

# NEWSLETTER

Space Telescope Science Institute



## Eta Carinae: Early Results & STIS Techniques

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Image Credit: Nathan Smith and Jon Morse.

**S**cientifically, our Hubble Treasury project on Eta Carinae has provided new insights into this unique astrophysical phenomenon and produced a data archive of lasting value to several branches of astrophysics. From an instrument standpoint, the archive documents STIS (Space Telescope Imaging Spectrograph) characteristics, and our techniques for processing the data may be useful for *Hubble* users in general. Thus, the Eta Car team<sup>1</sup> hopes the community will find this note on our preliminary scientific findings and technical contributions both interesting and beneficial.

Our article in the spring 2002 *Newsletter* describes the scientific goals on Eta Car, which is the most accessible extremely massive and unstable star in the sky. It is the site of a 'supernova impostor' event 160 years ago, which produced the famous, bipolar 'Homunculus' nebula. Our focus is on the 'spectroscopic events' involving both the star and the inner nebula. These events occur once every 5.5 years, and one was predicted for mid-2003. During a spectroscopic event, Eta Car's wind is strangely disturbed. The spectrum changes abruptly and then recovers a few weeks or months later. A companion star with a 5.5-year orbit seems implicated, but its existence is not sufficient to explain the phenomena, which may also involve an instability near the Eddington Limit.

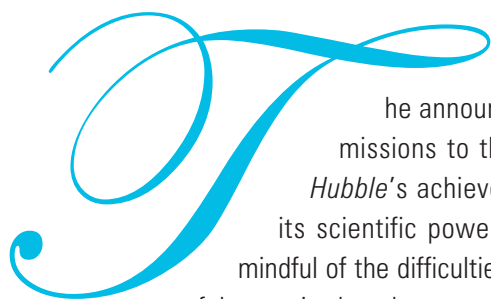
The spectroscopic event around 2003.5 did indeed occur—with some unexpected aspects. It was unlike the previous spectroscopic event, around 1998.0. For example, as shown in Fig.1, the hydrogen line profiles differed. Meanwhile, throughout 2003 and continuing, the star's apparent brightness has been increasing at such a rapid rate that, if it were to continue for just a few more years, it would appear as bright as it did in 1800, before the Great Eruption! (We do not really expect it to continue at that rate. J. Martin and M. Koppelman report on this development in the April 2004 *Astronomical Journal*.) This apparent brightening seems to be due to the destruction of circumstellar dust—but why? STIS observations found a comparable brightening during 1998, but otherwise nothing so dramatic appears in the star's record of the past 50 years. Perhaps the physical characteristics of Eta Car are currently changing, signaling a significant point in its recovery from the Great Eruption of the 19<sup>th</sup> century.

Our observing program obtained many new two-dimensional STIS spectra of Eta Car, extending from the ultraviolet to the near infrared. We have also incorporated earlier observations, from 1998 to 2002. In terms of complexity of spatial, spectral, and temporal detail, this may be the most extreme spectroscopic

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# Director's Perspective

Steven Beckwith, [svwb@stsci.edu](mailto:svwb@stsci.edu)



The announcement on January 16, 2004, that NASA would cancel all further servicing missions to the *Hubble Space Telescope* came as a shock to those who have followed *Hubble's* achievements, including millions of interested citizens. *Hubble* is at the height of its scientific powers, and it has been NASA's most productive mission for ten years. While mindful of the difficulties that the return to flight would bring to NASA, we in the *Hubble* community felt certain that the next servicing mission, SM4, was too important to the agency to be eliminated. We scientists were lulled by years of good fortune.

Mr. O'Keefe explained his decision as driven by a variety of factors—not a single reason—although he stressed astronaut safety as the primary concern. Nevertheless, a close examination of the costs to keep the shuttles flying suggests instead that the overriding difficulty is money to support an aging shuttle fleet. The Government Accounting Office recently reported that in absence of a new vehicle, NASA would have to rely on the current fleet of three shuttles for the next two decades to service the space station and carry out its other heavy-payload launches. The Columbia Accident Investigation Board recommended that NASA recertify the shuttle fleet by 2010 if it wants to continue flying shuttles thereafter, a process that will be enormously expensive, especially if it complies with all the Board's other recommendations. NASA chose to develop a new spacecraft rather than to maintain the aging shuttle fleet, which makes 2010 a hard deadline to complete all work requiring the shuttles.

NASA estimates that about 25 shuttle flights are needed to complete the space station, a requirement to fulfill international agreements. This means five flights per year for the next five years, assuming a return to flight in 2005. The flight schedule is so demanding that every non-station flight would put NASA at risk of missing the deadline to stop flying shuttles if the fleet is not recertified. Creating a new vehicle for human spaceflight while simultaneously completing construction of the station would require either new investments at a time of record-high federal deficits or the reduction or elimination of other NASA programs.

SM4 would be possible only if some constraint is relaxed.

Ironically, NASA's new vision involves redirecting its energies for human spaceflight from the station to the Moon and Mars. Because President Bush's budget gives NASA the expectation of only a 5% annual budget increase for the next five years, the agency will have to squeeze its other programs in any case to pay for the new development costs. Funding for the Explorer program has been delayed by one year, LISA and Constellation-X by one to two years, and the much-heralded

Einstein Probes have no budget in NASA's current plan. The agency will save several hundred million dollars by ending the *Hubble* mission early.

As a further irony, Administrator O'Keefe's refusal to risk a shuttle flight to *Hubble*, where the scientific and educational benefits are enormous, is in sharp contrast with his embrace of the huge risks to travel to the Moon and Mars, where the motivations are nebulous and the advantages unclear.

Public reaction to NASA's new course has not been favorable. Indeed, the outcry against the cancellation of SM4 has been overwhelming. Months after the announcement, newspapers around the world continue to carry editorials critical of the SM4 decision, including two in one week in the *New York Times*. We have received thousands of e-mail messages supporting a continuation of *Hubble's* mission, and petitions circulate asking NASA to reinstate SM4. Science is one of the most successful things NASA does, and *Hubble* leads all other missions in popularity.

Continued media attention has given *Hubble's* supporters a ray of hope that SM4 could still be reinstated. Congressman Mark Udall, D-Colorado, introduced a resolution to the House of Representatives, H. Res. 550, calling for an independent review of the decision to terminate *Hubble* early. Senators Barbara Mikulski and Sam Brownback introduced a similar resolution in the Senate, S. Res. 324. Congress recognizes the enormous benefit *Hubble* provides to the public, and they question the decision through these resolutions.

Scientists around the world continue to use *Hubble* to make great discoveries. We have two to four years left by our best estimates. *Hubble* is at the height of its powers, still capable of making crucial inroads on the most important problems in astronomy: the nature of dark energy, the structure of galaxies from the time of their formation, and the composition of extrasolar planets, to name just three.

