cycle 7 Calibration are encouraging in both areas, as reported at the recent STScI Calibration Workshop held at STScI in late September and as reported earlier in STANs. Specifically, using fringe flats obtained contemporaneously with the science data, Goudfrooij and Walsh were able to demonstrate realized signal-to-noise of ~100:1 for both point sources (a calibration standard star) and diffuse source (calibration observations taken of I_O) in G750L at long wavelengths. These observations were taken with the standard flat sequences recommended to long wavelength G750L and G750M observers. On the MAMA side, Kaiser, Bohlin, and Lindler reported signal-to-noise of ~100 per resolution element for aperture extracted point source standard star observations in G230L without a flat, and signal-to-noise of 150 using the pipeline flat, where the counting statistics from the source would have predicted a maximum signal-to-noise of 200:1. Here a resolution element is two standard (lowres) pixels and the aperture used for the extraction was the standard 11 pixels high. Similarly, for the FUV-MAMA, high signal-to-noise was obtained without application of a flat for calibration observations where the source counting statistics allowed and early signs suggest we may be able to create a robust flat by combining the ground and on orbit flat field data. In the echelle modes, the Doppler smearing smooths the data automatically and this should enhance the signal-to-noise achievable in echelle modes, though this still awaits on orbit confirmation. During the month of September 1997 a test of the FP-SPLIT slits designed to achieve high signal-to-noise with the MAMAs will be executed, so by the next newsletter we hope to have more news to report.

Throughout the coming months we will undoubtedly learn much more about STIS and be able to characterize its capabilities and uncertainties to a much degree. We will continue to work hard to provide GOs with the best possible calibrations, processing tools and documentation necessary to take and analyze their Cycle 7 data. There is a lot to be done however, and it won’t happen all at once so some patience will be required. We will continue to try and update the WWW pages so that the latest calibration and observing information is available to you as we analyze the data. We welcome your comments and suggestions as well as your questions (help@stsci.edu) and remind you that the cycle 7 calibration plan is posted to the Calibration Resources link of the STIS WWW pages and you can check to see when the programs relevant to your science will execute. Remember, all calibration data is immediately non-proprietary. We’ve seen the initial results of STIS and anticipate great science and many new and exciting discoveries as the Cycle progresses.

WFPC2

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The WFPC2 continues to work flawlessly, hence much of our recent effort has been in the area of documentation. Several new Instrument Science Reports have recently come out which may be of interest to WFPC2 users. Two are mentioned below, but please check our WWW page for the full listing.

One new report is a summary of the extensive series of tests and calibrations following the 1997 *HST* servicing mission. ISR WFPC2 97-09 by Biretta and the WFPC2 team shows that the servicing mission caused essentially no change in the performance and calibration of the WFPC2 (i.e., the photometric calibration, baseline far-UV response, focus, PSF, flat field, read noise, A-to-D gain, and dark current are all the same as before the servicing mission). The only discernible effect was a small and temporary increase in the rate of contamination as evidenced by slightly decreased UV throughput.

ISR WFPC2 97-08, by Whitmore and Heyer, has further characterized the charge transfer efficiency effect on the WFPC2. They provide a set of new formulae developed to correct for CTE loss, with dependencies on the X and Y positions, the background counts, and the brightness of the star. The use of these formulae reduces the observational scatter for aperture photometry from 4-7% to 2-3%.

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Still more new documentation will soon be available in the Data Handbook, which Casertano has updated. The primary changes are major additions to the astrometry and polarimetry sections, extensive modifications to the photometry section (including improved zeropoints), and a table of the expected accuracies of WFPC2 observations.

In July we started a program to obtain more frequent dark frames. The new program is designed to provide short (1000s) darks to be used primarily for the identification of hot pixels. The shorter darks are used so that observations can fit into almost any occultation period. The program is designed to complement the standard darks program whose longer individual observations are used to produce high-quality pipeline darks and superdarks. The "supplemental" darks will not be used in standard STScI products, but are available to observers via the Hubble Data Archive.

It was recently discovered that the keywords PA_V3 and ORIENTAT in the header of about 50 WFPC2 image have been assigned an incorrect value. Users affected by this problem have been informed directly, and the archival images will be corrected in the future. The images with this problem can be recognized from the following set of circumstances: several exposures of the same target taken in the same orbit all have the same value of PA_V3, except for the last one which is different (generally by several degrees). A quick fix is to copy the appropriate header parameters (image parameter PA_V3 and group parameter ORIENTAT) from one of the other images in the series.

Faint Object Camera

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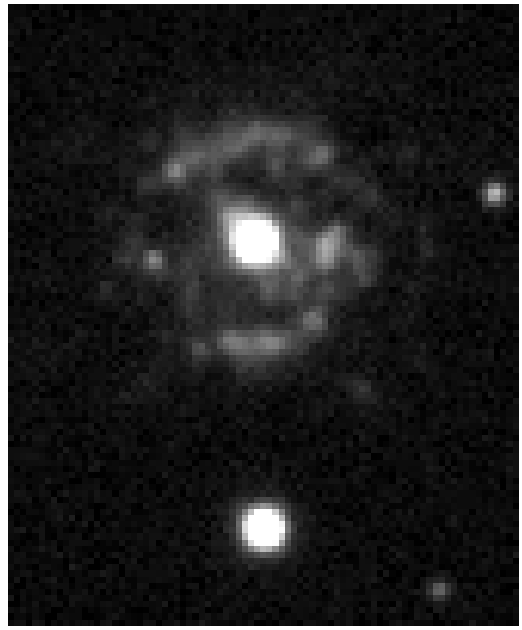
The FOC has had a relatively smooth period, with routine science observations and calibrations. As an item of interest,
a recent program imaging a CVZ target produced three exposures each of duration 9122s. These are the longest-ever single FOC exposures.

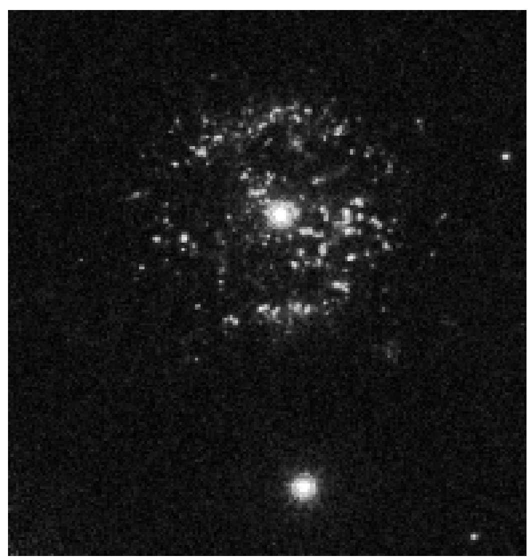
A minor bug in the BESTREF routine in Starview was fixed; the best UNI (flatfield) file had been incorrectly selected because the "UNITAB" resource was incorrectly used. The fix now means that the best flatfields are correctly indicated.

Instrument Science Reports, news, and other items of interest to FOC users can be found be referencing the FOC WWW pages at: http://www.stsci.edu/ftp/instrument_news /FOC/topfoc.html

HST Recent Release: Nova T Pyxidis



This image, taken by a ground-based telescope, shows shells of gas around the star that were blown off during several eruptions.



Closer inspection by the Hubble Space Telescope, however, reveals that the shells are not smooth at all. In fact, this high-resolution image shows that the shells are actually more than 2,000 gaseous blobs packed into an area that is 1 light-year across. Resembling shrapnel from a shotgun blast, the blobs may have been produced by nova explosions, the subsequent expansion of gaseous debris, or collisions between fast-moving and slow-moving gas from several eruptions.

Report From The HST Project Scientist

David Leckrone, Goddard Space Flight Center

The Cosmic Origins Spectrograph (COS)

This past August 12 the Office of Space Science at NASA Headquarters announced the selection of the Cosmic Origins Spectrograph (COS) to be designed and developed for insertion aboard *HST* during its final servicing mission in 2002. I'd like to congratulate the COS Principal Investigator, Dr. Jim Green of the University of Colorado, and his team for an outstanding proposal. COS will be by far the most sensitive spectrograph to fly on *HST*, 15 to 20 times more sensitive in the far-ultraviolet than STIS at comparable resolving power (about 20,000). The team has proposed a variety of exciting scientific programs for which COS will be very well suited, including observing distant quasars to measure the He II Gunn-Peterson effect, to map the structure of the Lyman-alpha forest, and to measure the D/H ratio and metallicity in primordial clouds. COS will be used to determine abundances and kinematics of intergalactic matter at very early epochs, and will trace the evolution of metal-enrichment of galactic halos over time. It will study nearby starbursting systems over a range of metallicities, and its spectra of globular cluster HB stars will allow refinement of the estimates of cluster ages.

