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NEWSLETTER

Space Telescope Science Institute

NASA's *Hubble Space Telescope* has captured the first-ever picture of a group of five star-like images of a single distant quasar courtesy of *ESA, NASA,* K. Sharon *(Tel Aviv University)* and E. Ofek *(Caltech)*. **http://hubblesite.org/newscenter/newsdesk/archive/releases/2006/23**

Cycle 15

Proposal Review & Science Program

D. Macchetto, *macchetto@stsci.edu*, **B. Blacker**, *blacker@stsci.edu*, **C. Leitherer**, *leitherer@stsci.edu*, **N. Reid**, *inr@stsci.edu*, **E. Villaver**, *villaver@stsci.edu*, and **B. Williams**, *wms@stsci.edu*

The peer review of the Time Allocation Committee (TAC) defined the Cycle 15 science program for the *Hubble Space Telescope* at meetings in Baltimore from 20–24 March 2006. After evaluating all the proposals, the TAC recommended a total of 203 programs to the Director for awards of observing time or funding to support archival research. After review and approval by the Director—within ten days of the TAC meetings—the Principal Investigators (PIs) of successful programs were notified of their selection. The first observations of Cycle 15 should be executed in July 2006, only six months after the submission of the Phase 1 proposals.

Cycle 15 is the second cycle with no moderate- to high-resolution spectroscopy available on *Hubble* (the Space Telescope Imaging Spectrograph failed in 2004). Due in part to this limitation, the number of proposals submitted (733) remained below the number in Cycle 13 (949), but slightly above the number in Cycle 14 (727).

The two-gyro mode of operation, implemented at the beginning of Cycle 14, is performing excellently. Its success allowed a small increase in the number of orbits available in Cycle 15. While two-gyro mode has somewhat reduced efficiency and flexibility in scheduling, close cooperation between PIs and Institute staff have largely mitigated the impact on science.

In Cycle 15, the oversubscription ratio for General Observer programs is 4.52 in orbits and 3.9 in proposals. The oversubscription ratio for funding for Archival Research remains high at 3.3.

The size and disciplinary distributions of the proposals are similar to previous cycles (see accompanying tables and figures). A substantial fraction of Cycle 15 observations is devoted to extragalactic astronomy.

Due to increased familiarity and recent improvements in the software, proposers tell us they found the Astronomer's Proposal Tool (APT) easier to work with in Cycle 15.

Peer Review Process

The peer review process for Cycle 15 was basically the same as in recent cycles (see the summer 2004 *Newsletter*). At the suggestion of previous panelists and the Users Committee, we did make one change, which was to involve *all* panelists in the pre-meeting triage of proposals. This triage removes from consideration the bottom one-third of the proposals in each panel—unless any panelist objects in a specific case. Formerly, the triage was based solely on the evaluations of a proposal's primary and secondary reviewers. We received positive feedback on this change, even though it required considerably more time and effort on the part of panelists.

Continued page 4

Flagships of Science

Matt Mountain, *mmountain@stsci.edu*

Not since the times of Copernicus and Galileo have scientific discoveries so expanded our horizons, challenged basic physics, and invited everyone to reconsider their place in Nature. The flagships of NASA's space science program have carried us to this point, sailing until now before the wind of public generosity.

In these slackening times, we realize that success is not durable in itself, but demands thoughtful planning and sustained commitment to continued leadership. Therefore, we should reflect on the terms and conditions of leadership in science, and remind ourselves of its historical substance and value.

When I first came to this country 15 years ago, we had not seen water geysers anywhere in the Solar System besides Earth—yet recently NASA's *Cassini* spacecraft saw them on Enceledus, one of Saturn's moons. We did not know that Pluto has a system of moons, or that we had a tenth planet, Sedna, which is a twin of Pluto in size and probably one of many similar objects lurking in the Kuiper Belt. We had not yet found planets around other stars, and we certainly did not begin to know their properties—as we now have done with the *Hubble* and *Spitzer Space Telescopes*. We did not know that 20% of stars like the Sun have disks of planetary debris, signaling the presence of planets—probably including some planets like Earth. Back then, we believed in black holes, but did not know that *Hubble* would find them at the centers of nearly every large galaxy, or that *Chandra* would find them ubiquitous across the X-ray sky. We estimated that the universe was between 12 and 15 billion years old—and argued passionately about which end of that range was correct. Today, thanks to *Hubble* and the *Wilkinson Microwave Anisotropy Probe*, we know the universe is 13.7 $\pm$ 0.2 billion years old. In 1991, we did not know about dark energy, but now *Hubble* has told us that this ineffable entity makes up 70% of the universe.

Before these years of success, in 1962—I was still a child, but five centuries had passed since Copernicus moved the Earth from the center of the universe, and four centuries had elapsed since Galileo used the first astronomical telescope to discover Jupiter's planetary system—Lyman Spitzer wrote:

> "The detection of planets around other stars… is a matter of great philosophical and cultural as well as of scientific interest. Our view of man and his place in the universe naturally depends very much on whether planetary systems like our own are exceptional or whether they occur very frequently throughout the Galaxy. In fact, in many ways, the question of how frequently stars are accompanied by planets capable of supporting life is fully as important as the over-all structure of the universe, i.e., whether space is flat or curved."[1]

From these perspectives of decades, career spans, and centuries, we recognize the durability of great questions and noble goals in science. We see the human value of NASA's accomplishments. We see the benefits of steady hands, sustained leadership, and flagship programs that take years to develop and operate to full capacity.

When I travel around Europe and Japan, I find that our flagship programs define America's leadership in space science, not our ability to produce post-docs or to mount an average of one medium-class mission a year. The flagship missions tackle the biggest questions and cut the widest path into the unknown. What enthralls the world is this country's ability to take pictures of the moon Mimas silhouetted against the limb of Saturn, and to launch and service *Hubble*, which currently dominates NASA's scientific and public landscape. They see our leadership in our overcoming the immense technological challenges of building the huge, high-precision optics of *Chandra*, which provide an X-ray view of the sky comparable to *Hubble*'s in the optical. They see it is our ability to push cryogenic and detector technologies to the limits with *Spitzer*, to achieve completely new views into dusty regions of star formation and the planetary zones around stars.

Figure 1: Flagships of NASA's space science program. *Spitzer*, *Chandra*, *Hubble* and *Cassini* Space Telescopes.

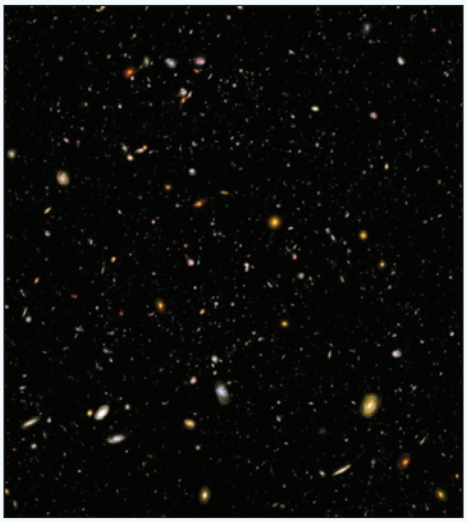

Figure 2: The Hubble Ultra Deep Field captured galaxies less than 700 millions years old.

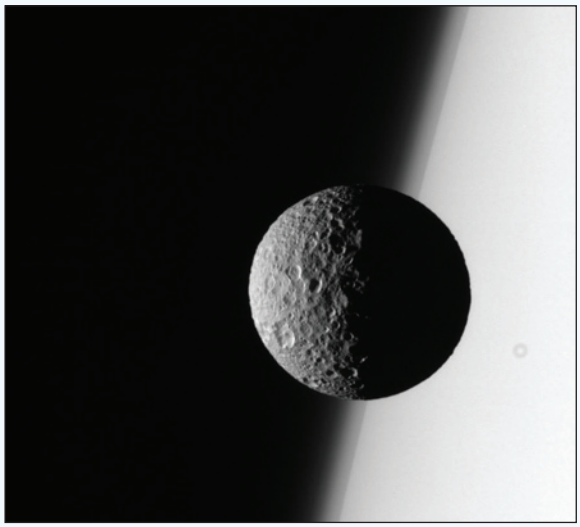

Figure 3: The moon Mimas, seen against Saturn's limb by the *Cassini* spacecraft.

This is why people like me come to this country—to be part of an enterprise that has the uncanny audacity, scientific courage, and technological prowess to thrive on the frontiers of science. We come to help launch a *Webb Space Telescope* with a deployable 6-meter telescope into L2 for investigating primordial galaxies. We come to help design a coronagraphic *Terrestrial Planet Finder* with a grasp of light and optical finesse adequate to study the habitability of Earth-like planets around nearby stars. These flagship endeavors truly define America's leadership in space science.