It is premature to mourn the impending loss of *Hubble*, especially when we have so much more good work to do. [Ω](#)

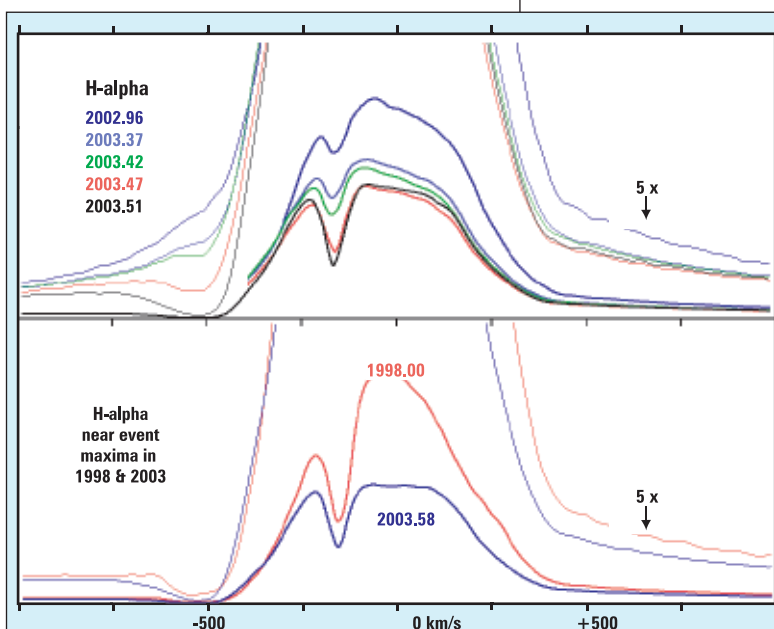
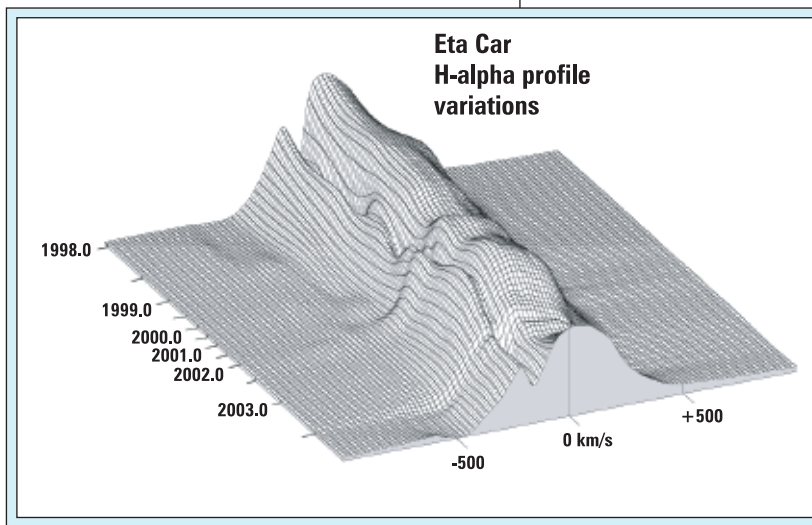
data set that *Hubble* will ever produce. We have barely begun to assess this vast and rich data set on Eta Car. Nevertheless, this is a good time to introduce our data-reduction techniques, which users may wish to apply to other STIS data, particularly where they desire the best possible spatial resolution.

So far we have concentrated on STIS/CCD/slit spectra, though the project also includes STIS/MAMA/echelle data. Initially, we have grappled with three problems:

- *Pixel trouble.* The 0.05-arcsec pixels of the STIS/CCD do not adequately sample the *Hubble* point-spread function at ultraviolet and visible wavelengths. The lack of sub-pixel modeling software to deal with this fact means that obtaining high spatial resolution has been difficult for most users. Sub-pixel modeling is essentially a form of interpolation, needed for correcting distortion, rectifying spectra, performing wavelength calibration, and extracting spectra. For example, if one uses standard software to obtain a high-spatial-resolution spectrum by extracting fewer than four STIS/CCD rows, the resulting fluxes are stricken with wavy, scalloped artifacts, and the effective spatial resolution for studying a faint object near a bright one is  $\sim 0.2$  arcsec, far worse than the basic optical quality of *Hubble* and STIS. ('Dithering,' the technique used to improve the sampling of *Hubble* images, is usually not feasible for spectroscopy, particularly in the direction of the dispersion.)

Based on mathematical reasoning and experiments, we have adopted a simple, unconventional, but effective interpolation procedure, which practically eliminates the scallop artifacts at a spatial resolution of 0.1 arcsec. For example, Fig. 2 compares a real stellar continuum obtained by three different methods: the standard pipeline processing, an improved version employed by the STIS instrument team, and our new procedure. Our procedure is quite different from textbook methods and can be applied to *Hubble* imaging. We will process all archival data on Eta Car with this technique.

- *Ghost trouble.* STIS spectral images contain various ghosts or reflections. Most injurious to spatial resolution is a satellite image adjoining the main spectrum image, the strength and position of which depend on wavelength. We have found a good analytic model for the underlying spatial point-spread function and measured the parameters of the model by fitting the data on various stars. If they desire, users can virtually eliminate the ghost using software implementing our model.




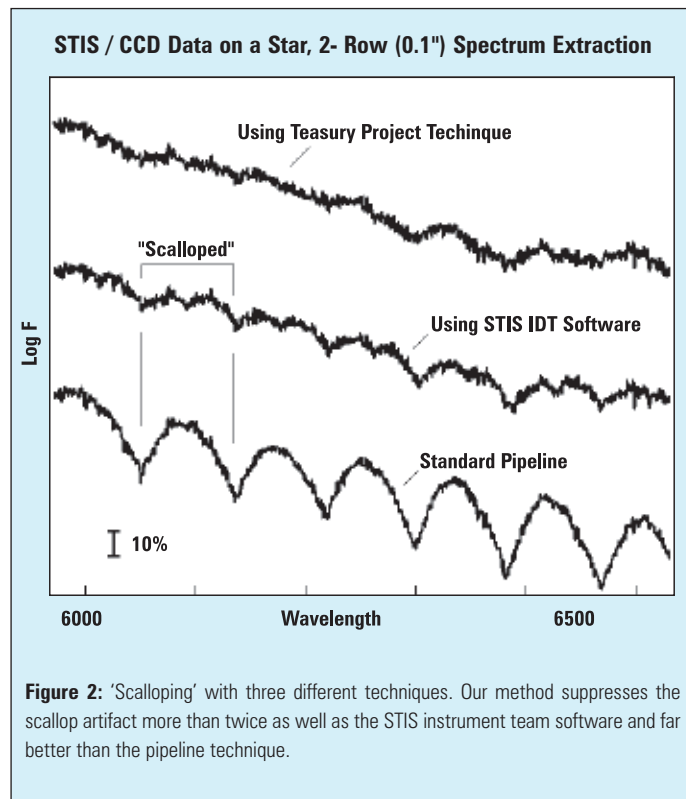
**Figure 1:** Eta Carinae's record-holding stellar wind produces tremendously strong hydrogen emission lines, whose Doppler-velocity structures vary during each spectroscopic event. During the 2003 event, they became strangely flat-topped—a clue to the structure of the outburst, and they were very different from the previous event, in 1997–98. This figure shows the H-alpha emission profile. (Reassurance for experienced observers: The flat-topped appearance was not caused by saturation of CCD pixels.)