To achieve its very high sensitivity, the COS optical path contains only one element, a concave aspheric grating, which simultaneously corrects for spherical aberration and astigmatism, and images the dispersed light onto a delay-line microchannel-plate detector located on the Rowland circle. COS is a relatively inexpensive instrument, which takes good advantage of our prior instrumentation heritage. It will be housed in the GHRS structure that was returned from orbit at the end of the second servicing mission this past February. It also will re-use the GHRS optical bench and an updated version of the GHRS grating carrousel. Once again Ball Aerospace in Boulder will be the prime contractor for the development of this newest HST instrument.

Status of the NICMOS Cooling System (NCS)

We continue to make good progress in the design and development of the new, high-tech mechanical cooling system (reverse Brayton-cycle cryocooler) which is being considered for flight on the *HST*'s third servicing mission in 1999 to extend the operational life of NICMOS. A Critical Design Review (CDR) of NCS was held at Goddard Space Flight Center on September 4-5, closely followed by an Independent Science Review (ISR) on September 10-12. The latter was organized by AURA at the request of the *HST* Project and was chaired by Martin Harwit. The NCS received high marks from the CDR team, which, however, identified as its major concern the present uncertainties about the thermal margin in the design. The design requirement is to maintain the NICMOS detectors at 72 K and the filters and cold masks at 160 K with a high level of stability. Detector temperatures exceeding 77 K would be unacceptable. The system performance will be carefully measured during a thermal vacuum test next April, and this will give us a basis for accurately assessing the thermal margins. We are planning to test-fly the NCS on a shuttle mission in October, 1998 - well in advance of the *HST* Servicing Mission in December, 1999.

In his report to the *HST* Project, Martin Harwit divided the conclusions of the ISR into two parts. 1) The development and flight testing of the NICMOS cryocooler system is, in its own right, a very important step for the future of infrared science and should be continued, and 2) There remain a number of areas of continuing uncertainty with regard to the performance of the cryocooler, the prognosis for NICMOS itself, and the possible effects of the cryocooler system on other instruments and the *HST*, so that it is not yet possible to conclude that the NCS should definitely be installed on the *HST*. The ISR has requested the opportunity to reconvene in about one year, shortly after the flight test of the system. By that time we will know a great deal more than we do today about these issues, and the ISR team will be in a much better position then to make a final recommendation.

The *HST* Project strongly concurs in these recommendations and we will be happy to host another meeting of the ISR team in late 1998. I personally want to thank Martin Harwit and his blue-ribbon ISR team for conducting such a thorough and thoughtful review. We will make their report available on the web and in this Newsletter.

The Future Of WFPC2

As is now widely known, the *HST* Project and AURA have negotiated a five-year extension of the STScI's contract (extending it to 2002). We are now approaching an era of dramatically declining budgets for *HST*. One consequence of this is the necessity to operate *HST* less expensively, and so we were compelled to negotiate a contract cost for the STScI somewhat lower than AURA had originally proposed. The STScI drew up a long list of options for reducing costs, while minimizing impacts to the science productivity of *HST*, and one such option was to phase out regular use of WFPC2 as the new Advanced Camera for Surveys (ACS) comes on line after the third *HST* Servicing Mission in 1999. This possibility was described to

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Editor's Note:

In the last Newsletter the article titled "The NASA-STScI Contract" was incorrectly attributed to the HST Project Scientist, David Leckrone. It was, in fact, jointly written by John Campbell, the HST Project Manager, David Leckrone, and Ed Ruitberg, the HST Project's Science Operations Manager.

We regret this mistake.

Advanced Camera for Survey

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It's just over two years until launch for the 1999 Servicing Mission. During this mission the Advanced Camera for Surveys (ACS) will be installed in the axial bay currently occupied by the Faint Object Camera (FOC). ACS will offer a number of new imaging capabilities to the user of *HST*, including a wide field (200 × 200 arcsec) channel (WFC) optimized for deep imaging in the optical and near-IR (360-1100 nm), a high resolution channel (HRC) optimized for near-UV and optical imaging (200 to 1100 nm), and a high-throughput FUV solar-blind channel (SBC). The Principal Investigator for ACS is Prof. Holland Ford of the Johns Hopkins University (JHU).

The construction of ACS is proceeding at a very rapid pace to meet the schedule for final delivery to Goddard Space Flight Center (GSFC). The optical bench has been assembled (see Figure 1), tested and installed in its alignment fixture at Ball Aerospace in preparation for the integration of the optics. Before this can start, however, the two WFC/HRC filter wheels have to be installed. In contrast with previous *HST* instruments, everything associated with the WFC channel of ACS is large scale. One of the two WFC/HRC filter wheels is shown in Figure 2 and gives a good impression of the large size of each individual filter. The two WFC/HRC filter wheel assemblies just fit within the envelope of the ACS optical bench, so they have to be installed early. The ACS filters are being procured in a joint effort between JHU, GSFC, and Ball Aerospace, and initial optical testing of delivered filters is being conducted at GSFC and JHU. At this time, a significant number of the filters are already in hand. Most of the remaining filters are in fabrication or are undergoing initial testing at GSFC.

One of the main elements of ACS is its complement of detectors. During the last eight months, the ACS science team has been especially busy with the selection of CCDs for ACS. The devices for both WFC and HRC are being fabricated at at Scientific Imaging Technology (SITe) under the supervision of Dr. Morley Blouke, who has previously designed the WF/PC and the STIS CCDs. The WFC CCD is a 2048 × 4096 (2k × 4k) array with 15 micron pixels, also designed by Dr. Blouke. The CCD is thinned and backside-illuminated to provide high quantum efficiency. The processing of the CCD's backside surface is selected from one of two possible processes. Most of the devices are processed at SITe using a Boron ion implant to passivate the backside surface plus an anti-reflection (AR) coating. This approach yields a typical QE of ~70% at 700 nm and ~55% at 800 nm, our baseline wavelength for the specification of WFC sensitivity. A smaller number of devices has recently been sent to Dr. Mike Lesser at the Steward Observatory CCD laboratory, where the backside surface is processed using the Steward Catalytic treatment plus an AR coating. The QE of devices processed at Steward peaks at ~80% at 700 nm.

The final selection of flight devices is currently underway and requires a tradeoff between several CCD specification parameters. Clearly high QE is essential; low read noise (<4 electrons RMS) and low dark current (<50 electrons/pixel/hr) are also mandatory to ensure the overall low noise performance of ACS CCDs. Other important factors in selecting WFC CCDs include charge-transfer efficiency, an especially important factor for such large arrays, the full well depth, and the cosmetic appearance of the devices. It is currently planned to build two 4096 × 4096 CCD flight assemblies, requiring four 2k × 4k CCDs. The two first two devices have been provisionally selected and the second two devices will be selected within the next month.

In the case of the HRC channel, a single 1024 × 1024 CCD with 21 micron pixels is employed. This CCD is fabricated to the same specification as the STIS CCD, except that we have used the same approach to backside processing as was used for the WFC. Half of the HRC CCDs are backside processed at SITe using a SITe NUV treatment, while the remaining half are processed at the Steward Observatory

using a catalytic backside process. Once again two flight packages will be built, each consisting of one CCD. Overall performance of the CCDs is similar to the STIS CCDs, however the SITe process yields QE of ~35% at 300 nm, while the Steward process yields ~70% at 300 nm. The current baseline is to build a flight package with one of each type.

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The "Sociology" of the HST Archive

Megan Donahue and Tim Kimball, STScI donahue@stsci.edu, kimball@stsci.edu

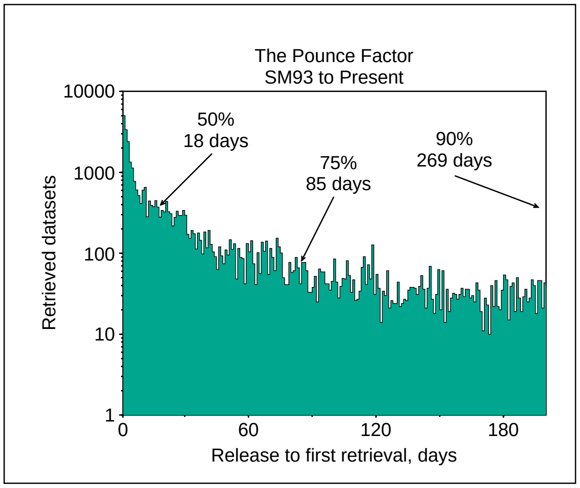

Figure 1. "The Pounce Factor." The number of datasets as a function of the number of days between the release of a dataset and its first retrieval. 50% of the data retrieved at all were retrieved within 18 days of release.