Why is leadership in science so important?

One answer is provided by the recent report—"Revealing the Hidden Nature of Space and Time"—of the National Research Council's Committee on Elementary Particle Physics in the 21st Century. The committee chairman is the former president of Princeton University—economist, not physicist—Harold Shapiro. Arguing that the next large accelerator should be built in the United States, the report states:

> "Leadership in science remains central to the economic and cultural vitality of the United States. To fuel the innovation economy of the 21st century, to maintain national security, and to produce the knowledge needed to ensure our wellbeing in the face of an uncertain and challenging world, the United States needs more than ever before to have a strong base of science and technology. A strong scientific enterprise attracts ambitious and talented students to science. It also makes the United States a desirable place for excellent scientists from abroad to pursue some of the most important challenges on the scientific frontier."[2]

Let us remind ourselves what the particle physics community seeks: not to build a grants program, nor to maintain moderate accelerators, but to build here, on American soil, the next flagship accelerator.

Any NASA decision to give up on a small number of flagship missions would not be merely a quotidian decision of economics and resource distribution. It would be a sea change—a strategic shift by a pioneering nation away from the grandest problems of science, at a time when we know they are within our reach. Ω

[1] Spitzer, L. Jr. 1962, *American Scientist*, 50, 473.

[2] National Research Council of the National Academies. Committee on Elementary Particle Physics in the 21st Century. *Revealing the Hidden Nature of Space and Time: Charting the Course for Elementary Particle Physics.* Washington, DC: The National Academies Press, 2006.

Cycle 15
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The Science Program

As in previous years, the Cycle 15 science program spans the gamut of astrophysical research—from the Solar System to the early universe. The following examples illustrate this variety.

The year 2007, which is the fiftieth anniversary of the International Geophysical Year, has been designated the International Heliophysical Year. A variety of Cycle 15 investigations will explore interactions between the Sun, planets, and the interstellar medium. For example, *Hubble* will monitor aurorae on Jupiter and Saturn at opposition. Furthermore, the jovian observations will coincide with *in situ* measurements of the solar wind by the *New Horizons* spacecraft as it swings by Jupiter on its way to Pluto.

Two large programs in Cycle 15 address the formation and evolution of spiral galaxies. One investigates the halo of M31 (Andromeda), which, according to conventional wisdom, should consist of ancient stars from the first major episode of star formation. In Cycle 11, M31 observations with the Advanced Camera for Surveys (ACS) revealed that the inner halo was, in fact, much younger than expected, but subsequent ground-based surveys discovered that, at 30 kpc from the nucleus, the stars transition from a bulge-like population to one that more closely resembles a canonical halo. The Cycle 15 program will measure the star formation history in the outer halo of M31, using the ACS to observe fields bracketing this 30-kpc transition point. The other program on spiral galaxies will investigate the nature and origin of the Milky Way's most enigmatic component, the thick disk. The ACS, the Near Infrared and Multi-Object Spectrometer (NICMOS) and the Wide Field and Planetary Camera 2 will be used for deep imaging of the extended disks in seven nearby, edge-on, spiral galaxies to measure their distributions of metallicity and density for comparison with the Milky Way.

Two *Hubble* Treasury programs were selected in Cycle 15. In one, the ACS will be used to conduct a survey of about 70 galaxies that lie within 3.5 Mpc and span a wide range of types. Combined with an extensive archive program, the ACS images will provide structural information on individual galaxies and offer insights into the history of star formation in a large volume, extending well beyond the Local Group. In the other Treasury program, the ACS will be used to produce high-resolution, multicolor images of several thousand galaxies in the Coma cluster, including numerous dwarf systems in a wide range of environments.

Through the complementary strategies of two programs devoted to refining the value of the *Hubble* constant (H_0), this signature quest of *Hubble* is taken up again in Cycle 15. The first investigation aims to directly link the distance scales of Type Ia supernovae (SNe) and Cepheid variable stars. NICMOS will be used to obtain near-infrared photometry of known Cepheids in six galaxies hosting Type Ia SNe. Parallel observations with the ACS will be used to identify new high-redshift supernovae. The second program on H_0 will search for Cepheids in two spiral galaxies in the outer Coma cluster, which should avoid the usual chain of secondary distance indicators and establish the far-field *Hubble* flow directly from primary indicators.

Future Cycles

We foresee no major changes in the TAC peer review process in future cycles. However, the capabilities of the telescope will change with time due to ageing equipment or the installation of new instruments—if another servicing mission is undertaken. We will advise the community of any changes affecting the submission of Phase 1 proposals.

We urge the community to take increased advantage of the combined power of *Chandra*, *Spitzer*, and *Hubble* for multi-mission, multi-spectral investigations. Recent meetings have highlighted the benefits. A *Chandra* workshop, held in July 2005 in Cambridge, MA, focused on star formation and the early stages of stellar evolution, and produced an insightful white paper. (Wolk, S. J. etal. 2006, PASP, 118, 939; **http://www.journals.uchicago.edu/PASP/journal/issues/v118n844/300051/300051.html**). In May 2006, the observatories jointly organized a meeting in Pasadena, CA, to promote synergistic investigations across the full range of astrophysical research. We hope these meetings will stimulate ideas for new research projects to take full advantage of the simultaneous operations of the three Great Observatories.

Defining the science program of the *Hubble Space Telescope* is one of the most important responsibilities of the Institute. The community's involvement in the TAC process is crucial to success. We are indebted to the many panelists who devote their time and energy to evaluating proposals and writing up the panel assessments and comments to be passed on to the PIs. We thank them all—especially the Cycle 15 TAC Chair, Dr. Rolf Kudritzki—for their thoughtfulness and diligence in determining the *Hubble* observing programs for the next year.

In briefing the Director on its recommendations, the TAC emphasized how impressed they were with the overall quality of the proposals for this cycle. TAC members who have served as panelists in previous cycles affirmed that the quality of the proposed observations for this cycle was as high as it has ever been in their experience, and that they are confident that head-turning discoveries will continue to flow abundantly from *Hubble* in Cycle 15. Ω

Cycle 15: TAC and Panel Members

Member	Institution
TAC Chair	
Rolf Kudritzki	University of Hawaii at Manoa
TAC At Large	
Piero Madau	University of California, Santa Cruz
Piet van der Kruit	Kapteyn Astronomical Institute
Extragalactic Panels	
Itziar Aretxaga	Instituto Nacional de Astrofísica, Óptica Y Electrónica
Dave Axon (Chair)	Rochester Institute of Technology
John Beckman	Instituto de Astrofísica de Canarias
Eric Bell	Max-Planck-Institut für Astronomie (MPIA)
Joel Bregman	University of Michigan
Brent Buckalew	Caltech/Jet Propulsion Laboratory
Annalisa Celotti	Scuola Internazionale Superiore di Studi Avanzati
Scott Chapman	California Institute of Technology
Jim Condon	National Radio Astronomy Observatory
Gianfranco De Zotti	INAF - Osservatorio Astronomico di Padova
Arjun Dey	National Optical Astronomy Observatory
Sara Ellison	University of Victoria
Eric Emsellem	Observatoire de Lyon
Mike Eracleous	The Pennsylvania State University
Dawn Erb	Harvard-Smithsonian Center for Astrophysics
Gary Ferland	University of Kentucky
Laura Ferrarese	Herzberg Institute of Astrophysics
Don Garnett	Steward Observatory
Karl Glazebrook	The Johns Hopkins University
Ann Hornschemeier	NASA/Goddard Space Flight Center
Jim Houck	Cornell University
Shardha Jogee	University of Texas, Austin
Bill Keel	University of Alabama
Jean-Paul Kneib	Observatoire Astronomique de Marseille
Chip Kobulnicky	University of Wyoming
David Koo	University of California, Santa Cruz
Paulina Lira	Universidad de Chile
Lori Lubin	University of California, Davis
Alessandro Marconi	INAF - Osservatorio Astrofisico di Arcetri
Paul Martini	Ohio State University
Francesca Matteucci	Università di Trieste
George Miley (Chair)	Leiden Observatory
Chris O'Dea	Rochester Institute of Technology
Ernesto Oliva	Instituto Nazionale di Astrofísica
Brad Peterson (Chair)	Ohio State University
Almundena Prieto	Max-Planck-Institut für Astronomie (MPIA)
Eliot Quataert	University of California, Berkeley
Piero Rosati	European Southern Observatory (ESO)
Renzo Sancisi	Osservatorio Astronomico di Bologna
Henrique Schmitt	Naval Research Laboratory
Joe Shields	Ohio University
Thaisa Storchi-Bergmann	Instituto de Física
Jean Surdej	Université de Liège
Harry Teplitz	Spitzer Science Center
Roger Thompson	Steward Observatory
Monica Tosi (Chair)	INAF - Osservatorio Astronomico di Bologna
Christy Tremonti	Steward Observatory
Tommaso Treu	University of California, Santa Barbara
Pieter van Dokkum	Yale University