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- *Focus-variation trouble.* One of our project goals is splicing together the STIS spectral images obtained with many different grating tilts, to create a unified 30,000 x 500 image for each observing epoch. One obstacle to this task is the variation of instrumental focus across the detector: for each grating tilt, the long-wavelength side is in better focus than the short-wavelength side. Therefore, two-dimensional splicing requires convolution with a position-dependent blur function. We have been assessing this intricate problem, and although full success is not yet assured, we hope ultimately to provide software for splicing STIS/CCD data taking focus variations into account.

Our Hubble Treasury data archive will be useful decades into the future, when both Eta Carinae and the instruments to observe it will have changed. To ensure the enduring utility of STIS observations of this object, we have developed a special database structure and metadatabase for queries by observation characteristics. Without these tools, it would be difficult for the user to find which data images were appropriate for a particular application. We have also developed convenient software for extracting and viewing spectra, as well as for other data-handling tasks.

The author would be happy to help users with special requirements related to STIS spectra, especially where spatial resolution is an issue. Current information on the Eta Car project, references to previous research, as well as documentation and software tools are available at <http://etacar.umn.edu>. 



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# News from the Multimission Archive at STScI (MAST)

Rachel Somerville, [somerville@stsci.edu](mailto:somerville@stsci.edu), on behalf of the MAST team

As of February 1, 2004, the *Hubble* archive contains 17.6 terabytes of data. The average ingest rate from November 2003 to January 2004 was 15.7 gigabytes per day, and the average retrieval rate during this period was 49.5 gigabytes per day. Since installation of version 10.2 of the DATA ARCHIVING AND DISTRIBUTION SYSTEM (DADS) software in early December 2003 (see below), median retrieval times have been around 2–4 hours—even during the busy *Hubble* and *Spitzer* proposal season.

## Upgrades are paying off

Over the past six months, we implemented major hardware upgrades, including a 32-terabyte EMC ‘spinning disk’ storage array and a multi-CPU SunFire 15K server. The SunFire server now hosts the latest version of the OPERATION PIPELINE UNIFIED SYSTEM (OPUS) software, as well as the DADS. These upgrades make data retrieval from MAST much faster, more reliable, and more convenient.

Because archive operators now have more control over the queue of retrieval requests, a large or problematic request can no longer create a bottleneck for all pending jobs.

DADS 10.2 offers several new options to users, and these have quickly become popular. For example, users can now request only files with certain extensions or request raw data only (by checking a button on StarView or on the web interface). An anonymous retrieval option is now available, which means that it is no longer necessary to have a MAST account in order to retrieve non-proprietary *Hubble* or *Far Ultraviolet Spectroscopic Explorer (FUSE)* data. (Just enter ‘anonymous’ as your archive username and your email as your password.) Also, users can now retrieve data with secure FTP (SFTP), either by staging the data and pulling it over to their home machine or by having the data automatically ‘pushed’ to their home machine. To use SFTP, users must be running an SSH daemon on their system that supports sshv2. (If not, the SFTP may time out frequently or the data transfer could be slow.)

We thank our users for their patience during the transition to the new system. We think all will agree that it has been well worth the wait!

## New FTP services at MAST

MAST now has a new FTP server. This Covalent Enterprise FTP Server is based on Apache and brings many of the capabilities of a web server to FTP.

The biggest change is that data staged from DADS is now protected. Previously, when a user had data staged, it was accessible to them—and everyone else—through anonymous FTP. Now, the data will be staged in a directory that only the user can see, by logging into the FTP server with the same archive username and password used to retrieve data from DADS. Other users will not be able to see the data. While users cannot store files in their directories, they can delete them after downloading, to eliminate clutter.

Besides offering more privacy for retrievals, these protected staging directories will allow us to stage proprietary data. This new feature will become available after the next release of DADS, and it will work for both *Hubble* and *FUSE* data.

We are also using the Covalent server to create areas for project teams to exchange data with each other—but not the world—in preparation for publishing the data. Once the data are ready for publication we can open the area up to the public, even while maintaining restricted areas for the project teams.

With such a flexible server at our disposal, we are looking at other possible ways to improve data transfer services in MAST and at the Institute in general. More information about the new server can be found on Covalent’s web site (<http://covalent.net>).

## New tools at MAST: VizieR Catalog Cross-Correlation and VOPlot

We invite users to explore the new MAST ‘search toolbox’ at [http://archive.stsci.edu/mast\\_search\\_toolbox.html](http://archive.stsci.edu/mast_search_toolbox.html). It contains several familiar tools, like the Scrapbook, Pointings Tables, Abstract Search, and Parallel search, as well as some new ones.

The new VizieR Catalog Search and Cross-Correlation tool allows MAST users to search the entire set of 4,000 VizieR catalogs and cross correlate the results with any MAST mission. This web-based search tool accesses one of the several VizieR catalog servers (e.g., at the Center for Astrophysics) as a web service and retrieves the search results in a machine-readable VOTable XML format.

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The user can use the VizieR search form (<http://archive.stsci.edu/vizier.php>) to search for a particular catalog, using catalog name, mission name, target name, wavelength range, author name, or keywords (as in the VizieR search based at the Centre de Données astronomiques de Strasbourg (CDS)). The user can select a catalog of interest from the returned list and then search within the catalog based on internal object parameters. The user can cross correlate the full catalog or the refined list of objects with any selected MAST mission. In the cross-correlation mode, the search tool retrieves ra and dec values for each found VizieR catalog entry and performs a cone search using a specified search radius. Because this process is repeated for each VizieR catalog entry and each selected MAST mission, execution times can become rather long for large requests.

A new JAVA-based graphical display tool called VOPlot can plot search results from any MAST mission or the VizieR catalog search (<http://vo.iucaa.ernet.in/~voi/voplot.htm>). This allows users to plot the search results from any numerical field returned in a search, as a histogram or as a scatter plot, against any other field. It can also display statistics on the results. VOPlot was developed as a part of the Virtual Observatory/India initiative, which involves Persistent Systems, the Inter-University Centre for Astronomy and Astrophysics, CDS, and the European Astronomical Virtual Observatory project.