Did you ever wonder just how many people are accessing your now-public GO data? How long retrieval from the Archive takes? How long to wait until you check the archive for your GO observations? The answers (or lack thereof) to these questions may not cause you to lose sleep at night, but for you statistics and data junkies out there, have we compiled some informal archive stats for you! As amateur sociologists, we note some societal influences on archive use, such as weekends and holidays, hence the title "HST Archive Sociology." See what others you can discover. Enjoy.

The Hubble Data Archive has over 3.45 terabytes of science and engineering data stored on 509 Sony optical platters, most of which reside in 4 coffin-sized jukeboxes for quick retrieval. Roughly half of this volume is the raw and calibrated *HST* science data. The archive receives the data immediately after it is processed through the calibration pipeline here at the institute, and is thus available for immediate retrieval by authorized users. Most, but not all, of the data goes public one year after we receive it. Some data, such as calibration data and some special parallel and snapshot programs go public on a much shorter time scale.

Have you ever wondered what happens to your data after it has gone public? We have studied the fate of *HST* data, for data taken since 1994. (Data taken before that were distributed by a different system.) Of the over 95,000 datasets eligible for retrieval, a surprising 18.3% have never been retrieved after they have gone public. This data spans all of the instruments and all Cycles since 1994. For the datasets that have been retrieved, we have generated a histogram of the

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Project Scientist Report *from page 14*

our User's Committee at its meeting last May, and from there rumors quickly spread in the community that the *HST* Project was planning to decommission WFPC2. Ed Weiler, Bob Williams and I received many emails voicing concern over this issue and pointing out the unique capabilities of WFPC2, particularly with regard to its filter set.

I solicited scientific discussions from the WFPC2 Science Team and from the ACS Science Team, and carefully considered the comments I had received from other imaging science experts about this issue. I have reached the conclusion that it is important to maintain WFPC2's availability for new, TAC-selected programs, at least through Cycle 9. This will allow us to gauge the continued demand for its usage in the era of the ACS. It will also allow a full Cycle's overlap of operation of the two cameras, so that their performance can be properly compared and cross-calibrated. After that we will re-evaluate the level of usage of WFPC2 on a Cycle-by-Cycle basis. If it falls to a very low level, then we will reopen the question of keeping WFPC2 on-line, in full consultation with the *HST* User's Committee and our other advisory committees. In any event, we must maintain a basic capability to operate WFPC2 as a contingency backup to ACS. We are still discussing with the STScI the details of implementing this approach, but I am confident we will be able to keep WFPC2 fully available to the community, at least through Cycle 9.

Advanced Camera *from page 15*

The solar-blind channel of ACS employs a FUV MAMA detector of the STIS design. The baseline selection for ACS is to use the STIS flight spare, pending results from the testing of a new detector which was recently fabricated.

The next year promises to be an exciting time as ACS starts to come together and its performance is characterized. We will bring you further news as ACS passes significant milestones on its path to delivery.

HST Archive from page 16

number of datasets as a function of the number of days between the release of a dataset and its first retrieval (Figure 1). We call this the "Pounce Factor" plot. 50% of these data are first retrieved within 18 days of public release, with a significant amount of data being retrieved between 1 to 3 days of release (yes, we have resolved the weekend here!)

What data has been the most popular? Certainly the Hubble Deep Field was one of the most popular data collections, but most HDF researchers accessed that data, particularly the processed versions, via ftp, not the archive. Of data that have been retrieved through archive requests, we found no real single dataset that was clearly the most popular, with over 40 datasets having been retrieved of order 30 times each or so. We also compiled a list of the top 40 proposals since 1994, ordered by number of requests. The single most popular program, as rated by number of data requests or number of datasets retrieved, has been, hands down, the WFPC2 Seyfert snapshot survey led by Matt Malkan of UCLA. This survey is comprised of about 300 snapshots (mostly PC) of Seyfert galaxies, which, at *HST* resolution, show a remarkable variety of beautiful and exotic morphologies. Listed at #40 is Bob William's HDF program.

We have recently begun moving some of the HDA data from the jukeboxes to off-line storage. In the process of planning that move, we wondered whether there were some data which were less popular than other data. We knew that the engineering data are not as popular as the science data, so we immediately began segregating science and engineering data onto separate platters. We speculated that old data from Cycles 0 to 3 would be less popular than the post-COSTAR data, but we were surprised to find that the old data were not as ignored as we might have suspected. In fact, through the years 1995 to 1996, we found that while the fraction of requests for data from Cycles 0 to 3 may be gradually decreasing, the number of datasets and retrieval requests for cycle 0 to 3 data has remained remarkably constant (See Figure 2ab.)

In recent months, the volume demand for *HST* data has increased, largely because of the huge data quantities generated by the new instruments, STIS and NICMOS. The monthly volume of data archived and retrieved have both increased by a factor of 3 between July, 1996, and July, 1997 (Figure 3). We note the dips in the retrieval rates around proposal time (August 1996) and winter holidays (Dec 1996) as evidence that even astronomers can be slowed by other demands on their time, like family and *HST* proposals (not to be considered equivalent!).

We have nearly 1300 registered archive users. Users must, at least now, register to retrieve any data from the archive. Browsers do not need to register. For the last year, we have offered *HST* observers and anyone they authorize the opportunity to get their proprietary data by electronic means rather than tape. As of August 1, 252 people are authorized for 523 different proposals. Over 30% of the GOs in Cycle 7 opted for this new mode of data receipt exclusively, although they still might receive a tape until our software is fully updated. We suspect that this means of obtaining *HST* data, in the post-SM2 era, will become more popular than tapes by mail.

Where is my data? (I want my MTV!) Figure 4 shows the distribution of time intervals between observation and availability from the HDA since the March 1, 1997. These times are affected by a few variables, such as when the data were read down from the telescope, and time spent in the processing and calibration pipelines. The time between when the archive receives a dataset from the pipeline and when it is archived is a matter of minutes. Figure 5 shows that about 50% of the data are available within 11 hours of observation, with a peak of 6 hours. 90% of the data are available

continued page 19

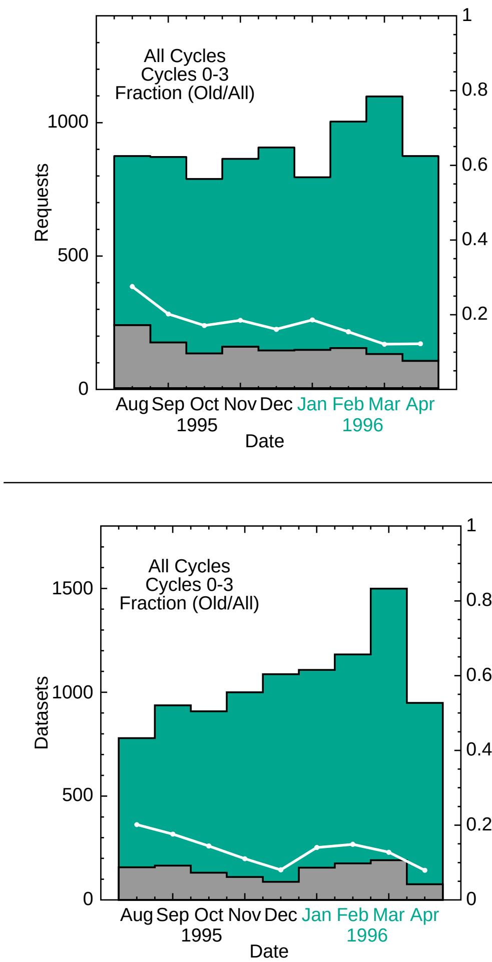


Figure 2ab. Demand for data from Cycles 0 to 3 (pre-COSTAR data) during the years 1995 and 1996. Figures courtesy of Marc Postman.

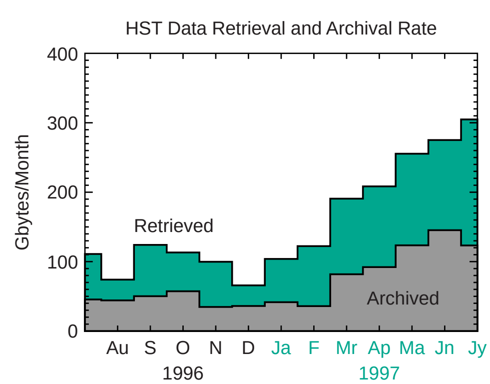


Figure 3. Demand for all HST data during the time between July 1996 and July 1997.