Member	Institution
Galactic Panel Members	
Roberto Abraham (Chair)	University of Toronto
Taft Armandroff	National Optical Astronomy Observatory
Mary Barsony	San Francisco State University
Martin Barstow (Chair)	University of Leicester
Fritz Benedict	University of Texas
Adam Burgasser	MIT Kavli Inst. for Astrophysics and Space Research
Timothy C. Beers	Michigan State University
Patrizia Caraveo	INAF/IASF
John Carpenter	California Institute of Technology
Brian Chaboyer	Dartmouth College
Gille Chabrier	Ecole Normale Supérieure de Lyon
Rupali Chandar	The Johns Hopkins University
Pat Côté	Herzberg Institute of Astrophysics
Kelle Cruz	American Musuem of Natural History
Andrew Dolphin	Steward Observatory
Adam Frank	University of Rochester
Jon Fulbright	The Johns Hopkins University
Dave Golimowski	The Johns Hopkins University
Eva Grebel	Astronomical Institute
Nigel Hambly	Institute for Astronomy
Brad Hansen	University of California, Los Angeles
Margaret Hanson (Chair)	Xavier University
Suzanne Hawley (Chair)	University of Washington
M. Heydari-Malayeri	Observatorie de Paris
Jordi Isern	Institute for Space Study
Eric Jensen	Swarthmore College
Michael Jura	University of California, Los Angeles
Karen Kwitter	Williams College
Phil Lucas	University of Hertfordshire
Claudia Maraston	University of Oxford
Sergey Marchenko	Western Kentucky University
Jeff McClintock	Harvard-Smithsonian Center for Astrophysics
Dante Minniti	Steward Observatory
Patrick Morris	California Institute of Technology
Bob O'Dell (Chair)	Vanderbilt University
Manuel Peimbert	Instituto de Astronomia, UNAM
Seth Redfield	University of Texas
R. Michael Rich	University of California, Los Angeles
Abi Saha (Chair)	National Optical Astronomy Observatory
Rahavendra Sahai	Jet Propulsion Laboratory
Ravi Sankrit	The Johns Hopkins University
Harry Shipman	University of Delaware
Edward Sion	Villanova University
Nathan Smith	University of Colorado
Jonathan Williams	University of Hawaii
Erick Young	Steward Observatory
Dennis Zaritsky	Steward Observatory
Solar System Members	
Lotfi Benjaffel	Institut d'Astrophysique de Paris
Diana Blaney	Jet Propulsion Laboratory
Marc Buie	Lowell Observatory
Alan Fitzsimmons	Queens University Belfast
Denis Grodent	Université de Liège
Phil James	Space Science Institute
Phil Nicholson (Chair)	Cornell University
Larry Sromovsky	University of Wisconsin, Madison
Alex Storrs	Towson University
David Trilling	Steward Observatory

Proposals by Country

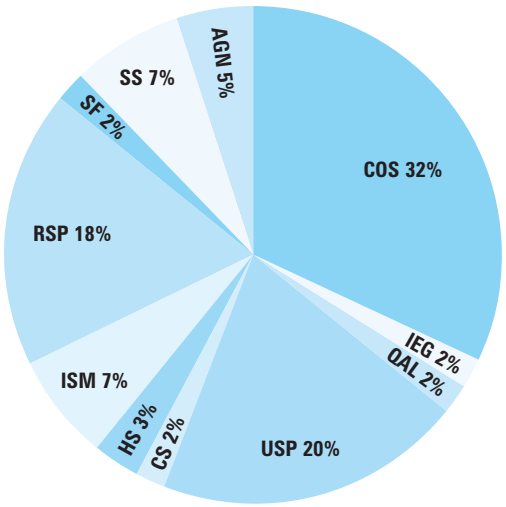
Country	Submitted	Approved
Argentina	1	0
Australia	2	0
Austria	1	0
Belgium	1	0
Brazil	2	0
Canada	11	3
Chile	5	1
Denmark	1	0
France	11	3
Germany	21	2
Italy	14	3
Japan	1	0
Korea	1	0
Mexico	1	0
Russia	1	0
Spain	8	0
Sweden	5	2
Switzerland	4	1
The Netherlands	10	2
UK	28	12
USA	604	174
ESA Proposals	113	27

Summary of Cycle 15 Results

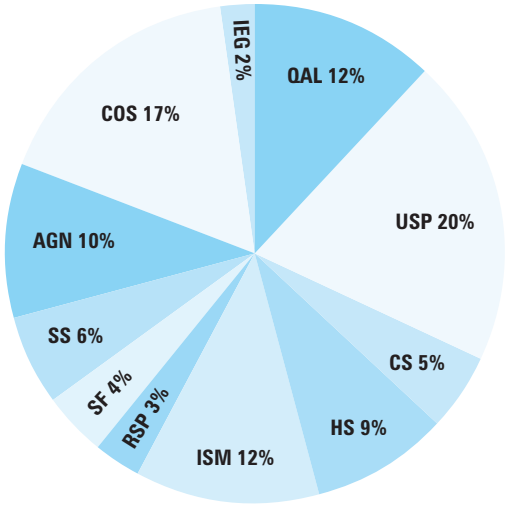
Proposals	Requested	Approved	% Accepted	ESA Accepted	ESA % Total
General Observer	522	135	25.9%	25	18.5%
Snapshot	53	11	20.8%	2	18.2%
Archival Research	113	42	37.2%		
AR Legacy	10	3	30.0%		
Theory	35	12	34.3%		
Total	733	203	27.7%	27	18.5%
Primary Orbits	**14581**	**3223***	**22.1%**	**484**	**15.0%**

*Does not include 9 calibration orbits

Orbits by Science Category



Proposals by Science Category



AGN: Active Galactic Nuclei
CS: Cool Stars
COS: Cosmology
HS: Hot Stars
IEG: ISM in External Galaxies
ISM: Interstellar Medium
QAL: Quasar Absorption Lines
RSP: Resolved Stellar Populations
SF: Star Formation
SS: Solar System
USP: Unresolved Stellar Populations

Instrument Statistics

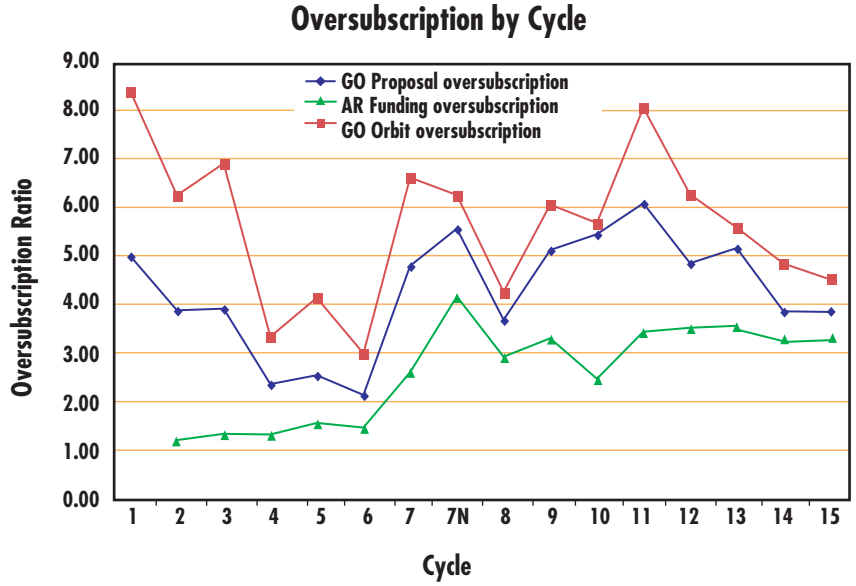
Instruments	Mode	Requested Orbits	%	Approved Orbits	%
ACS/HRC	Imaging	1813	9.2%	543	
ACS/HRC	Spectroscopy	111	0.6%	21	
ACS/SBC	Imaging	532	2.7%	273	
ACS/SBC	Spectroscopy	237	1.2%	66	55.1%
ACS/WFC	Imaging	9706	49.2%	2249	
ACS/WFC	Spectroscopy	64	0.3%	24	
FGS	POS	219	1.1%	49	
FGS	TRANS	29	0.1%	25	1.3%
NIC1	Imaging	459	2.3%	186	
NIC2	Imaging	2002	10.1%	727	24.2%
NIC3	Imaging	1995	10.1%	485	
NIC3	Spectroscopy	168	0.9%	48	
WFPC2	Imaging	2405	12.2%	1073	18.6%
Total Orbits[1]		**19740**		**5769**	
	Imaging[2]		**96.0%**		
	Spectroscopy[2]		**2.7%**		
	FGS[2]		**1.3%**		