#### **New additions to the Pointings Search Tool**

ACS and WFPC2 associations join STIS images, FOC, WFPC, and NICMOS as two new options in the powerful Pointings Search Tool.<sup>1</sup> You may now get information about sky regions or 'pointings' for ACS and WFPC2 associations which have been observed  $N$  times or more, observed with 2 or more filters, or have been observed more than twice with a time separation of more than (or less than)  $N$  days for both ACS and WFPC2 associations. This search tool can be found at <http://archive.stsci.edu/cgi-bin/point>.

#### **GALEX Early Release Observations now available at MAST**

In the last newsletter, we announced the availability of simulated *Galaxy Evolution Explorer* (GALEX) imaging and spectral data. On February 2, 2004, MAST opened its public website offering the real thing—the early release observations, which have been touted in the news. This opening came at the same time as NASA's announcement of Cycle 1 of the GALEX Guest Investigator Program. GALEX was launched on April 28, 2003, and is in the process of imaging the sky in two bands, in the near-UV (1350–1750 Å) and far-UV (1750–2800 Å). GALEX is also conducting spectroscopic surveys at low resolution over smaller regions of the sky of particular interest for galaxy evolution studies.

The MAST GALEX website (<http://galex.stsci.edu>) provides users with the capability of searching GALEX data in a variety of ways. For example, users can search on a region of the sky, a single object, or a class of objects using a familiar 'MAST-style' or 'SQL' form. They can use the latter to construct complex queries employing the full set of database parameters. The results page includes direct images in the two bands and 1- and 2-dimensional spectra. The direct images are 'active,' allowing users to click on an object neighboring the one initially selected. This action generates a new results page centered on the newly-selected object. As an aid to navigation, a tutorial is available. We encourage interested users to explore the data from this exciting and productive mission. In the near future, look for a cross-correlator tool, which will enable searches of data from GALEX and other survey missions using 'virtual observatory' (VOTable) data formats.

#### **MAST and the Virtual Observatory**

MAST is an important part of the emerging virtual observatory, and we are getting ready by implementing standards and protocols developed by the National Virtual Observatory (NVO) and the International Virtual Observatory Alliance (IVOA). For example, the MAST web interface can now access information from other sites and return search results in the VOTable format, a standard designed for astronomical applications, which allows any kind of tabular data to be encoded in a standard, machine-readable XML format. A growing number of web-based tools are compatible with VOTable standards and protocols. Among these are VOPlot and the VizieR search/cross-correlation tool, where we use the VOTable format to communicate with the VizieR catalog database.

We are making some of MAST's image data, particularly High Level Science Products (HLSP), available through the Simple Image Access Prototype (SIAP) specification. Similar to VOTable, SIAP is simply a standard for retrieving astronomical image data through a uniform interface. Both VOTable and SIAP files contain not only the actual data, but also any relevant metadata, such as the world coordinates and the filter bandpass. Soon, popular HLSP, such as the GOODS images and catalogs, will be available via VOTable and SIAP at MAST. [Ω](#)

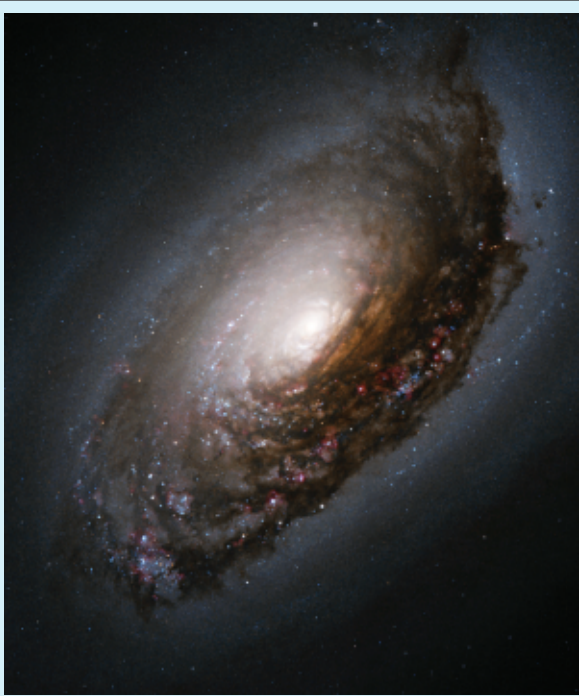
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<sup>1</sup> Advanced Camera for Surveys (ACS), Wide Field Planetary Camera 2 (WFPC2), Space Telescope Imaging Spectrograph (STIS), Faint Object Camera (FOC), WFPC (Wide Field & Planetary Camera), Near Infrared Camera and Multi-Object Spectrometer (NICMOS).

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# Wide Field & Planetary Camera 2 News

Roeland P. van der Marel, [marel@stsci.edu](mailto:marel@stsci.edu)



**Figure 1:** The 'Black Eye' or 'Evil Eye' galaxy, so called because of the spectacular dark band of absorbing dust in front of the bright nucleus. A collision has left the galaxy (better known as Messier 64) with this unusual appearance.


The Wide Field and Planetary Camera 2 (WFPC2) is still used for a subset of the *Hubble* science programs as well as for parallel observations. Expanding the large archive of *Hubble* imagery, WFPC2 continues to enable important scientific results.

Bill Keel and his team studied a galaxy that is being shredded apart as it plunges through the heart of a distant cluster of galaxies (see press release STScI-2004-02, available from <http://hubble.stsci.edu/newscenter/newsdesk/archive/>). The galaxy, 'C153,' is leaving behind a trail of gas 50 kiloparsec long as the cluster environment harasses it. In an unusually violent collision with ambient cluster gas, the galaxy is stripped down to its skeletal spiral arms, eviscerated of fresh hydrogen for making new stars. The galaxy has also been studied using the Very Large Array and the *Chandra X-ray Observatory*. The combined observations trace how stars, gas, and dust are being tossed around and torn from the fragile galaxy. C153 belongs to a cluster of galaxies that slammed into another cluster about 100 million years ago. This particular galaxy took the brunt of the beating, as it fell along a trajectory straight through the dense core of the other cluster. For this reason, it provides an unusual opportunity to study how the gas of a galaxy can be stripped away

when it flies through the hot cluster gas, shutting down star birth and transforming the galaxy.

WFPC2 has provided many beautiful views of the universe we live in. In the past few months, several teams released spectacular new images. The accompanying figure shows the galaxy M64 (press release STScI-2004-04). A collision of two galaxies has left the galaxy with an unusual appearance and produced bizarre internal motions. Due to a dark band of absorbing dust in front of the galaxy's bright nucleus it has been called the 'Black Eye' and 'Evil Eye' galaxy.

Other recently released images show the turbulent neighborhood of the eruptive star Eta Carinae (press release STScI-2003-31), the star-forming nebula NGC 604 (press release STScI-2003-30) and the nearby dwarf star-forming galaxy NGC 1569 (press release STScI-2004-06).