Top 40 HST Programs as Ordered by Number of Archival Requests

1. *5479: Sub-Arcsecond Structure in Nearby AGNS*

PI: Matthew Malkan
Proposal type: SNAP
Number of requests: 588

2. *5476: Continuum Snapshots of 3CR Radio Galaxies*

PI: William Sparks
Proposal type: SNAP
Number of requests: 341

3. *5369: HST Medium-Deep Survey: Cycle4Medium High Gal. Lat.*

PI: Richard Griffiths
Proposal type: GO
Number of requests: 241

4. *5397: Determination of the Extra-Galactic Distance Scale*

PI: Jeremy Mould
Proposal type: GO
Number of requests: 215

5. *2424: Quasar Absorption Line Survey: Cycle 1 Observations-FOS*

PI: John Bahcall
Proposal type: GO
Number of requests: 212

6. *5446: The Nuclei of Nearby S0 and Spiral Galaxies: A PC Snapshot Imaging Survey*

PI: Garth Illingworth
Proposal type: SNAP
Number of requests: 194

7. *5642: Observations of the Impact of Comet Shoemaker-Levy (1993E) and Jupiter*

PI: Alex Storrs
Proposal type: GO/DD
Number of requests: 171

8. *5370: HST Medium-Deep Survey: Cycle4Medium High Gal. Lat - CR-SPLIT*

PI: Richard Griffiths
Proposal type: GO
Number of requests: 164

9. *3791: Quasar Absorption Line Survey: Cycle 2 Observations*

PI: John Bahcall
Proposal type: GO
Number of requests: 155

10. *6253: Pure Parallel Archive Program*

PI: John MacKenty
Proposal type: GO
Number of requests: 151

11. *2578: The Inner Regions of Quasars: Cycle 1 Observations*

PI: Beverley Wills
Proposal type: GO
Number of requests: 145

12. *5378: Morphological Evolution of Galaxies in Clusters at z = 0.5*

PI: Alan Dressler
Proposal type: GO
Number of requests: 144

13. *5090: Large Area/Multicolor Survey - Cycle 4*

PI: Edward Groth III
Proposal type: GTO/OS
Number of requests: 129

14. *7729: NICMOS Short One Orbit Parallel*

PI: William Sparks
Proposal type: GO
Number of requests: 125

15. *5560: WFPC2 Cycle 4 CAL: Internal Monitor.1*

PI: Mark Clampin
Proposal type:
Number of requests: 124

16. *5091: GTO High Latitude Parallel Program - Cycle 4*

PI: Edward J. Groth
Proposal type: GTO/OS
Number of requests: 121

17. *7726: NICMOS One Orbit Parallel*

PI: William Sparks
Proposal type: GO
Number of requests: 118

18. *7701: NICMOS Short One Orbit Parallel*

PI: William Sparks
Proposal type: GO/NIC
Number of requests: 117

19. *5562: WF/PC2 Cycle 4 CAL: Internal Monitor 3: Darks*

PI: Mark Clampin
Proposal type: CAL/WFC
Number of requests: 109

20. *5512: Cores of Early-Type Galaxies, Part II*

PI: Sandra Faber
Proposal type: GO
Number of requests: 108

21. *5454: Ellipticals with K*

PI: Marijn Franx
Proposal type: GO
Number of requests: 106

22. *7676: NICMOS One Orbit Parallel*

PI: William Sparks
Proposal type: GO/NIC
Number of requests: 106

23. *4308: Snapshot Survey for Companions to Planetary-Nebula Nuclei*

PI: Howard Bond
Proposal type: SNAP
Number of requests: 99

24. *1036: Imaging and Spectrophotometry of Seyfert Nuclei (FOS 14)*

PI: Holland Ford
Proposal type: GTO/FOS
Number of requests: 94

25. *5419: A Search for Very Low-Luminosity Active Galactic Nuclei in Nearby Galaxies*

PI: Wallace Sargent
Proposal type: GO
Number of requests: 94

26. *7675: STIS Non-Scripted Parallel Archive Proposal*

PI: Stefi Baum
Proposal type: ENG/STIS
Number of requests: 91

27. *5236: Nuclei of Nearly Normal Galaxies (WC12)*

PI: James Westphal
Proposal type: GTO/WFC
Number of requests: 86

28. *5501: The Structure of the Coma Cluster: A Search for Cool, Absorbing Gas*

PI: Claudia Urry
Proposal type: GO
Number of requests: 81

29. *6184: WF/PC2 Cycle 5 Photometric CAL Monitor UV/OPT STD*

PI: Chris Burrows
Proposal type: CAL/WFC
Number of requests: 79

30. *5092: GTO Low Latitude Parallel Program*

PI: Edward J. Groth
Proposal type: GTO/OS
Number of requests: 75

Top 40 *continued*

31. *5441: The Inner Regions of Quasars*

PI: Beverley Wills
Proposal type: GO
Number of requests: 73

32. *5664: Quasar Absorption Line Survey*

PI: John Bahcall
Proposal type: GO/CAR
Number of requests: 73

33. *5351: Properties of Intermediate Redshift Galactic Disks Causing Damped LY-A*

PI: Jacqueline Bergeron
Proposal type: GO
Number of requests: 72

34. *5140: Observations of the Narrow Line Regions in Nearby Seyfert Galaxies*

PI: Ferdinando Macchetto
Proposal type: GTO/FOC
Number of requests: 71

35. *5563: WF/PC2 Cycle 4 Photometric CAL Monitor 1: UV/OPT STD.*

PI: Mark Clampin
Proposal type: CAL/WFC
Number of requests: 71

36. *6254: GTO Pure Parallel Program*

PI: Edward J. Groth
Proposal type: GTO
Number of requests: 70

37. *3698: A Snapshot Survey of the Nuclear Regions of 102 Markarian Galaxies II*

PI: John MacKenty
Proposal type: SNAP
Number of requests: 69

38. *5453: Deep WF Imaging of the Giant Luminous Arcs in CL0024+16*

PI: Edwin Turner
Proposal type: GO
Number of requests: 68

39. *5957: Snapshots of 3CR Radio Galaxies*

PI: William Sparks
Proposal type: SNAP
Number of requests: 67

40. *6337: The Hubble Deep Field*

PI: Bob Williams
Proposal type: GO/DD
Number of requests: 67

HST Archive *from page 17*

within 42 hours of observation. We have not broken this down by the different instruments, whose various pipelines may take (or have taken) more or less time to process data, particularly for the newest instruments shortly after the servicing mission. This plot illustrates how quickly you might expect to gain access to the science data after it has been taken by *HST*. To generate tapes, we must wait for other files, such as engineering and data quality files, which can arrive several days after the science data. This delay means that science data tapes can take up to a couple of weeks to arrive on your desk, while electronic retrieval avails you of your data as soon as possible.

We also compiled the retrieval times for complete requests, regardless of size, since the beginning of August (Figure 5). The retrieval time for a complete request is defined as the time interval between the receipt of the request, or list of datasets, by DADS and the completion of the request (i.e. DADS has finished sending the data to the specified destination, whether the anonymous ftp disk on archive.stsci.edu or the user's machine.) Since August 1, 50% of the requests have been completed within 105 minutes. This chart includes times when DADS was down for scheduled upgrades in hardware and software as well as times when the system was down for unscheduled maintenance. On average, DADS has been up and running between 97% and 99% of the time for the last several months, and running in "undegraded" mode (no aspects of DADS, including ingest and retrieval, are turned off or slowed down) between 85% of the time during a bad hardware month and 95 to 97% of the time normally.

We can potentially compile statistics on even more arcane archive questions, such as whether the "pouncers" we count in Figure 1 are the same people all of the time, or whether they're a mix of folks. If you have any suggestions for future small newsletter items, let us know!

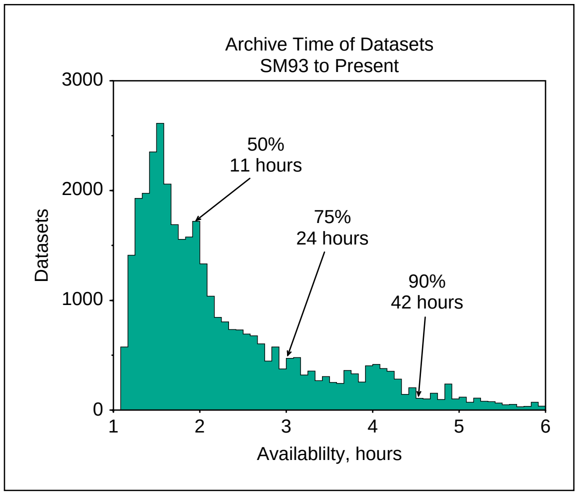


Figure 4. Time, in hours, after which an observation has been taken, when it is available for electronic retrieval from the archive. Data are available immediately after they are recorded to optical disk, but they must be downloaded from the telescope and processed through the calibration pipelines first. These times are for data taken since the servicing mission.