[1] Includes Coordinated Parallels
[2] Excludes Pure Parallel and Snapshot programs

US Proposals by State

State	Submitted	Approved
AL	5	1
AZ	55	10
CA	123	45
CO	18	3
CT	6	2
DC	7	1
FL	4	1
GA	6	3
HI	15	5
IL	14	3
IN	7	4
KY	5	2
LA	3	2
MA	27	11
MD	120	33
MI	19	5
MN	8	4
MO	2	1
NE	1	0
NH	4	2
NJ	6	3
NM	9	0
NV	1	0
NY	32	4
OH	12	5
OR	3	0
PA	34	6
RI	1	0
SC	2	0
TN	6	2
TX	18	3
VA	10	5
WA	16	6
WI	4	2
WY	1	0

Proposal Acceptance Ratio



Name	Institution	Type	Title
AR-Legacy Programs			
Julianne Dalcanton	University of Washington	AR	Archive of Nearby Galaxies: Reduce, Reuse, Recycle (ANGRRR)
Dennis Zaritsky	University of Arizona	AR	Novel Analysis of Stellar Populations and Constraints on Galaxy Evolution
Rychard Bouwens	University of California, Santa Cruz	AR	Probing the Galaxy Population at $z \sim 7$–10 Using Archival ACS + NICMOS Data
Large Programs			
Thomas Brown	Space Telescope Science Institute	GO	The Formation History of Andromeda's Extended Metal-poor Halo
John Clarke	Boston University	GO	Comprehensive Auroral Imaging of Jupiter and Saturn during the International Heliophysical Year
Kem Cook	Lawrence Livermore National Laboratory	GO	A Cepheid Distance to the Coma Cluster
Roelof de Jong	Space Telescope Science Institute	GO	The Nature of the Halos and Thick Disks of Spiral Galaxies
Adam Riess	Space Telescope Science Institute	GO	SHOES—Supernovae, H_0, for the Equation of State of Dark Energy
Treasury Programs			
David Carter	Liverpool John Moores University	GO	An ACS Treasury Survey of the Coma Cluster of Galaxies
Julianne Dalcanton	University of Washington	GO	ACS Nearby Galaxy Survey
Extragalactic Programs			
John Blakeslee	Washington State University	GO	Calibration of ACS F814W Surface Brightness Fluctuations
Joel Bregman	University of Michigan	GO	The Masses for Ultraluminous X-ray Sources
Christopher Conselice	University of Nottingham	GO	The Role of Environment in the Formation of Dwarf Galaxies
Arjun Dey	National Optical Astronomy Observatories	GO	Morphologies of the Most Extreme High-redshift Mid-IR-luminous Galaxies
Charles Hoopes	The Johns Hopkins University	GO	High-resolution Imaging of Nearby Lyman Break Galaxy Analogs in the *GALEX* All-Sky Survey
Kelsey Johnson	The University of Virginia	GO	Probing the Birth of Super Star Clusters with NICMOS
Inger Jorgensen	Gemini Observatory, Northern Operations	GO	Galaxy Evolution during Half the Age of the Universe: ACS Imaging of Rich Galaxy Clusters
Claus Leitherer	Space Telescope Science Institute	AR	Anatomy of the Nuclear Starburst in M83 from Integral Field Spectroscopy
Jifeng Liu	Harvard University	AR	Searching the Optical Counterparts for Ultraluminous X-ray Sources
Jason Melbourne	University of California, Santa Cruz	AR	The Sites and Triggers of Star Formation in Large Disk Galaxies since $z = 1$
Goran Ostlin	Stockholm University	GO	The Nearest Luminous Blue Compact Galaxies: A Window on Galaxy Formation
Steinn Sigurdsson	The Pennsylvania State University	AR	Modeling the Transition from Pop III to Pop II Star Formation in the Early Universe
S. Stanford	University of California, Davis	GO	The Red Sequence at $1.3 < z < 1.4$ in Galaxy Clusters
David Thilker	The Johns Hopkins University	GO	Star Formation in Extended UV Disk (XUV-disk) Galaxies
Michele Trenti	Space Telescope Science Institute	AR	Dynamical Evolution of Galaxy Bulges: Harassment, Tidal Streams and Interactions with Globular Clusters
Gary Wegner	Dartmouth College	SNAP	The Dynamical Structure of Ellipticals in the Coma and Abell 262 Clusters
Nate Bastian	University College London (UCL)	GO	Luminosity Profiles of Extremely Massive Clusters in NGC 7252
Colin Borys	California Institute of Technology	GO	Morphology of a Most Spectactular *Spitzer*-selected Galaxy
Andrew Bunker	University of Exeter	GO	Stellar Populations in a $z = 4$ Lensed Galaxy with NICMOS
Jane Charlton	The Pennsylvania State University	GO	Modes of Star Formation and Nuclear Activity in an Early-Universe Laboratory
Hsiao-Wen Chen	University of Chicago	GO	Unveiling Starburst Morphology of Distant Damped Ly-alpha Galaxies Hosting Gamma-ray Bursts
Michael Corbin	Arizona State University	GO	Deep Imaging of Extremely Metal-poor Galaxies
Marc Davis	University of California, Berkeley	AR	Galaxy Environments and Evolution in the GOODS-N Field
Derek Fox	The Pennsylvania State University	GO	Afterglows and Environments of Short-Hard Gamma-ray Bursts
Kajal Ghosh	Universities Space Research Association	AR	Probing the Nature and Local Environments of Ultraluminous X-ray Sources
Timothy Heckman	The Johns Hopkins University	GO	The Largest Galaxies in the Local Universe: New Light on Disk Galaxy Formation?