Our WFPC2 calibration work continues to focus primarily on routine monitoring and delivery of calibration reference files. Consult the WFPC2 web page at <http://www.stsci.edu/instruments/wfpc2/> for the latest information. We continue to welcome suggestions from the community for WFPC2 closeout calibration programs. For questions or suggestions, send email to the STScI Help Desk at [help@stsci.edu](mailto:help@stsci.edu). 

# Rodger Doxsey Honored with the 2004 George Van Biesbroeck Prize

Citing “his outstanding, unselfish dedication to making the *Hubble Space Telescope* one of the most scientifically productive telescopes of all time,” the American Astronomical Society (AAS) announced that Rodger Doxsey of the Space Telescope Science Institute will receive the 2004 George Van Biesbroeck Prize.

The prize “honors a living individual for long-term extraordinary or unselfish service to astronomy, often beyond the requirements of his or her paid position.” The announcement was made at the AAS winter meeting in Atlanta, Georgia. Doxsey is the second Institute scientist to win the award. The late Barry Lasker garnered the prize in 1999. The award is named for astronomer George Van Biesbroeck (1880–1974), who studied minor planets, comets, satellites, and double stars.

Doxsey, the head of the Institute’s Hubble Mission Office, said he was surprised at winning the award. So surprised, in fact, that he was vacationing in Sicily when an AAS official called him with the news.

“I appreciate the recognition of the astronomy community,” said Doxsey, who oversees *Hubble*’s science operations. “I really enjoy working with the group of people here that operate *Hubble*, with the engineers at NASA Goddard, and the scientists who use the telescope. There is an enormous group of people that makes *Hubble* work, and I am privileged to be part of that group, whose goal is getting the best science it can out of *Hubble*.”

In its citation, the Van Biesbroeck Prize committee credited Doxsey with helping to make *Hubble* a success. “The scientific success of the *Hubble Space Telescope* owes much to his personal efforts over the past 22 years, including operational developments, efficiency innovations such as the Snapshot Program, as well as the resolution of innumerable problems and emergencies.

His calm confidence and inspirational leadership over many long hours have earned him the respect and admiration of NASA space mission teams, as well as the gratitude of the international scientific community.”

Doxsey is one of the pioneers of the *Hubble* project. He arrived at the Institute in 1981, nine years before *Hubble* began looking at the heavens. Riccardo Giacconi, then the Institute director, and Institute astronomer Ethan Schreier recruited the young

astronomer to be the Institute’s Mission Operations Scientist. Doxsey was part of the science operations teams for the *SAS-3* and *HEAO-1 X-ray* space observatories. The science operations for those missions were at the Massachusetts Institute of Technology, where Doxsey earned a doctorate in physics.

“When I came here 22 years ago, there were only 15 or 20 people. The Institute was just getting started,” Doxsey said. “My experience with the X-ray satellites helped in understanding how science operations work. But *Hubble* was different because it had much grander goals. It had to have the support of the entire scientific community.”

But *Hubble* wasn’t destined for a smooth ride during its early years in space. Just after launch, scientists discovered that the telescope’s primary mirror was flawed. “When you launch any spacecraft there are always little things that you don’t expect,” Doxsey explained. “The mirror’s aberration was a big thing, though. NASA and the Institute were determined to figure out how to fix the problem. It was a very hectic time. In the meantime, we took the opportunity to learn a lot of lessons on how to run the telescope more efficiently. These lessons are still valuable for the telescope today.”




**“I am privileged to be part of that group, whose goal is getting the best science it can out of *Hubble*.”**

An important moment for Doxsey occurred during the first servicing mission in 1993, when astronauts installed the Wide Field Planetary Camera 2 (WFPC2), which helped fix the aberration. "The most exciting moment of my *Hubble* career came when we watched the first WFPC2 images come down from the telescope," Doxsey said. "They were wonderful."

Institute Director Steven Beckwith credits Doxsey with helping astronomers use *Hubble* to make important scientific discoveries. "We often say that Rodger is the only living person who really understands how the *Hubble Space Telescope* works. He has worked unselfishly for 22 years to make *Hubble* the greatest scientific facility in the world, and I am delighted that the AAS has rewarded him with the Van Biesbroeck prize, a most appropriate award to someone who has given his life to enabling others to do great science. The world owes him their gratitude."

Doxsey is currently working on another challenging problem: how to operate the telescope on only two gyroscopes. The telescope operates on three gyroscopes and has three in reserve. But with the next servicing mission uncertain, NASA is concerned that *Hubble* may have only two working gyroscopes before astronauts make another house call.

"Our goal is to make the telescope as scientifically productive as we can," Doxsey said. "There are always challenges with this job. After 22 years, the job has never gotten old or has never been routine. And any time I see a science result or a pretty picture, I get a lot of satisfaction knowing that I played a role in making that happen." 

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## JWST System Requirements Reviews and Deep Fields

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With *James Webb Space Telescope (JWST)* in the Phase B portion of its development, the *JWST* partners are refining the detailed design of the observatory and its science instruments. The first formal step in that process is establishing the system requirements. In November, two science instrument teams (NIRCam and MIRI) held their System Requirements Reviews (SRRs). In December, NASA held the SRR for the overall mission and observatory. Each review was preceded by a flurry of coordination meetings and document preparation. Such will continue throughout the remainder of this year until all major systems are covered and their requirements baselined. The Science and Operations Center (S&OC) will have its requirements review in October. The next milestone will be a similar set of Preliminary Design Reviews (PDR) in 2005 and 2006 before NASA approves the project to proceed into development.

### Instruments and instrument module requirement reviews

The *JWST* partners are solidifying the requirements for the science instruments and the Integrated Science Instrument Module (ISIM). They held system requirements reviews (SRRs) for the Near-Infrared Camera (NIRCam) and the Mid-Infrared Instrument (MIRI) in November 2003. The ISIM SRR took place in March 2004. The Fine Guidance Sensor (FGS) SRR was held in early April, and several sub-system reviews will follow.

The MIRI review board, comprised of representatives of the Goddard Space Flight Center (GSFC), Jet Propulsion Laboratory (JPL), and European Space Agency (ESA), identified the following issues:

- MIRI dewar mass/lifetime: For 5 years of life, the dewar must have a mass of 228 kg, which is 20 kg over its allocation. At the allocated mass, the lifetime is only 3.9 years. Also, cool-down during commissioning takes too long, about 100 days beyond the current milestone.
- Depth of focus: MIRI has a fixed pickoff mirror, and the design has a depth of focus of only 2 mm. The project has recently changed the requirement to 3 mm.
- Pupil alignment: MIRI can tolerate a misalignment of the telescope pupil only up to 2% of its diameter, which is a tighter specification than the ISIM module is currently expected to provide.

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The MIRI team met again with the review board in early March 2004 for a delta-SRR. Even though no final solution for these issues has yet been found, the review board approved the progress made and the approach taken by the team. The MIRI team is now moving toward a preliminary design.