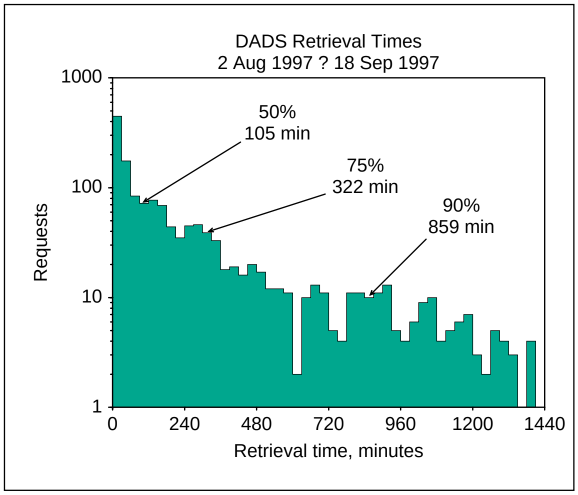


Figure 5. The time, in minutes, for the completion of a request to DADS, as measured between the receipt of the retrieval request and the completion of that request, as defined by the complete transfer of data either to the user's disk (in a NET transfer) or to the anonymous ftp site on archive.stsci.edu (in a HOST transfer.) These statistics were compiled for the interval since August 1, 1997 to mid-September 1997.

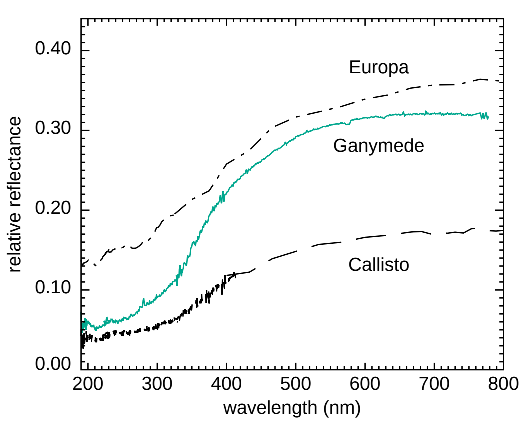
The Hidden Atmospheres of Icy Satellites

Keith Noll, STScI noll@stsci.edu

The *HST* has played a crucial role in the study of icy satellites in the solar system, a subject currently enjoying renewed attention as a result of the Galileo mission. However, the quiet evolution in our understanding of the tenuous atmospheres and unusual surfaces of these satellites began earlier.

Keith Noll

One of the first of the new discoveries made with *HST* was the detection of far-UV emission lines of atomic oxygen from Europa. Doyle Hall and colleagues were able to show that this emission was consistent with electron impact dissociation of molecular oxygen.



Spectra of Jupiter's three icy satellites, Europa, Ganymede, and Callisto from a variety of sources are shown. HST has allowed the extension of these spectra into the UV well beyond previous observations both in terms of wavelength coverage and in sensitivity. New discoveries made with HST include detection of SO2 in Callisto at 280 nm, O3 in Ganymede at 260 nm, and high S/N spectra of Europa's 280 nm feature for comparison with laboratory spectra. Many of these features show up as subtle differences between spectra of different hemispheres of these satellites whereby the high sensitivity of HST becomes crucial.

The molecular oxygen atmosphere needed to produce the observed line intensities was tenuous indeed with a surface pressure some 11 orders of magnitude less than at the surface of the Earth. Molecules in an atmosphere only slightly less dense would escape freely into space without collisions. This thin veil of molecular oxygen had been predicted by theoretical models of icy satellite surfaces; the match to the predicted surface pressure was nearly exact. Very recently, this same team has found a similar atmosphere around Ganymede.

At about the same time, however, another discovery was made by John Spencer, Wendy Calvin, and colleagues observing visible wavelength spectra of Ganymede. There they found two weak absorption bands of molecular oxygen. What made these features unusual was that these bands are normally seen only in condensed phases or very high pressure gas, far higher than could be present above the surface. Instead, they suggested, this gas was somehow trapped in the surface ice.

Meanwhile, my colleagues and I were engaged in the observation of UV spectra of all three of Jupiter's icy satellites, Europa, Ganymede, and Callisto. Taking advantage of the fact that all these satellites show micro-physical and compositional differences between their leading and trailing hemispheres caused by the asymmetric effects of charged particle and micrometeorite impacts, we were able to identify an additional absorber on Ganymede's trailing hemisphere with a peak absorption at 260 nm. Of products likely to be present in processed H_2O ice, only ozone, O_3, reproduces this spectral behavior. Like the O_2 bands, the O_3 absorption showed evidence of being in close proximity to a water-ice matrix. Because ozone is dissociated by the UV photons that produce this spectral feature, we could also conclude that ozone must be in proximity of molecular oxygen and must be in some kind of chemical equilibrium.

The most telling step came when we calculated the oxygen-ozone equilibrium using the well-established Chapman reaction sequence (that provides a quite accurate description of ozone in the Earth's atmosphere). This calculation showed beyond any doubt that both oxygen and ozone must exist in a high density, high pressure environment. Microscopic voids in the surface ice created by charged particle irradiation seem a natural possibility for these small aggregations of gas. If these small voids are similar to bubbles created in the metal walls of nuclear reactors, they could have dimensions of nanometers and contain up to 10^4 molecules. Experimental data for more closely matching conditions is, unfortunately, lacking.

Despite uncertainties about the details of how gas is trapped in Ganymede's surface ice, it is clear that this gas represents a major reservoir of volatile material. The column abundance of ozone alone is 10 times the column of O_2 in Ganymede's wispy atmosphere, while the buried O_2 in the upper few centimeters of ice outnumbers the atmosphere by 10^4 -10^5 times. One can rightfully conclude that Ganymede's real atmosphere lies buried in its icy surface!

Meanwhile, observations of Europa and Callisto showed not O_3, but SO_2 which absorbs in the UV at 280 nm. Very recent reports from the Galileo NIMS experiment as well as ground-based observations obtained by myself and colleagues confirm the UV

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Editor's Note:

Keith Noll is the 1996 recipient of the AURA science award, made each year to a scientist at STScI for outstanding research achievement. This article briefly summarizes some of the work he reported on in a recent colloquium at STScI at the time of this award

Tenure for Stefi Baum

Stefi Baum was recently promoted to Associate Astronomer with tenure at STScI. She is presently Group Lead for the Space Telescope Imaging Spectrograph (STIS). She has been associated with our STIS efforts since 1994, but came to STScI in 1991 as an Archive Scientist.

Stefi did not set out to become an astronomer, although she has always had a strong interest in science. She grew up in Princeton, New Jersey, where her father worked as a mathematician for the Institute for Defense Analysis (a part of the National Security Agency), and her mother taught history in middle school. She admits to not being in the top of her Radcliffe class, instead enjoying the opportunity to participate in soccer, squash, lacrosse, etc. She majored in physics and had ambitions at the time to become a doctor.

After graduating from Radcliffe she had made plans to go to Israel to teach high school chemistry but that fell through. After looking around Cambridge in 1980 she ended up at the Center for Astrophysics, working as a data analyst in the Einstein group, with Bill Forman and Christine Jones. She stayed there for nearly three years and was encouraged to do research as well as the direct support tasks. She was also encouraged to consider graduate school in astronomy and could see that these people she was working with were successful in their careers while starting families of their own.

An opening became available at the University of New Mexico, in Albuquerque, in January, 1983, and she then went on to a summer position at the Very Large Array that summer, with Jaqueline van Gorkom and Ron Ekers. That summer research assistantship proved to be a key event for her, in that she realized better what she wanted to do in astronomy. That led her to go to the University of Maryland at College Park, where she worked on her thesis with Tim Heckman (then at U MD) and Alan Bridle (NRAO) on a NRAO grad student fellowship at Charlottesville. In Albuquerque while contra dancing she also met Chris O'Dea, who is now her husband. She finished her Ph.D. in 1987, while seven months' pregnant with their first child, then started a post-doc at Dwingeloo, in the Netherlands. After three years there she came to Johns Hopkins as a Hubble Fellow, and then to STScI.


Stefi Baum

Stefi and Chris now have four children, ranging in age from 5 to 9 1/2. In the time she can call her own she likes to walk in the woods with the dog, and wishes she could get back to playing the piano.
After being asked which of her papers best showed her work, she suggested:

Long Slit Optical Spectroscopy of Emission Line Nebulae in Radio Galaxies: Interpretation, by S.A. Baum, T.M. Heckman, and W. Van Breugel (1992, ApJ, 389, 208)

HST and MERLIN Observations of 3C264 - A Laboratory for Jet Physics and Unified Schemes, by S.A. Baum et al. (1996, ApJ, 483, 178)

The Next May Symposium: Stellar Evolution

Mario Livio, STScI
mlivio@stsci.edu

The next STScI May Symposium will be on "Stellar Evolution," and will take place May 4 to 7, 1998. All aspects of stellar evolution, as partly revealed by *HST* observations, will be presented and discussed.
The deadline for registration is April 1, 1998. People interested in participating should contact Cheryl Schmidt at STScI by mail:

STScI
3700 San Martin Drive,
Baltimore, MD 21218, USA),

e-mail (schmidt@stsci.edu), or phone (410- 338-4404).