Name	Institution	Type	Title
Bradford Holden	University of California, Santa Cruz	GO	The Formation Epoch of Early-type Galaxies: Constraints from the Fundamental Plane at $z = 1.3$
Paul Martini	The Ohio State University Research Foundation	GO	Secular Evolution at the End of the Hubble Sequence
Lucimara Martins	Space Telescope Science Institute	AR	A High Resolution Alpha-Enhanced Stellar Library for Evolutionary Population Synthesis
Robert O'Connell	The University of Virginia	GO	UV-Luminous Globular Clusters in NGC 1399
Russell Ryan	Arizona State University	AR	The Unresolved Stellar Populations of Galaxies in the HUDF: Constraints on Hierarchical Formation
Gregory Sivakoff	The University of Virginia	GO	Probing the Globular Cluster/Low Mass X-ray Binary Connection in Early-type Galaxies at Low X-ray Luminosities
Linda Smith	University College London	GO	M82 as a Fossil Starburst: Probing the Super Star Cluster Content of Region B
Rodger Thompson	University of Arizona	GO	Delayed Negative Feedback in the Super Star Clusters of SBS0335–052E
Yogesh Wadadekar	Space Telescope Science Institute	AR	Galaxy Bulges in Clusters: Formation and Evolution to $z \sim 1$
Andreas Zezas	Harvard-Smithsonian Center for Astrophysics	AR	Classification of X-ray Sources in M82
John Biretta	Space Telescope Science Institute	GO	*HST/Chandra* Monitoring of a Dramatic Flare in the M87 Jet
Adam Bolton	Harvard-Smithsonian Center for Astrophysics	GO	The Sloan Lens ACS Survey: Towards 100 New Strong Lenses
Marusa Bradac	Stanford University	AR	HAGGLeRS: *HST* Archive Galaxy-Galaxy Lensing at High Resolution with Simulations
Alan Dressler	Carnegie Institution of Washington	GO	Galaxy Properties in a Filament in Abell 851
Avishay Gal-Yam	California Institute of Technology	GO	A Survey for Supernovae in Massive High-Redshift Clusters
Jean-Paul Kneib	Observatoire de Marseille	SNAP	SL2S: The Strong Lensing Legacy Survey
Mark Lacy	California Institute of Technology	GO	Relating the Host Galaxies of Type-2 Quasars to Their Infrared Properties
Kyoung-Soo Lee	The Johns Hopkins University	AR	Constraining the Small-scale Clustering: Towards Better Understanding of Galaxy Light- and Dark-matter Connection
Richard Massey	California Institute of Technology	AR	Correcting Effects of Charge Transfer Inefficiency in the ACS Wide Field Camera
Ken-Ichi Nishikawa	University of Alabama in Huntsville	AR	Simulation Study of Diffusive Synchrotron Radiation from Hot Spots in Relativistic Jets such as M87
John O'Meara	Massachusetts Institute of Technology	SNAP	An ACS Prism Snapshot Survey for $z \sim 2$ Lyman Limit Systems
Marc Seigar	University of California, Irvine	AR	Central Mass Concentrations of Disk Galaxies: the Nuclear Spiral Connection
Alice Shapley	Princeton University	GO	Constraints on the Assembly and Dynamical Masses of $z \sim 2$ Galaxies
Isaac Shlosman	University of Kentucky	AR	The Obscuring Tori of AGN: Merging Disk Wind with Radiative Transfer
Nial Tanvir	University of Hertfordshire	GO	GRB Afterglows and Host Galaxies at Very High Redshifts
Harry Teplitz	California Institute of Technology	GO	Lyman Continuum Emission in Galaxies at $z = 1.2$
Liliya Williams	University of Minnesota, Twin Cities	AR	Mapping Out Substructure in Galaxy Clusters Using Strong Lensing
Lin Yan	California Institute of Technology	GO	NICMOS Imaging of the $z \sim 2$ *Spitzer* Spectroscopic Sample of Ultraluminous Infrared Galaxies
Farhad Yusef-Zadeh	Northwestern University	GO	Precise Measurements of Sgr A* Flare Activity
Wei Zheng	The Johns Hopkins University	GO	Search for Extremely Faint $z > 7$ Galaxy Population with Cosmic Lenses
Scott Anderson	University of Washington	GO	New Sightlines for the Study of Intergalactic Helium: A Dozen High Confidence, UV-Bright Quasars from SDSS/*GALEX*
Jack Baldwin	Michigan State University	AR	Hard Ionizing Photons at High Redshift—A New Method for Measuring the QSO Continuum Shape
David Bowen	Princeton University	GO	MgII Absorption Line Systems: Galaxy Halos or the Metal-Enriched IGM?
Romeel Dave	University of Arizona	AR	The Evolution of Metals in the Intergalactic Medium
Harald Ebeling	University of Hawaii	SNAP	A Snapshot Survey of the Most Massive Clusters of Galaxies
Harry Ferguson	Space Telescope Science Institute	AR	The Extragalactic Background, the Zodiacal Foreground, and the Integrated Light of Faint Galaxies
Patrik Jonsson	University of California, Santa Cruz	AR	Quantifying Observed Timescales in Galaxy Mergers Using Simulations
Leon Koopmans	Kapteyn Astronomical Institute	GO	Dark Halos and Substructure from Arcs and Einstein Rings
Matthew Malkan	University of California, Los Angeles	GO	Identifying $z > 7$ Galaxies from *J*-dropouts
Leonidas Moustakas	Jet Propulsion Laboratory	GO	A New Wide-separation Einstein Cross at $z = 2.7$
Henrique Schmitt	Naval Research Laboratory	SNAP	The Host Galaxies of QSO2s: AGN Feeding and Evolution at High Luminosities
Graham Smith	University of Birmingham	SNAP	The Ultimate Gravitational Lensing Survey of Cluster Mass and Substructure
John Stocke	University of Colorado at Boulder	GO	Imaging the Nearest Damped Lyman-alpha Absorbers
R. Tully	University of Hawaii	GO	The Dynamic State of the Dwarf Galaxy Rich Canes Venatici I Region
Pieter van Dokkum	Yale University	GO	The Nature of "Dry" Mergers in the nearby Universe
Sylvain Veilleux	University of Maryland	GO	The Fundamental Plane of Massive Gas-rich Mergers: II. The QUEST QSOs
Mark Whittle	The University of Virginia	GO	The Radio-quiet Jet Flow in Markarian 34
Jong-Hak Woo	University of California, Santa Barbara	AR	Testing the Coevolution of Black Holes and Massive Host galaxies to $z = 1.5$
Dan Batcheldor	Rochester Institute of Technology	AR	Resolving the Critical Ambiguities of the M-Sigma Relation
Dan Batcheldor	Rochester Institute of Technology	GO	The NICMOS Polarimetric Calibration

Name	Institution	Type	Title
Edo Berger	Carnegie Institution of Washington	GO	Gotcha! Using Swift GRBs to Pinpoint the Highest Redshift Galaxies
Gabriela Canalizo	University of California, Riverside	AR	Are Classical QSO Host Galaxies Bona Fide Elliptical Galaxies?
Matthias Dietrich	The Ohio State University Research Foundation	GO	Quasars at Redshift $z = 6$ and Early Star Formation History
Gary Ferland	University of Kentucky	AR	Understanding *HST* observations of IGM and ISM clouds
David Finley	Eureka Scientific Inc.	AR	Absolute Spectrophotometric Calibration to 1% from the FUV through the Near-IR
Wendy Freedman	Carnegie Institution of Washington	GO	Reducing Systematic Errors on the Hubble Constant: Metallicity Calibration of the Cepheid PL Relation
Peter Garnavich	University of Notre Dame	GO	Sweeping Away the Dust: Reliable Dark Energy with an Infrared Hubble Diagram
Michael Gladders	Carnegie Institution of Washington	GO	The Halo Structure of RCS2–2327.4–0204
Anthony Gonzalez	University of Florida	GO	Magnifying the High-z Universe with the Bullet Cluster 1E0657–56
Knud Jahnke	Max-Planck-Institut für Astronomie, Heidelberg	GO	HE0450–2958: Lonesome Black Hole, Scantly Dressed Quasar or Massively Dust-Obscured Host Galaxy?
Gerard Kriss	Space Telescope Science Institute	GO	Imaging Polarimetry of the Seyfert 1 MCG–6-30–15: Clues to the Structure of Warm Absorbers
Neal Miller	Associated Universities, Inc.	GO	J170902+641728: ACS Imaging of an Unusual Compact Object
Chien Peng	Space Telescope Science Institute	AR	An Accurate Determination of the Black Hole Mass vs. Bulge Luminosity Relation for Nearby AGNs
Bradley Peterson	The Ohio State University Research Foundation	GO	Host Galaxies of Reverberation Mapped AGNs
Jesper Sollerman	Stockholm University	GO	Are (Some) Short Gamma-ray Bursts Associated with Young Progenitors?
William Sparks	Space Telescope Science Institute	SNAP	Emission Line Snapshots of 3CR Radio Galaxies
John Tonry	University of Hawaii	AR	Revisiting the Supernova Ia Rate at $z > 1$
Pieter van Dokkum	Yale University	GO	Morphologies of Spectroscopically Confirmed "Red and Dead" Galaxies at $z \sim 2.5$
Galactic Programs			
Alessandra Aloisi	Space Telescope Science Institute - ESA	GO	Deep Photometry of NGC 1569: Understanding the Closest and Strongest Starburst of the Nearby Universe
Bruce Balick	University of Washington	AR	Planetary Nebula Image Catalogue: *HST* Data
Dinshaw Balsara	University of Notre Dame	AR	The Interaction of Supernova Remnant Shocks with Interstellar Clouds
Edwin Bergin	University of Michigan	GO	The Gas Dissipation Timescale: Constraining Models of Planet Formation
David Bersier	Liverpool John Moores University	GO	Exploring the Diversity of Cosmic Explosions: the Supernovae of Gamma-ray Bursts
Karen Bjorkman	University of Toledo	AR	Be Stars and Circumstellar Disks in NGC 346
Howard Bond	Space Telescope Science Institute	GO	Trigonometric Calibration of the Distance Scale for Classical Novae
Howard Bond	Space Telescope Science Institute	GO	The Light Echoes around V838 Monocerotis
Howard Bond	Space Telescope Science Institute	GO	*HST* Observations of Astrophysically Important Visual Binaries
Joel Bregman	University of Michigan	AR	Binary Burning in Globular Clusters
Thomas Brown	Space Telescope Science Institute	GO	The Blue Hook Populations of Massive Globular Clusters
Nuria Calvet	University of Michigan	GO	The FUV Fluxes of Tauri Stars in the Taurus Molecular Cloud
Rupali Chandar	The Johns Hopkins University	GO	A Proper Motion Search for Intermediate-mass Black Holes in Globular Clusters (2nd Epoch Observations)
You-Hua Chu	University of Illinois at Urbana, Champaign	AR	Archival Imaging Survey of the Formation and Energy Feedback of Massive Protostars in the LMC
Geoffrey Clayton	Louisiana State University and A & M College	AR	Dust Formation and Evolution in SN 1987A
Judith Cohen	California Institute of Technology	GO	Very Young Globular Clusters in M31?
Haldan Cohn	Indiana University System	GO	Probing the Central Dark Mass Concentration of the Collapsed-Core Globular Cluster M15
Andrew Cole	University of Minnesota, Twin Cities	GO	Complexity in the Smallest Galaxies: Star Formation History of the Sculptor Dwarf Spheroidal
Kris Davidson	University of Minnesota, Twin Cities	GO	Following Eta Carinae's Change of State
Orsola De Marco	American Museum of Natural History	GO	Planetary Nebulae, Globular Clusters and Binary Mergers
Andrea DeLuca	CNR, Istituto di Astrofisica Spaziale	GO	Proper Motion May Nail Counterpart of Unique X-ray Pulsar
Rosanne Di Stefano	Smithsonian Institution Astrophysical Observatory	AR	Exploring the Center of M31
Mike Disney	University of Wales, College of Cardiff (UWCC)	GO	The Nearest Gas-rich Giant Galaxy
Laurent Drissen	Université Laval	GO	UV Spectroscopy of the LBV NGC 2363–V1
Reginald Dufour	Rice University	GO	CIII Imagery of Planetary Nebulae
Martin Durant	University of Toronto	GO	The Spectrum of a Magnetar in the Blue and Ultraviolet
Kristoffer Eriksen	University of Arizona	AR	Chemical Abundances in Young Supernova Remnants: Connecting Observations with Hydrodynamics
Nancy Evans	Smithsonian Institution Astrophysical Observatory	GO	The Dynamical Mass of the Bright Cepheid Polaris