The NIRCam review board approved the team's moving on with its preliminary design. Since NIRCam doesn't require a dewar and its design incorporates an articulated pick-off mirror, the major concerns affecting the MIRI review were not a factor. Nevertheless, NIRCam board members noted a number of issues:

- The NIRCam wavefront error exceeds its allocation (70 nm vs. 56 nm) across a broad range of wavelengths.
- Understanding of point-spread function variations across the field and of ghosts caused by the refractive optics should be improved.
- NIRCam exceeds its mass allocation by 7.7 kg (out of 140 kg).
- There is no independent validation and verification plan for procuring the detectors, as the vendor, Rockwell, is also doing the acceptance testing.
- There are general concerns about unsettled, higher-level requirements and the effects of their flow down to the NIRCam level.

### Mission and observatory SRR

On December 16 to 18, 2003, the GSFC hosted the mission and observatory SRR, linking Northrop Grumman Space Technologies (NGST) in California and the Institute by videoconference. Staff from NGST, Ball Aerospace, NASA, and the Institute presented an overview of the mission and spacecraft design and described how requirements have been allocated to the different subsystems in the observatory. The review board, chaired by Dennis Dillman, was composed of experienced NASA and ESA scientists and engineers with no direct ties to *JWST*. During the three days, the board commented on the presentations and volumes of supporting material and submitted formal requests for action. Some of these requests must be addressed promptly; others set conditions for passing the later Preliminary Design Review. Despite the volume of requests (49), the board deemed the SRR to be a success. This achievement permits the project to proceed with the next steps in the design and budget processes.

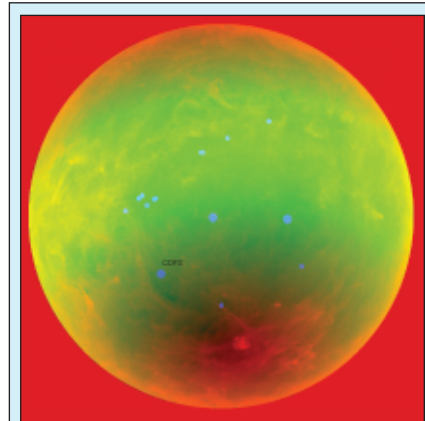
The overall scientific capabilities of the observatory remain the same as those defined by last year's 'replan,' described in the summer 2003 *Newsletter*. The project is currently examining the cost of the capability to observe Solar System targets beyond the orbit of Mars.

### *JWST* Deep Fields

The *JWST* Science Working Group and the operations team at the Institute have started to evaluate the implications of the present observatory design for the science operations of *JWST*.

Deep surveys to study first-light sources will be among the most demanding types of *JWST* observations. A combination of factors—such as low zodiacal background, low extinction and low cirrus, absence

of bright foreground sources, existence of complementary data from other observatories, and observability by *JWST*—will determine the target location of such surveys. Figure 1 gives the example of the south Galactic cap as an example of these considerations. We highlight the location of the Chandra Deep Field South (CDFS) because it is one of the best areas for deep surveys in the southern hemisphere. Extensive, multi-wavelength observations by *Chandra*, *XMM*, *Hubble* [including UDF (Ultra Deep Field), GOODS (Great Observatories Origins Deep Survey), and GEMS (Galaxy Evolution from Morphology and Spectral Energy Distributions)], and *Spitzer* have targeted the CDFS, and this field is ideally suited for ALMA observations. [Ω](#)



**Figure 1:** The south Galactic cap, a possible target for *JWST* deep fields. Existing surveys are shown, along with the distribution of Galactic dust (red) and the ecliptic latitude (green). Larger circles indicate surveys with lower background and contamination.

# Staffing at the Institute

Steven Beckwith, [svwb@stsci.edu](mailto:svwb@stsci.edu), & Rodger Doxsey, [doxsey@stsci.edu](mailto:doxsey@stsci.edu)

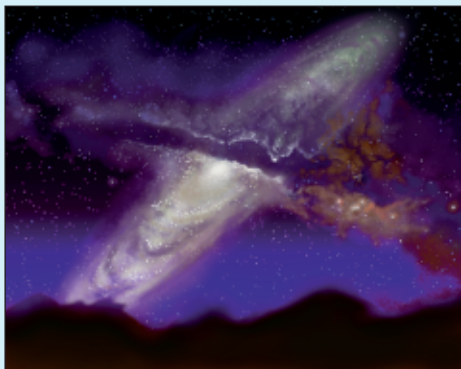
This summer, after a long period of stability, we will begin to reduce the number of people at the Institute dedicated to the *Hubble Space Telescope*. We have expected this change for several years, even before the January 16th announcement of no future *Hubble* servicing. Our work on preparations for Servicing Mission 4 was essentially complete prior to that announcement, with the exception of testing and calibration of COS and WFC3 and development of the detailed plan for Servicing Mission Orbital Verification. Future changes in *Hubble* servicing plans may further affect staffing levels, depending on *Hubble*'s lifetime. The upcoming reduction is in recognition that NASA will not support *Hubble* forever.

It will be painful to see some of our colleagues, long associated with *Hubble* and the Institute, depart for other opportunities. We will wish them well, and we will miss them. We are working now to ensure smooth transitions.

At the start of the government fiscal year 2005, on October 1, 2004, the *Hubble* effort at the Institute will support about 220 staff working directly on our *Hubble* contract, down about 10% from the present number. These staff members are employees of the Association of Universities for Research in Astronomy (AURA) and the Computer Sciences Corporation (CSC). This reduction will not be mitigated by an increase in people working on the *James Webb Space Telescope* (JWST), a project with a flat level of effort at STScI for the next year or two. We expect the JWST staff to grow slowly thereafter as we approach the scheduled 2011 launch.

While our *Hubble* users may be concerned about the level of support that we can provide with fewer people, we will maintain strong support for activities of high scientific value. We expect that our major user-oriented activities—scientific support, telescope scheduling, data calibration and archiving, and grants—will continue pretty much as before. We will maintain the level of support by improving our processes while reducing the resources required carrying them out. With the end of the *Hubble* mission in sight, there will be less need to continue modernization efforts for our operational systems. In particular, we will not need to upgrade these systems to support future *Hubble* instruments. Despite these adjustments, we intend to ensure that *Hubble* remains NASA's premier mission until the program comes to an end.