The registration fee is $150. More information can be obtained at http://www.stsci.edu/ftp/meetings/meetings.html.

Hidden Atmospheres *from page 20*

detection of SO2 by identifying an infrared band of this molecule at 4.05 um. The NIMS data also show evidence for widespread CO_2 on both Ganymede and Callisto. *HST* spectra obtained by us of two of Saturn's satellites, Rhea and Dione, show clear evidence of O_3 in their spectrum. We lack a complete understanding of why some surfaces end up with SO_2 and others with O_3, although the simplest hypothesis is that this is a function of the composition of the surfaces themselves. Whatever the explanation, it is clear that the process manufacturing oxygen in water ice surfaces irradiated by charged particles is widespread.

The existence of a non-biological mechanism such as this one that can produce significant quantities of oxygen and oxygen byproducts should be considered at least as a cautionary footnote as we set off to build missions like Gaia and the Planet Finder. An overly simplistic equation between the presence of ozone in a planet's spectrum and the presence of life does a disservice both to the intricacies of evolutionary biology and to the continually surprising complexity of the physical universe.

STScI's Summer Student Program

David Soderblom, STScI soderblom@stsci.edu

These smiling faces belong to some of the undergraduates who came to STScI this summer to participate in our Summer Student Program. Although similar to NSF-funded programs known as Research Experiences for Undergraduates, the STScI program is entirely supported with internal funds and by individual grant holders.

This year we had 15 students:

Student	*Home Institution*	*STScI Supervisor*
Todd Barto	Washington College	Todd Henry
Erin Chaney	College of Notre Dame of Maryland	Kailash Sahu
Aimee D'Onofrio	University of Michigan	Daniela Calzetti
Sally Goff	Albion College	Ron Allen
Jennifer Heldmann	Colgate University	Claus Leitherer
Rebecca Johnson	University of Texas, Austin	Ray Villard
Jessica Kim	Towson University	Anuradha Koratkar
Dale Kocevski	University of Michigan	Chris O'Dea and Harry Payne
Cissy Ng	Atholoton High School	Barry Lasker
Rhianna Riebau	Univ. Md. Baltimore County	David Soderblom
Tommaso Treu	University of Pisa	Massimo Stiavelli
Michael Westover	Caltech	Megan Donahue
James Wicker	University of South Florida	Trish Pengra
Qing Zhang	Johns Hopkins University	Mike Fall
Andrew Zirm	Johns Hopkins University	Bill Sparks

Anyone seeking information on our 1998 program should look at the STScI web page after January 1, 1998,
or contact soderblom@stsci.edu.

Graduate Studies at STScI

Rachel Gibbons, STScI
gibbons@stsci.edu

Graduate study at the Space Telescope Science Institute offers a unique opportunity to interact with a large number of astronomers who are involved in a wider range of research interests than is found among most university graduate programs. There are normally 15 to 20 PhD candidates at a time, each working closely with an STScI staff member, who acts as their primary advisor. But because STScI does not officially grant degrees, students remain in close contact with their home institution. One of the things that makes graduate life at STScI interesting is the fact that the large majority of students are not from the US, therefore we all learn a bit about how differently programs are run at institutes world-wide. Currently, we have students from Italy, Germany, India, China, the Netherlands, Australia, and the U.S. We also have the opportunity to interact with another large group of grad students, who are in the JHU program.

Biweekly we hold informal seminar sessions during which one or two of us present our work to the others, with no PhDs allowed unless invited personally by the speaker of the week. These sessions allow us to not only practice giving talks, but also to practice asking questions, which we might not otherwise feel comfortable doing in a more formal setting. This also provides a way to stay in tune with the other students, as all of us have finished our course work and therefore might not otherwise interact with each other scientifically.

Although ultimately each student must finish the thesis at their home institution, each views the stay at STScI as a valuable addition to their PhD program.

Science with the Next Generation Space Telescope: A Look into the Future for a Telescope that Probes the Past.

Peter Stockman, STScI, and Eric Smith, GSFC

The Next Generation Space Telescope (NGST) is the concept of a large aperture (~6 to 8 m diameter) passively-cooled space telescope optimized for cosmological studies in the near infrared (NIR, 1 to 5 microns). The origins of the NGST go back to several workshops held in 1989-1991 and the recommendations of the HST & Beyond Committee (Dressler 1995). Each of these groups highlighted the role that such a large aperture NIR telescope, limited only by the zodiacal background, could play in the era after SIRTF and near the end of the *HST* mission. This spring, April 7-9, the Goddard Space Flight Center (GSFC) and the STScI hosted the conference "Science with the NGST" at GSFC as the first step in shaping the potential scientific program for this facility.

Enlisted by Rob Kennicutt and John Mather, a pride of pundits described the state of our knowledge, and predicted how new facilities and the NGST would address many of today's major themes: the earliest formation of stars and galaxies, the cosmic history of heavy metal production, and the origins of stars and planetary systems capable of nurturing life. All of these themes have enjoyed major advances in the last five years and will continue to flourish to the start of the NGST mission, 2007, when over one dozen 8 to 10 m ground-based telescopes will be operating, and after SIRTF and MAP will have revealed entirely unexpected phenomena. With so many superb facilities already under development, the task of looking beyond their power was not easy. Even normally exuberant speakers could be excused some apprehension and timidity. But after considering the potential for orders-of-magnitude sensitivity improvements in the NIR and mid-infrared (MIR, 5 to 25 microns), they warmed to the task. Jerry Ostriker and Simon White convinced us that the state-of-the-art in modeling the early universe is in qualitative agreement with recent observations but is still several doubling times away from satisfactorily handling the formation of individual galaxies. Avi Loeb described the processes that led to the "end of the dark ages." Cooling by molecular hydrogen should trigger the earliest formation of stars at z ~ 15-30 in globular cluster-sized associations (the upper panel in Figure 1). If massive stars form in these groups at rates similar to those observed in local star-forming regions, their ultraviolet light at wavelengths above the Lyman limit would eventually permeate the universe and photo-dissociate most of the molecular hydrogen clouds (the middle panel). This destruction of the major low-temperature coolant will dramatically increase the critical Jeans Mass so that the next generation of stars must form in larger groups (M_{baryon} > 108 M_{solar}). The ultraviolet light from these stars will further warm the intergalactic medium and lead to a rapid phase change when the H II regions surrounding each large ground overlap and the neutral hydrogen "fog" is lifted (the lower panel). If, as several groups predict, these steps occur between redshifts of $5 < z < 30$, the NGST would be capable of seeing these first two generations of stars and tracing the reheating and reionization of the universe. Even mini-QSOs may be used as probes of these early conditions since baby black holes, M ~ 106 M_{solar} , are probably growing by accretion during this epoch.

Len Cowie, Richard Ellis and Mark Dickinson described how studies of faint galaxies in the HDF and other deep surveys appear to show the peak in star formation at redshifts of $z = 1$ to 2. These results are in qualitative agreement with simple "closed-box" models coupling star formation and metal enrichment as determined from Lyman-alpha forest observations. Maybe we have already seen the primary epoch of galaxy formation in these new data. However, Michael Rowan-Robinson warned that early results from ISO suggest that telescopes with MIR-capabilities may be needed to detect the reprocessed luminosity from significant amounts of star formation inside thick dust cocoons at intermediate redshifts, z ~ 1 to 2. Whatever the eventual verdict, Alan Dressler in his summary remarks compared this debate in terms of

continued page 24

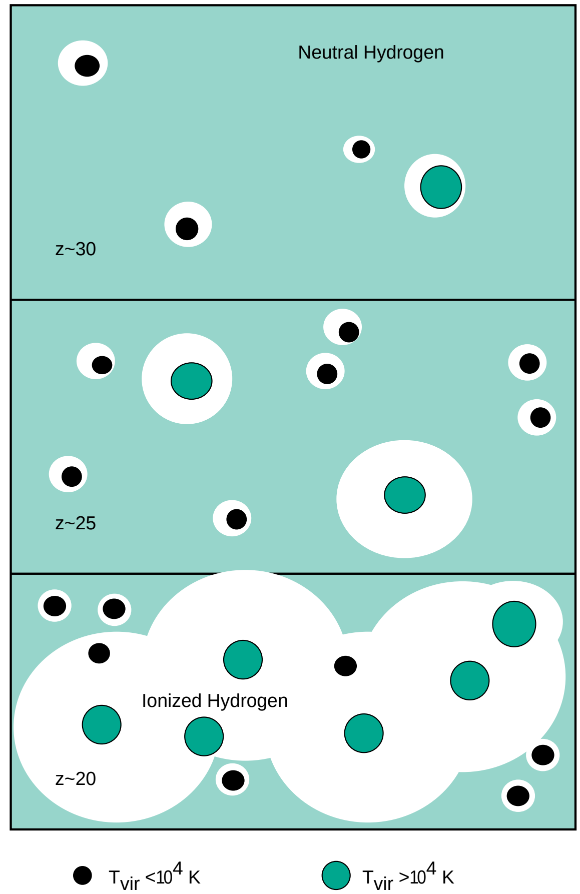

Figure 1: The stages of reheating and reionization of the universe from the first populations of massive stars. Based on work by Haimon & Loeb, ApJ, 476, 458, 1997.