Name	Institution	Type	Title
Francesco Ferraro	Universita di Bologna	GO	Hunting for Optical Companions to Binary Millisecond Pulsars in Terzan 5 and NGC 6266
Robert Fesen	Dartmouth College	GO	A Study of SN Ejecta in the Core-Collapse Supernova Remnant G292.0+1.8: Cas A's Older Cousin
Alex Filippenko	University of California, Berkeley	AR	The Local Environments of Supernovae
Peter Garnavich	University of Notre Dame	GO	Imaging Dust Near Type Ia Supernovae: A New Light Echo Candidate
Marla Geha	Carnegie Institution of Washington	GO	Direct Age Determination of the dE Galaxies NGC 147 and NGC 185
Oleg Gnedin	The Ohio State University Research Foundation	GO	Measuring the Shape and Orientation of the Galactic Dark-Matter Halo using Hypervelocity Stars
Carol Grady	Eureka Scientific Inc.	GO	Mapping the Gaseous Content of Protoplanetary and Young Planetary Systems with ACS
Edward Guinan	Villanova University	GO	Eclipsing Binaries in the Local Group: II - Calibration of the Zeropoint of the Cosmic Distance Scale and Fundamental Properties of Stars in M33
Theodore Gull	NASA Goddard Space Flight Center	AR	Chemical Abundances in the Ejecta of Eta Carinae
Graham Harper	University of Colorado at Boulder	AR	Molecular Envelopes of M Supergiants
William Harris	McMaster University	GO	The Halo of Centaurus A: Tracing its Outermost Limits, Metallicity Distributions, and Merger Models
Todd Henry	Georgia State University Research Foundation	GO	Calibrating the Mass-luminosity Relation at the End of the Main Sequence
John Hillier	University of Pittsburgh	AR	Eta Carinae and its Extended Wind
Dean Hines	Space Science Institute	GO	Coronagraphic Polarimetry of *HST*-Resolved Debris Disks
Roberta Humphreys	University of Minnesota, Twin Cities	GO	A SNAP Image of the Circumstellar Ejecta of AE And in M31
Wei-Chun Jao	Georgia State University Research Foundation	GO	The Weight-Watcher Program for Subdwarfs
Stefan Jordan	Universität Tübingen, Institut für Astronomie & Astrophysik	GO	Mass and Radius of a Near-Chandrasekhar-limit Magnetic White Dwarf
Paul Kalas	University of California, Berkeley	GO	Closure on the IRAS "Big Four": A High Contrast Study of Epsilon Eridani's Dust Belt in Scattered Light
Paul Kalas	University of California, Berkeley	GO	An Efficient ACS Coronagraphic Survey for Debris Disks around Nearby Stars
Oleg Kargaltsev	The Pennsylvania State University	GO	ACS Polarimetry of the Vela Pulsar Wind Nebula
Robert Kirshner	Harvard University	GO	SAINTS - Supernova 1987A INTensive Survey
Konrad Kuijken	Universiteit Leiden	GO	Dynamics of the Galactic Bulge/Bar
Alain Lecavelier des Etangs	CNRS, Institut d'Astrophysique de Paris	GO	The Upper Atmosphere and the Escape State of the Transiting Very-hot-Jupiter HD 189733b
Jean-François Lestrade	Observatoire de Paris	GO	Coronagraphic Imaging of the Submillimeter Debris Disk of a 200 Myr old M-dwarf
Aigen Li	University of Missouri, Columbia	AR	Scattering and Absorption Properties of Porous Dust Grains: A Library for Modeling the *HST* Optical and Near-infrared Scattered Light Images of Protoplanetary and Debris Disks
Weidong Li	University of California, Berkeley	SNAP	A Snapshot Survey of the Sites of Recent, Nearby Supernovae
Michael Liu	University of Hawaii	GO	Debris Disks around Nearby Young M Dwarfs
Jesús Maíz-Apellániz	Space Telescope Science Institute	GO	The Orbit of the Most Massive Known Astrometric Binary
Stanimir Metchev	University of California, Los Angeles	GO	Imaging Scattered Light from Debris Disks Discovered by the *Spitzer Space Telescope* around 21 Sun-like Stars
Roberto Mignani	Mullard Space Science Laboratory	GO	Optical Polarimetry of PSR B0540–69 and its Synchrotron Nebula
Edmund Nelan	Space Telescope Science Institute	GO	Dynamical Masses for Four White Dwarf Stars
C. O'Dell	Vanderbilt University	AR	A Compilation, Analysis, and Distribution of *HST* Orion Nebula Data
C. O'Dell	Vanderbilt University	GO	Tangential Velocities of Objects in the Orion Nebula and Locating the Embedded Outflow Sources
Brian Patten	Harvard-Smithsonian Center for Astrophysics	GO	Solving the Microlensing Puzzle: An *HST* High-resolution Imaging Approach
Anne Pellerin	Space Telescope Science Institute	AR	Catching Dissolving Clusters: the Resolved Stellar Populations Approach
Ruth Peterson	Astrophysical Advances	AR	Germanium Abundances for Stars with Near-Solar Metallicities
Slawomir Piatek	New Jersey Institute of Technology	AR	The Proper Motion of the Sagittarius Dwarf Spheroidal Galaxy
Giampaolo Piotto	Università di Padova	GO	Searching for Signs of a Double Generation of Stars in Galactic Globular Clusters
Frederic Pont	Observatoire de Genève	GO	Measuring the Size of the Close-in Transiting Extrasolar Planet HD 189733b
Alice Quillen	University of Rochester	AR	The Structure of HD 100546's Self-shadowed Circumstellar Disk
Iain Reid	Space Telescope Science Institute	SNAP	A Search for Planetary-mass Companions to the Nearest L Dwarfs—Completing the Survey
Armin Rest	National Optical Astronomy Observatories - CTIO	GO	Resolving the LMC Microlensing Puzzle: Where are the Lensing Objects?
R. Rich	University of California, Los Angeles	GO	A Precision White Dwarf Cooling Age for NGC 6397
Robert Rubin	NASA Ames Research Center	AR	Using Archival Data to Improve Atomic Data and Address the Nebular Iron Problem
Raghvendra Sahai	Jet Propulsion Laboratory	GO	Solving the Riddle of the Red Rectangle: Proper Motion Study of a Bipolar Nebula around a Binary
Bradley Schaefer	Louisiana State University and A & M College	GO	The Shell of the Recurrent Nova T Pyx
Glenn Schneider	University of Arizona	GO	Coronagraphic Polarimetry with NICMOS: Dust-grain Evolution in T Tauri Stars
Stephen Smartt	The Queen's University of Belfast	GO	Detecting the Progenitors of Core-collapse Supernovae