The Institute has additional staff working on other programs, including about 35 on JWST, 40 in the Office of Public Outreach, and others supporting a variety of smaller projects such as the Independent Detector Testing Laboratory, National Virtual Observatory, *Galaxy Evolution Explorer* (GALEX), *Kepler*, and the Multi-mission Archive at Space Telescope (MAST). We house 29 employees of Lockheed Martin and Honeywell Technology Solutions, who comprise the Hubble Flight Operations Team and their support, a group formerly located at the Goddard Space Flight Center. We host 15 employees of the European Space Agency, who work on *Hubble* at no cost to NASA. We also have a large number of postdocs and students, along with our supporting staff. All told, there are about 500 people at the Institute, half of whom are working directly on *Hubble*. The Institute, although smaller, will continue to be as vibrant, busy, and intellectually exciting as ever. [Ω](#)



## Cosmic Collision: The End of the Milky Way

The clock is counting down to an encounter that will change our galaxy forever. "Cosmic Collision: The End of the Milky Way," is an online show that explores the awe-inspiring power of galactic collision and reveals the fate of our home galaxy, racing toward its own showdown in space. The show is presented by HubbleSite, the official Web site of NASA's *Hubble Space Telescope*, and features many of the telescope's stunning images of this phenomenon.

Seen only on HubbleSite. Visit <http://hubblesite.org/go/collision> to view the free show.



# STIS Observations of the Flux Standard Vega

Ralph Bohlin, [bohlin@stsci.edu](mailto:bohlin@stsci.edu), and Ronald Gilliland, [gillil@stsci.edu](mailto:gillil@stsci.edu)

Some astronomical projects require knowing the absolute flux of very faint sources. For example, cosmologists studying the effects of dark energy on the expansion of the universe need to know absolute fluxes of supernovae at different redshifts in order to compare their relative fluxes in the rest frame. Astronomers calibrate stellar fluxes in absolute terms by comparing instrumental responses between stars in a chain of successively brighter standards until reaching the bright star Vega, which has been well studied and compared with laboratory standards. Recently, we used the Space Telescope Imaging Spectrograph (STIS) to recalibrate the absolute flux of Vega. Our results are included in the June 2004 *Astronomical Journal*. The data file of these fluxes is `alpha_lyr_stis_002.fits` at <http://www.stsci.edu/instruments/observatory/cdbs/calspec>, and the complete paper is available at <http://arxiv.org/abs/astro-ph/0403712>.

Our low-dispersion CCD spectrograms from STIS are 80-times overexposed, yet linear to  $\sim 0.1\%$ , because the excess signal simply bleeds along the CCD columns and is not lost.

The STIS flux calibration depends on models of three pure-hydrogen, white-dwarf stars. The models are normalized to the differences between the observed  $V$  magnitudes of the white dwarfs and Vega. (Bohlin 2000, Bohlin 2003).

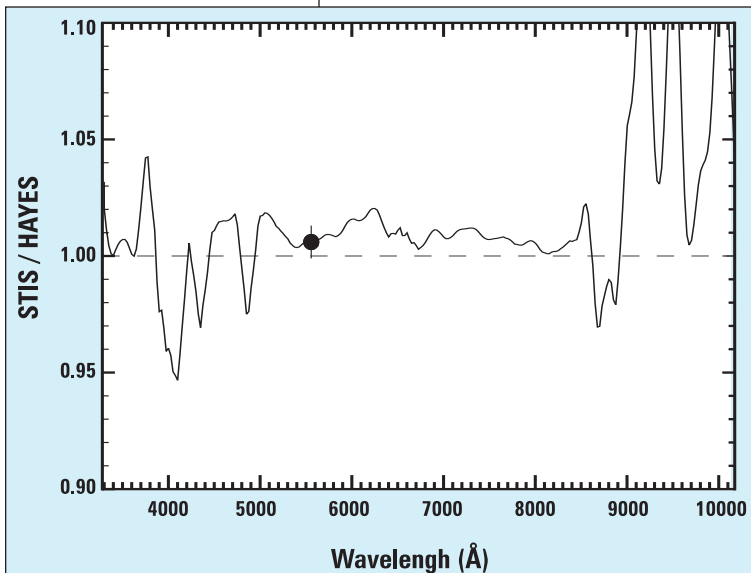
Fig. 1 illustrates the ratio of the STIS flux to the previously accepted flux of Vega, which came from the ground-based measurements of Hayes (1985). The ratio is fairly constant from 5000 to 8500  $\text{\AA}$ , which suggests that both sets of observations give the correct slope with an accuracy of  $< 1\%$  over this range. However, problems with the ground-based spectrum cause the structure in the regions of the Balmer and Paschen lines, which is demonstrated in Fig. 2 for the Paschen region. The STIS data agree with a specially tailored model for Vega (Kurucz 2003), and the differences with the ground-based results may be due to the limited precision of the Hayes composite flux distribution. The occasional 1–2% differences between the STIS results and the Kurucz model are due to

the limitations of the STIS de-fringing algorithm at these long wavelengths.

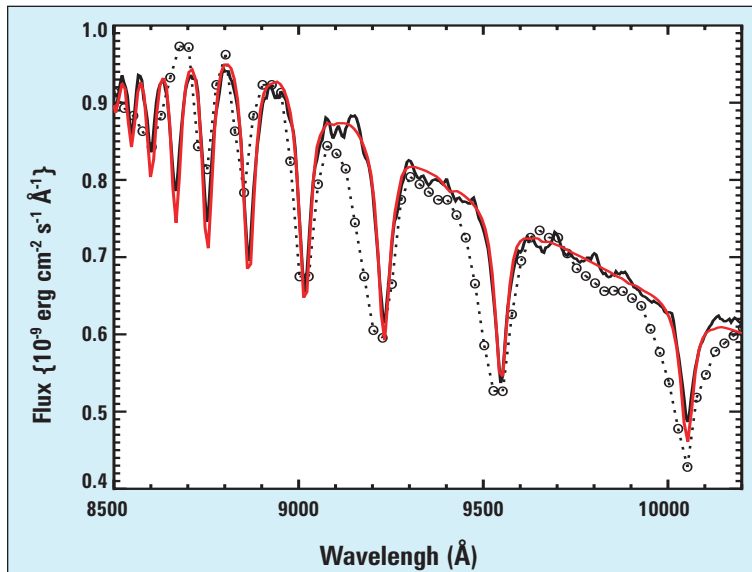
At wavelengths longer than 4200  $\text{\AA}$ , our final flux distribution for Vega is equal to the Kurucz model. From 1675 to 4200  $\text{\AA}$ , because of differences up to  $\sim 6\%$  with the model, the STIS data define our final spectrum. Below 1675  $\text{\AA}$ , archival *International Ultraviolet Explorer* observations complete the new flux distribution.

The normalization of the STIS absolute flux scale depends on the Landolt-Johnson  $V$  magnitude for Vega, which we refine to  $V = 0.026 \pm 0.008$ . The net effect of the new STIS observations of Vega is to reduce the absolute fluxes of the three white-dwarf standards—GD71, GD153, and G191B2B—by only 0.5%. In the infrared beyond the one-micron limit of the STIS data, the applicability of the Kurucz model to the real Vega is limited by the fact that the star is a rapid rotator, which is viewed pole-on and has a hot pole and cool equatorial region. Refinement of the fundamental absolute flux scale in the infrared awaits either the publication of composite models for Vega or future STIS observations of Sirius, which is a slow rotator, for which a single temperature model should permit extrapolation into the infrared of observations made in the visible wavelength range.