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historians ignoring all events before 1900 as irrelevant because of the recent increases in global birthrates! Certainly we want to understand the origin of the almost primeval globular clusters and the metal-poor stars in the Milky Way and its neighbors. If MACHOS add appreciably to the mass of the Galaxy as suggested by microlensing surveys, the parent stellar population must have been born before redshifts of z ~ 4.

Several speakers described major advances that can be made closer to home in the areas of stellar populations in neighboring galaxies, the formation of low-mass stars in nearby stellar nurseries and young associations, and studies of nearby stellar remnants and our Solar Nebula. Steve Beckwith predicted that 30 to 1000 young, Jupiter-mass objects would be found in the Orion nebula, depending on the initial mass function. Figure 2 shows the sensitivity of NGST compared to other planned facilities for detecting these sources in Orion in one hour of integration. With this sensitivity, other, more distant star-forming regions and nearby young associations such as the Hyades could also be surveyed. T Tauri stars may be detected to distances of 6 Mpc. With an MIR capability, the NGST would be capable of resolving 100s of enshrouded, accreting proto-stellar disks in Orion and detecting these early phases of proto-stellar evolution anywhere within the Local Group. NGST can also study the fossils of early star formation, the remnants of stars made within the first billion years. Mike Rich pointed out that by extending imaging capabilities to visible wavelengths, the NGST could study the stellar populations of Virgo cluster galaxies by observing stars evolving along the horizontal branch. Jim Liebert described the fading embers of cool white dwarfs in the disk and halo, “stellar vermin” to those who are concerned about contamination of the deep samples of faint, nearly unresolved galaxies.

We have highlighted a few of the two dozen talks to exemplify the impact that NGST would have in astronomy. The proceedings of the conference will be published in the Astronomical Society of the Pacific Conference Series within six months. Those interested in technical aspects of NGST should request a copy of the recently published booklet, The Next Generation Space Telescope, Visiting a Time When Galaxies Were Young (you can send email to `momberger@stsci.edu`). NGST news, including opportunities to participate in scientific and technical studies, is available on the NGST Web site: `http://ngst.gsfc.nasa.gov/`

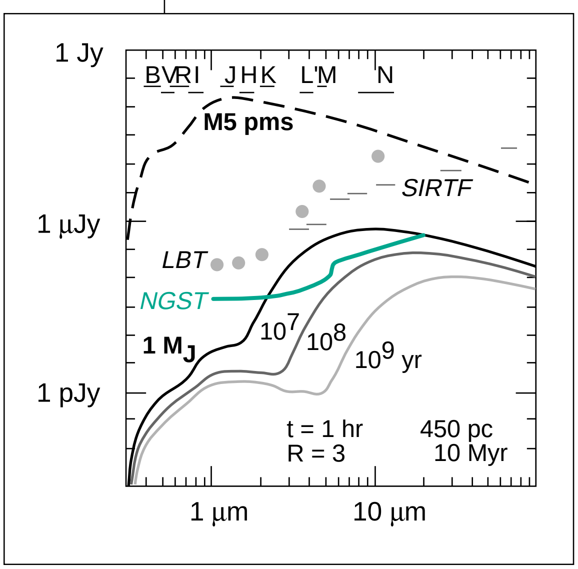


Figure 2: The predicted flux from young, planetary-mass objects in Orion. The spectra are from Saumon et al., ApJ, 460, 993, 1996. The sensitivities of different telescopes are given for a one hour exposure and a single, wide spectral band, *R* = 3.

NGST Ad Hoc Science Working Group Selected

Peter Stockman and John Mather

NASA has selected the members of the NGST Ad Hoc Science Working Group (ASWG) based upon 23 responses to the Request for Offer. The ASWG is responsible for defining the science mission of the NGST during this early phase of the study and for providing scientific assistance to the NGST Project Manager, Bernie Seery. We expect to add another half dozen scientists to the ASWG in the near future: representatives from Europe and the teams selected under the current procurement for science instrument concepts. The first meeting of the ASWG will be held on 22 October at the STScI and will deal with the organization and responsibilities of the group. Future meetings will be open and will announced on the NGST Web site: `http://ngst.gsfc.nasa.gov/`

John Mather
GSFC (Co-Chair)

Peter Stockman,
STScI (Co-Chair)

Mike Fall, STScI

John Gardner, GSFC

Don Hall, U. Hawaii

Avi Loeb, Harvard

Bob Kirshner, Harvard

Simon Lilly, U. Toronto

Bruce Margon, U. Washington

Mike Meyer, Steward Obs.

Marcia Rieke, Steward Obs.

Mike Rich, Columbia

Massimo Stiavelli, STScI

IUE Archive Support Moving to STScI

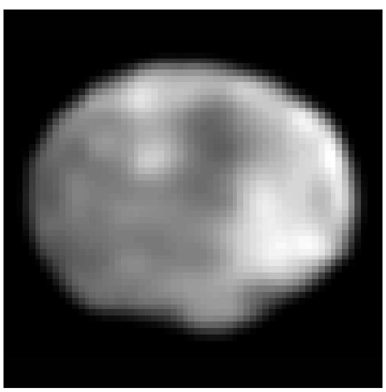
Bob Hanisch and Marc Postman, STScI hanisch@stsci.edu, postman@stsci.edu

Starting in mid-October, support for the International Ultraviolet Explorer (IUE) archive will be provided by the Space Telescope Science Institute. Following the advice of the IUE Users Committee, STScI, working jointly with GSFC Code 680 (Laboratory for Astronomy and Solar Physics), the IUE Project, and the National Space Science Data Center (NSSDC), developed a concept proposal for providing long-term support for the IUE archive in conjunction with the *HST* archive. This proposal was submitted to NASA-HQ earlier this summer. We have just received word from NASA-HQ of their intent to fund this effort. At this time arrangements are being made for the transfer of staff from the IUE Project to STScI to provide support for users of the IUE archive.

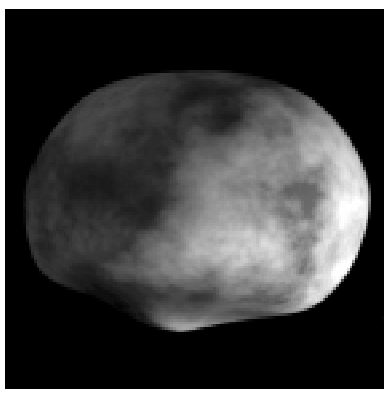
The primary activities for the IUE archive support group will include user support (answering questions and providing assistance with using the final archive data products and the IUE data analysis software), further organizing IUE documentation and converting much of the information into electronic form, and, in conjunction with the NSSDC, assuring the completion of the ingest of data from VILSPA, the European operations center for IUE, into the archive at NSSDC. We plan to make IUE data available through the same WWW and StarView interfaces used for data in the Hubble Data Archive, and to enable users to locate, examine, and retrieve data from both *HST* and IUE with a single query.

I'm sure there will be a few rough edges as we transition staff and user support functions from GSFC to STScI, and we ask for patience from users of IUE data during the first month or so of the changeover. We will endeavor to keep current contact addresses — e-mail and WWW links, for example — active, or with pointers to new locations at STScI.

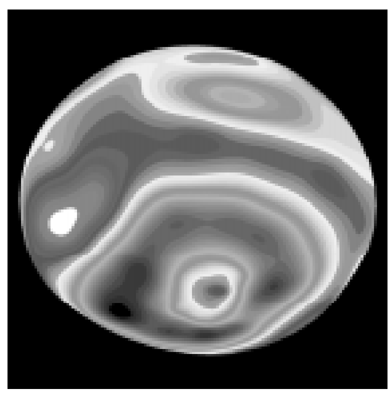
HST Recent Release: Hubble Reveals Huge Crater on the Surface of the Asteroid Vesta



A NASA Hubble Space Telescope image of the asteroid Vesta, taken in May 1996 when the asteroid was 110 million miles from Earth. The asymmetry of the asteroid and "nub" at the south pole is suggestive that it suffered a large impact event. The image was digitally restored to yield an effective scale of six miles per pixel (picture element).