Name	Institution	Type	Title
Ulysses Sofia	Whitman College	AR	Relating Extinction to Specific Grain Types in Individual Sight Lines
Karl Stapelfeldt	Jet Propulsion Laboratory	GO	Coronagraphic Imaging of Bright New *Spitzer* Debris Disks II
Danny Steeghs	Harvard-Smithsonian Center for Astrophysics	GO	Accretion in the Closest Binary Systems Known
Matthias Stute	Jet Propulsion Laboratory	GO	The Knotty Jet of He 2–90: An Ideal Laboratory for Studying the Formation and Propagation of Jets in Dying Stars
John Subasavage	Georgia State University Research Foundation	GO	Calibrating Cosmological Chronometers: White Dwarf Masses
Mark Swain	Jet Propulsion Laboratory	GO	The Near-IR Spectra and Thermal Emission of Hot Jupiters
Laurence Trafton	University of Texas at Austin	AR	Continuum and Monochromatic L-Flats for the ACS Ramp Filters
Toshiya Ueta	USRA SOFIA Office/NASA Ames Research Center	GO	Establishing the Nature of a Mysterious Evolved Star, HD 179821
Bart Wakker	University of Wisconsin, Madison	AR	Characterizing Lyman Spitzer's Galactic Corona
Lifan Wang	Lawrence Berkeley National Laboratory	SNAP	Light Echoes for Type Ia Supernovae
Alycia Weinberger	Carnegie Institution of Washington	GO	Are Organics Common in Outer Planetary Systems?
Daniel Zucker	University of Cambridge	GO	Understanding the Least Luminous Galaxies in the Nearby Universe
Solar System Programs			
Michael Brown	California Institute of Technology	GO	The Largest Kuiper Belt Objects
Marc Buie	Lowell Observatory	GO	Rotational State and Composition of Pluto's Outer Satellites
Marc Buie	Lowell Observatory	AR	Constraints on the Formation and Evolution of the Pluto System
John Clarke	Boston University	AR	Flat Field Calibration of ACS and STIS UV Images
Lucy-Ann McFadden	University of Maryland	GO	Photometric Mapping of Vesta's Southern Hemisphere
Keith Noll	Space Telescope Science Institute	SNAP	Kuiper Belt Binaries: Probes of Early Solar System Evolution
Keith Noll	Space Telescope Science Institute	GO	Direct Determination of Kuiper Belt Object Diameters with *HST*
Mark Showalter	SETI Institute	GO	The Ring Plane Crossings of Uranus in 2007
Mark Showalter	SETI Institute	AR	Orbital Evolution and Chaos among the Inner Moons of Uranus
John Spencer	Southwest Research Institute	GO	Observations of the Galilean Satellites in Support of the New Horizons Flyby
Lawrence Sromovsky	University of Wisconsin, Madison	GO	ACS Imaging of Uranus' Atmosphere Near Equinox

Making the Most of the Great Observatories

N. Reid, *inr@stsci.edu*

"To every thing there is a season" (Ecclesiastes 3:1)

Over the last three years, the astronomical community has had the privilege of access to three superb space observatories: *Chandra*, *Hubble*, and *Spitzer*. Those circumstances will change in the near future; while *Chandra* faces no immediate lifetime issues, *Spitzer* has only two complete cryogenic cycles (4 and 5) remaining, and without a servicing mission, *Hubble*'s batteries are likely to fail around mid-2009. With those concerns in mind, the three Great Observatories organized a joint workshop about "making the most" of their current availability. The workshop was supported by ~80 attendees and was held 22–24 May 2006 in Pasadena, CA.

A goal of the meeting was to identify key science areas that need to be tackled by the Great Observatories, particularly those studies that rely on synergism between observations by at least two Observatories, as well as those that will lay the foundation for science programs with future ground- or space-based observatories. Tom Soifer (Caltech) provided a more succinct summary: "What projects would make us look like idiots if they weren't completed before the Observatories die?"

The meeting included ten wide-ranging review talks. Eight covered broad science areas: planets and planetary systems (Drake Deming, Goddard), stellar astrophysics (Jim Liebert, U. Arizona), star formation (Ed Chuchwell, Wisconsin), nearby galaxies (Rob Kennicutt, Cambridge), AGN and QSOs (Niel Brandt, Penn. State), galaxy formation (Michael Strauss, Princeton), galaxy clusters (Megan Donahue, Michigan State), and cosmology and large-scale structure (David Weinberg, Ohio State). These reviews were complemented by breakout sessions and two panel discussions.

The first panel discussed synergy with future ground-based programs, with contributions from Jeremy Mould (NOAO), Dale Frail (NRAO) and Chris Carilli (NRAO). The second panel discussion combined summaries of the current performance of *Spitzer* (Lisa Storrie-Lombardi, SSC), *Chandra* (Belinda Wilkes, CXO) and *Hubble* (Harry Ferguson, STScI) with anticipations of *Webb* (Jon Gardner, Goddard), *Herschel* (Bill Latter, NHSC) and *Con-X* (Ann Hornschemeier, Goddard). Finally, Meg Urry (Yale) and Richard Ellis (Caltech) presented complementary über-reviews.

Each speaker and each discussion session was asked to identify three or four high-priority science topics where the Great Observatories could (and should) make key contributions. With the aid of several participants (notably David Weinberg), we have compiled a summary of the suggestions, which is available at the workshop's website: **http://ssc.spitzer.caltech.edu/mtgs/greatobs/**. While the projects are not formally endorsed by any of the Great Observatories, the community may, nevertheless, wish to pay due attention to these recommendations in answering future calls for proposals.

Besides the overall science summary, the workshop's website provides links to copies of the review presentations, together with summaries of the discussion and panel sessions. The website also offers documents compiled for the workshop, including instructions on applying for time on multiple Great Observatories, a catalogue of large programs already being undertaken on the Great Observatories, and summaries of the capabilities of current and future ground- and space-based facilities.

Setting aside the recommendations for specific observational projects, the workshop reached consensus on four broader issues:

1. There are no obvious key scientific questions that are currently ignored by the Great Observatories. All of the projects highlighted during the workshop build on past contributions. (As one speaker commented, this

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Scientific Organizing Committee

Neill Reid (*STScI*)
Lisa Storrie-Lombardi (*Spitzer Science Center*)
Paul Green (*Chandra X-ray Observatory*)
Martin Elvis (*Smithsonian Center for Astrophysics*)
Julia Lee (*Center for Astrophysics*)
Pat McCarthy (*Observatories of the Carnegie Institution of Washington*)
Leisa Townlsey (*Penn. State University*)
Mike Werner (*JPL*)
Brad Whitmore (*STScI*)

Great Observatories from page 13

either reflects the resourcefulness of the astronomical community, or the lack of imagination of the workshop participants.)

2. Archival research will become increasingly important in the near future. It is imperative that the Great Observatories provide efficient cross-linking between their individual data archives.

3. All time assignment committees (ground- and space-based) should bear in mind the limited cryogenic lifetime of *Spitzer*. There was strong (but not unanimous) sentiment for examining means of streamlining the proposal process for projects that require medium to large allocations on two or more Great Observatories. The available options are being explored.

4. While several projects were proposed that are comparable in scale to the initial *Hubble* Key Projects, *Spitzer*'s schedule does not allow sufficient time for the formal selection of officially sanctioned, large, multicycle programs. The onus is, therefore, on the astronomical community to devise successful co-operative strategies for proposing important science. Ω

MAST News

R. White, *rlw@stsci.edu*, for the MAST team

As of May 1, 2006, the Multimission Archive at STScI (MAST) contained about 41 Tbytes of data, including 28 Tbytes of *Hubble* data. Over the last year, users retrieved a total of about 29 Tbytes, an average of nearly 80 Gbytes/day. The typical retrieval time for *Hubble* data is usually under one hour, with on-the-fly-reprocessing (OTFR) requests taking a median time of about 50 minutes and non-OTFR requests taking about 10 minutes.

MAST User Survey

The 2006 MAST User Survey drew a record 364 responses. Thanks to all who participated for taking the time to give us feedback! The results are summarized at **http://archive.stsci.edu/surveyresults/2006/survey_mar2006.html**. We have already implemented some changes in response to your comments. For example, the algorithm used to create the display of previews for data from the Advanced Camera for Surveys (ACS) has been greatly improved, so that the browser images are much more useful. More changes will appear in the coming months. We welcome additional suggestions at any time via the MAST Suggestion Box (**http://archive.stsci.edu/suggestions.html**) or through email to *archive@stsci.edu*.

Figure 1: Sample *XMM-OM* images. Left: NGC 2403 through the *U*, *UVW1* (300 nm) and *UVM2* (230 nm) filters. Right: NGC 4631 through the *B*, *U*, and *UVW1* filters.

Happy Sweet Sixteen, Hubble Telescope!

To celebrate the *Hubble Space Telescope*'s 16 years of success, the two space agencies involved in the project, NASA and the European Space Agency (ESA), are releasing this image of the magnificent starburst galaxy, Messier 82 (M82). This mosaic image is the sharpest wide-angle view ever obtained of M82. The galaxy is remarkable for its bright blue disk, webs of shredded clouds, and fiery-looking plumes of glowing hydrogen blasting out of its central regions.

http://hubblesite.org/newscenter/newsdesk/archive/releases/2006/14/
Image Credit: *NASA*, *ESA*, and The Hubble Heritage Team (*STScI/AURA*)

New High-Level Science Products

The MAST High-Level Science Products (HLSPs) are science-ready images, spectra and catalogs based on MAST data. Recent additions include the COSMOS ACS survey of two square degrees (**http://archive.stsci.edu/prepds/cosmos**/), the Eta Carinae Hubble Treasury Program (**http://archive.stsci.edu/prepds/etacar**/), Hubble Ultra-Deep Field follow-up observations (**http://archive.stsci.edu/prepds/udf05**/), and the Catalog and Atlas of Cataclysmic Variables from Ron Downes et al. (**http://archive.stsci.edu/prepds/cvcat**/).