Writing the referee report for this paper was one of the last tasks of Bev Oke before he passed away. We acknowledge his valuable contribution to the final version of this work.  $\Omega$



**Figure 1:** Ratio of the final STIS flux for Vega to that of Hayes (1985). The revised monochromatic flux of Megessier (1995) at 5556  $\text{\AA}$  is shown as the filled circle.



**Figure 2:** The region of the hydrogen Paschen lines, where the Hayes (1985) spectrophotometry differs most from STIS and the Kurucz model. Solid line: final STIS flux; red line: Kurucz (2003)  $R = 500$  model scaled to  $3.46 \times 10^{-9} \text{ erg cm}^{-2} \text{ s}^{-1} \text{ \AA}^{-1}$  at  $5556 \text{ \AA}$ ; dotted line with open circles: Hayes fluxes adjusted by 1.006 and wavelengths converted to vacuum, to match STIS and the model. At these longest wavelengths of the STIS CCD data, the de-fringing technique leaves some residuals at the  $\sim 2\%$  level. The STIS data and  $R = 500$  model agree within the uncertainty of the de-fringing.

Bohlin, R. C. 2000, *AJ*, 120, 437

Bohlin, R. 2003, *2002 HST Calibration Workshop*, ed. S. Arribas, A. Koekemoer, and B. Whitmore, (Baltimore: STScI), p. 115

Bohlin, R. C., & Gilliland, R. L. 2004, *AJ*, in press

Hayes, D. S. 1985, in *Calibration of Fundamental Stellar Quantities, Proc. of IAU Symposium No. 111*, eds. D. S. Hayes, L. E. Pasinetti, A. G. Davis Philip, (Reidel, Dordrecht), p. 225

Kurucz, R. 2003, <http://kurucz.harvard.edu/>

Megessier, C. 1995, *A&A*, 296, 771



## The Lure of the Rings

**R**esembling a diamond-encrusted bracelet, a ring of brilliant blue star clusters wraps around the yellowish nucleus of what was once a normal spiral galaxy in this new image from NASA's *Hubble Space Telescope*. The sparkling blue ring is 150,000 light-years in diameter, making it larger than the Milky Way. The galaxy, cataloged as AM 0644-741, is a member of the class of so-called "ring galaxies." It lies 300 million light-years away in the direction of the southern constellation Dorado.

**Image Credit:** NASA, ESA, and The Hubble Heritage Team (AURA/STScI)

# HUBBLESITE flubbub

Comments pulled from the HubbleSite mailbag.



"Start a fund, we will donate. We need food, shelter, clothing – but we also need WONDER, ASTONISHMENT, HOPE – *Hubble* brings the entire world all of that and more." **-Bogota, Columbia**

"I am sad to see *Hubble* die ... The walk on the moon was child's play compared to the views of the universe *Hubble* has shown us." **-Anonymous**

"We are amazed and overwhelmed by the beauty of the pictures ... we pray the *Hubble* will live on ..." **-York, Pa.**

"My name is Kari Stausmire. I am a 5th grader at Starr Elementary School in Oregon, Ohio. We found out today (2-2-04) that in 2006 the *Hubble Space Telescope* would be shut down. Our school would like to donate money to keep the telescope up and working. If you could please help us by sending us some info ..." **-Oregon, Ohio**

"Why not put *Hubble* on e-bay before it goes down? It would be interesting to watch the bids ... Maybe someone could save it even?" **-Anonymous**

"Love the images from *Hubble*. Can't wait until we get images from your new telescope, I've been hearing about it!!! Keep up the great work!!" **-Anonymous**

"It's been a rough year, and I've had the *Hubble* photos on my computer saver screen so I can keep my problems in perspective. Please reconsider the decision to let *Hubble* go out early. It's certainly been my window to the universe!" **-Anonymous**

"The *Hubble* is America; it is one of the greatest symbols of America that I can see. It is the peaceful use of space technology to increase humanity's understanding of how we came to be and where we came from. Save the *Hubble*." **-Norman, Okla.**



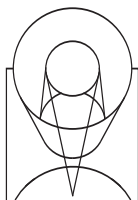
**W**ith more than a million visitors a month, HubbleSite.org is used to a steady stream of e-mail from the public. People take time to express admiration for the images, pose science questions, and offer their own theories about the cosmos.

Following the cancellation of Servicing Mission 4, the messages increased by the hundreds. Some were poignant, some outraged; some practical, some ... well, interesting. But all were united in their passionate defense of the telescope. Read on for some excerpts.

## Grains of Cosmic Sand

**W**hat appear as individual grains of sand on a beach in this image obtained with NASA's *Hubble Space Telescope* are actually myriads of stars embedded deep in the heart of the nearby galaxy NGC 300. *Hubble's* exquisite resolution enables it to see the stars as individual points of light, despite the fact that the galaxy is millions of light-years away.

**Image Credit:** NASA, ESA, and The Hubble Heritage Team (AURA/STScI)



## Contact STScI:

The Institute's website is: <http://www.stsci.edu>  
Assistance is available at [help@stsci.edu](mailto:help@stsci.edu) or 800-544-8125.  
International callers can use 1-410-338-1082.

For current Hubble users, program information is available at:  
<http://presto.stsci.edu/public/propinfo.html>

The current members of the Space Telescope Users Committee (STUC) are:

Debbie Elmegreen (chair), Vassar College, [elmegreen@vassar.edu](mailto:elmegreen@vassar.edu)

David Axon, RIT	C. Robert O'Dell, U. Vanderbilt
Martin Elvis, Harvard-Smithsonian	Regina Schulte-Ladbeck, U. Pittsburgh
Eric Emsellem, CRAL	Lisa Storrie-Lombardi, Caltech
Karen Meech, IfA	Monica Tosi, OAB
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To record a change of address or to request receipt of the Newsletter, please send a message to [address-change@stsci.edu](mailto:address-change@stsci.edu).



## ST-ECF Newsletter

**T**he Space Telescope - European Coordinating Facility publishes a 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.

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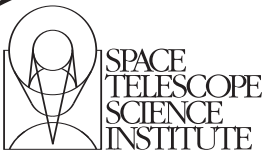
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# Calendar

NAS Committee for Assessment of Options for Extending  
the Life of the Hubble Space Telescope meeting, in DC area: ..... 1–2 June, 2004  
Webb Science Working Group meeting, in Boulder, CO: ..... 2–3 June 2004  
Space Telescope Institute Council meeting, in Paris: ..... 21–22 June, 2004  
Financial Review Committee meeting: ..... 23–25 June, 2004  
Cycle 13 commencement: ..... 1 July, 2004  
PIs notified of funding: ..... late July-early August 2004



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