A color-encoded elevation map of Vesta clearly shows the giant 285-mile diameter impact basin and "bull's-eye" central peak. The map was constructed from 78 Wide Field Planetary Camera 2 pictures. Surface topography was estimated by noting irregularities along the limb and at the terminator (day/night boundary) where shadows are enhanced by the low Sun angle.



A 3-D computer model of the asteroid Vesta synthesized from Hubble topographic data. The crater's 8-mile high central peak can clearly be seen near the pole. The surface texture on the model is artificial and is not representative of the true brightness variations on the asteroid. Elevation features have not been exaggerated.

The Institute Fellowship Program

Ron Allen, STScI rjallen@stsci.edu

With the cooperation of the *HST* Project Office at Goddard Space Flight Center, the Institute created a Postdoctoral Fellowship Program in the mid-1980s in order to enhance the research atmosphere and boost science staff morale after the Challenger disaster led to additional delays in launching *HST*. This program, and later its Hubble Fellow analog, stimulated the careers of some of the best young people in the field and created a pool of highly-qualified astronomers from which the Institute has greatly benefited in recruiting personnel.

Roeland van der Marel

In the wake of the round of budget-cutting which culminated in the staff reductions of July 1994, the IF program was discontinued in order to maintain operational capabilities. The last IF was Mark Dickinson, who has recently gone on to a Davis Fellowship at JHU.

The demise of the IF program has been lamented by many members of the science staff, and a proposal to re-create this program using internal research funds was adopted last year. The purpose remained much the same as before, namely, to offer the opportunity for exceptionally-gifted young researchers to devote their full energies to astronomy and astrophysics in the stimulating environment at STScI. Patterned after the highly-successful Hubble Fellow program, Institute Fellows have complete freedom to carry out a research program unencumbered by other functional duties for up to three years and, in addition, have at their disposal an annual research budget for travel, publications, and equipment expenses.

An announcement for the first Institute Fellowship was placed in Physics Today and in the AAS job register in the fall of 1996. This generated 220 applications, even exceeding the number of applicants for the Hubble Fellows Program of that year. This demonstrates not only that we have struck the right chord in creating this Fellowship, but also confirms that the Institute is widely considered to be one of the most stimulating environments to pursue an astronomical research career. After a rigorous selection process, Roeland van der Marel was picked to be the first STScI Fellow.

Roeland received undergraduate degrees in astronomy and mathematics from Leiden University in the Netherlands. He continued his PhD studies at the same institution, under the supervision of Professors Tim de Zeeuw and Marijn Franx. With them and several other collaborators, including James Binney, Roger Davies, Simon White and Hans-Walter Rix, he worked on a variety of topics related to the dynamics of galaxies. In 1994 this resulted in a thesis “Velocity Profiles and Dynamical Modeling of Galaxies,” for which the University awarded him its annual C.J. Kok Prize. The main emphasis in Roeland’s work was on the properties of the nuclei of galaxies, and on the possible presence and prevalence of black holes. Among other things, the ground-based observations of M87 in his thesis revealed rapid gas motions in the nucleus that could be ascribed to the gravitational influence of a black hole; this was subsequently confirmed by *HST* through the detection of the well-known gas disk.

After his thesis, Roeland accepted a Hubble Fellowship at the Institute for Advanced Study in Princeton to work on his proposed research project “Black Holes in Galactic Nuclei,” under the supervision of Professor John Bahcall. He obtained observations with the HST/FOS of various galaxies, and paid special attention to the case of M32. His observations of this galaxy provide the highest spatial resolution stellar-kinematical measurements obtained to date with the *HST*. Interpretation with state-of-the-art dynamical models shows that there must be a three-million-solar-mass dark object in the center of M32, contained within the central 0.3 parsec. The implied density leaves few other options except to infer that the object must be a black hole. The stellar motions in the nucleus of M32 are nicely illustrated by an animation that Roeland made on the basis of N-body simulations done on the Cray T3D of the Pittsburgh Supercomputing Center. This animation is available from `http://oposite.stsci.edu/pubinfo/mpeg/m32anim.mpg` or from Roeland’s home page, `http://sol.stsci.edu/~marel` which also describes his research interests in more detail.

At STScI, Roeland will continue his research on the structure and dynamics of galaxies. Among other things, he will use NICMOS in Cycle 7 to study the structure, density and brightness of a sample of merger-remnants. He is also involved in studies of the gas disks in NGC 7052 and IC 1459, in a study of the ultraluminous IRAS galaxy NGC 6240, and in a ground-based study of the dynamics of the stars in the nucleus of the dense globular cluster M15. Future plans include the construction of dynamical models to better interpret the ongoing microlensing observations towards the LMC, and observations and modeling of lensed quasars to study the structure of dark halos of intermediate redshift galaxies.

We have just advertised for the second Institute Fellowship; a copy of the advertisement is posted elsewhere in this Newsletter.

Postdoctoral Fellowship

Applications are invited for the 1997 INSTITUTE FELLOWSHIP, tenable at the STScI on the campus of the Johns Hopkins University in Baltimore. Fellowships provide support for up to 3 years with an annual stipend of at least $41,000 plus benefits. An annual allocation of approximately $11,000 for research travel and related costs is also available.

Institute Fellows will be chosen on the promise of their research program and the strength of their accomplishments in observational astronomy or theoretical astrophysics. No additional duties are required. Applicants must have a Ph.D. or equivalent degree by the date of appointment. There are no restrictions on citizenship.

Applications must include a signed cover letter, a curriculum vita, a list of publications, a summary of previous and current work (limited to 3 pages), and a description of the research program to be carried out at STScI (also limited to 3 pages). Applicants must arrange for three letters of reference to be sent directly to STScI.

Applicants for Institute Fellowships may also be considered as candidates for other, more project-oriented, postdoctoral positions available at STScI.

Applications may be sent to the Institute Postdoctoral Fellowship Committee, c/o Human Resources, at the address below. Applications received by 1997 December 15 will receive full consideration. Letters of reference also should arrive by December 15. Offers of appointments normally will be made by 1998 February 1.

Further questions may be directed to Ron Allen at the STScI Research Programs Office, 410-338-4574 (rjallen@stsci.edu).

Human Resources Office, Attn: Employment Officer

Space Telescope Science Institute
3700 San Martin Dr.
Baltimore, MD 21218

The Space Telescope Science Institute is operated by the Association of Universities for Research in Astronomy

EEO/AA/M/F/D/V

Calendar

Cycle 8:

Call for Proposals released	April 1, 1998, (tentative)
Phase I proposals due	June 1, 1998, (tentative)
Proposers notified	October 15, 1998, (tentative)

Cycle 9

Call for Proposals issued	May 1, 1999, (tentative)
Phase I proposals due	July 15, 1999, (tentative)
Proposers notified	October 15, 1999, (tentative)

Meetings and Symposia

Space Telescope Institute Council	November 6-7, 1997
Space Telescope Users Committee	November 24-25, 1997
STScI May Workshop	May 4-7, 1998

ST-ECF Newsletter

The Space Telescope — European Coordinating Facility publishes a quarterly newsletter which, although aimed principally at European Space Telescope users, contains articles of general interest to the HST community. If you wish to be included in the mailing list, please contact the editor and state your affiliation and specific involvement in the Space Telescope Project.

Robert Fosbury *(Editor)*
Space Telescope — European Coordinating Facility

Karl Schwarzschild Str. 2
D-85748 Garching bei München
Federal Republic of Germany

E-Mail: rfosbury@eso.org

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How to contact us:

First, we recommend trying our Web site: `http://www.stsci.edu` You will find there further information on many of the topics mentioned in this issue.

Second, if you need assistance on any matter send e-mail to `help@stsci.edu` or call 800-544-8125. International callers may use 1-410-338-1082.

Third, the following address is for the HST Data Archive: `archive@stsci.edu`

Fourth, if you are a current *HST* user you may wish to address questions to your Program Coordinator or Contact Scientist; their names are given in the letter of notification you received from the Director, or they may be found on the Presto Web page (`http://presto.stsci.edu/public/propinfo.html`)

Finally, you may wish to communicate with members of the Space Telescope Users Committee (STUC). They are:

Fred Walter (chair), SUNY Stony Brook, `fwalter@sbast1.ess.sunysb.edu`
John Bally, U. Colorado
John Clarke, U. Michigan
Alex Filippenko, U.C. Berkeley
Bob Fosbury, ESO
Marijn Franx, Kapteyn Astron. Inst.
Laura Kay, Barnard College
Regina Schulte-Ladbeck, U. Pittsburgh
Ted Snow, U. Colorado
Rodger Thompson, U. Arizona
John Trauger, JPL
Will van Breugel, Lawrence Livermore

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Design and layout: John Godfrey
Production Assistance: Pat Momberger and Trish Pengra

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STScI N-97-04