We welcome contributions of additional HLSP datasets based on MAST data. HLSPs are MAST's most heavily used data, so this is a great way to increase the impact of your science projects! For more information see our guidelines for HLSP contributions (**http://archive.stsci.edu/hlsp/hlsp_guidelines.html**) or contact us at *archive@stsci.edu*.

GALEX GR2 release

The second major data release from the *Galaxy Evolution Explorer* (*GALEX*) is now coming online. The data volume is about four times larger than the first release, and the data quality has also seen improvements. The first subset of the *GALEX* GR2 data products were released to the public in May 2006 for the Medium and Deep Imaging Surveys and the Nearby Galaxies Survey. In early June the All-Sky Imaging Survey will be available; about one month later, the new spectroscopic grism survey will be released. These data can be searched and downloaded through the *GALEX* website (**http://galex.stsci.edu/GR2**/).

XMM-OM: A New MAST Mission

The *X-ray Multi-Mirror* (*XMM*) *Telescope*, launched by the European Space Agency in December 1999, carries a 30-cm optical/ultraviolet telescope with a microchannel-plate pre-amplified CCD detector in its focal plane. The Optical Monitor (OM) spatial pixel size in normal operation is 1 arcsecond with a 17 arcminute field of view, and the limiting sensitivity is $B = 24$ for a star viewed with the detector in unfiltered light. Filters cover the 160–600 nm wavelength range. The OM telescope is coaligned with the X-ray telescope, and most *XMM* X-ray observations have accompanying OM images.

MAST now distributes the *XMM*-OM images (**http://archive.stsci.edu/xmm-om**/). These will be of interest to many of our users, since they are typically more sensitive and higher resolution than comparable *GALEX* images. Most fields have images through multiple ultraviolet and optical filters (see figure on facing page for examples.) Ω

NICMOS Count-Rate Nonlinearity

R. de Jong, *dejong@stsci.edu* **& R. Bohlin,** *bohlin@stsci.edu*

We have discovered a new nonlinearity in the Near Infrared Camera and Multi-Object Spectrometer (NICMOS). It depends on count rate and is distinctly different from the classical nonlinearity shared by all near-infrared detectors, which depends only on the total counts in a pixel. The latter is well understood, and the NICMOS pipeline routinely corrects it. The new nonlinearity produces errors up to 0.3 magnitudes, depending on the wavelength and which NICMOS camera is used. In this article, we recount the discovery and characterization of the new effect, and announce the availability of beta-test software to correct it.

We discovered the new anomaly by comparing data from NICMOS and the Space Telescope Imaging Spectrograph (STIS) in the 0.8–0.95-micron wavelength range, where their sensitivities overlap. We compared the relative count rates in STIS spectra and NICMOS grism spectra for several stellar objects (Figure 1). Compared to STIS, we found that NICMOS measured bright objects as too bright and faint objects as too faint.

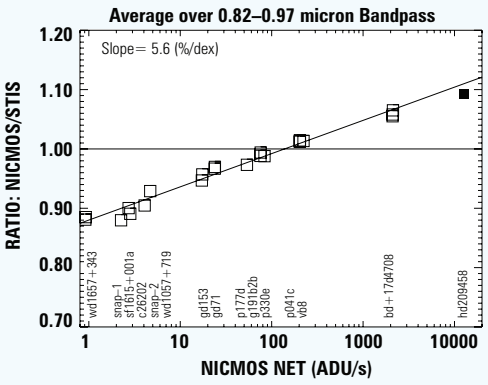

Figure 1: The ratio of NICMOS to STIS fluxes as a function of the NICMOS count rate in the wavelength region where they overlap. The calibration is based on our standard stars GD71, GD153, and G191B2B.

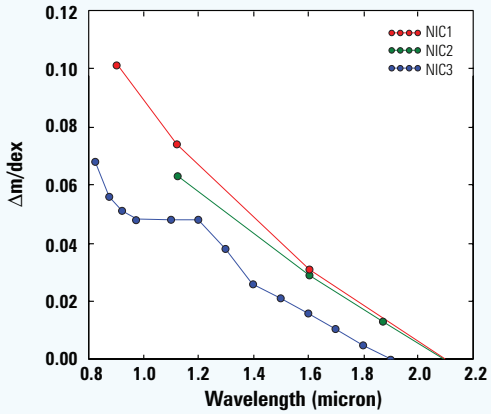

Figure 2: Nonlinearity index. The magnitude offset (Δm) per factor ten changes in incident flux, as function of wavelength. The NIC1 and NIC2 points are from the lamp on-off test, and the NIC3 points are from grism observations.

Either NICMOS or STIS could have caused the problem. However, further comparisons with photometry and grism spectroscopy by the Advanced Camera for Surveys (ACS) made it clear that NICMOS is the culprit. Subsequent comparisons showed that NICMOS imaging suffered from the same problem as spectroscopy, which meant that spectral data reduction could not be blamed.

Despite the limited overlap of the NICMOS and STIS spectral ranges, we were able to determine the wavelength dependence of the new irregularity, even into the near infrared. We compared NICMOS grism observations to the extrapolated spectral energy distribution (SED) models of white dwarfs calibrated by STIS. The nonlinearity is most severe at shorter wavelengths and decreases at longer wavelengths (Figure 2).

We sought direct evidence to supplement the indirect evidence from instrument comparisons based on filter models and estimated SEDs. For this, we exploited the fact that NICMOS continues to observe the sky during flat-field exposures with the internal lamp. This feature enables NICMOS to observe objects with and without background light from the lamp. For a linear system, the extra light should add noise, but not change the measured flux from the object. When a lamp-off image is subtracted from a lamp-on image, the NICMOS nonlinearity is obvious (Figure 3); Figure 4 shows it quantitatively. Bright pixels have large absolute differences between lamp-on and lamp-off. Faint pixels show the largest *relative* change in count rate, because their count rates are changed relatively more when the lamp is on.

A power law fits the measured nonlinearity well: *count rate* $\sim$ *flux*$^{\alpha}$, as shown in Figure 4. The value of α ranges from 1.0 to 1.04, depending on wavelength and NICMOS camera. We have not observed a turnover. The normalization is arbitrary—we don't know if bright pixels overcount or faint pixels undercount.

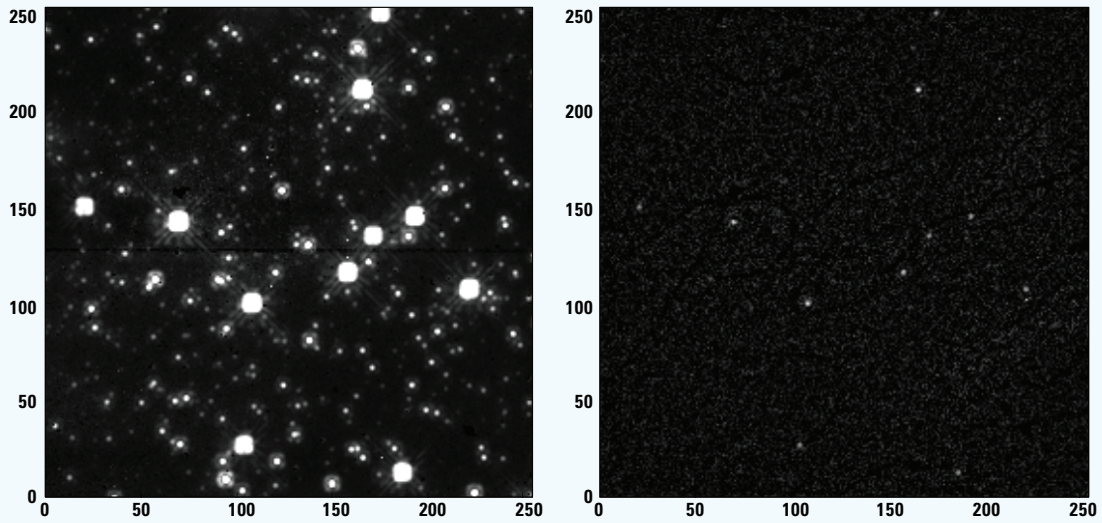

Figure 3: (Left) NIC1 image of F110W image of NGC 1850 with the lamp off. (Right) Lamp-on minus lamp-off difference image. Clearly, bright stars are not canceled—a signature of a count-rate dependent nonlinearity.

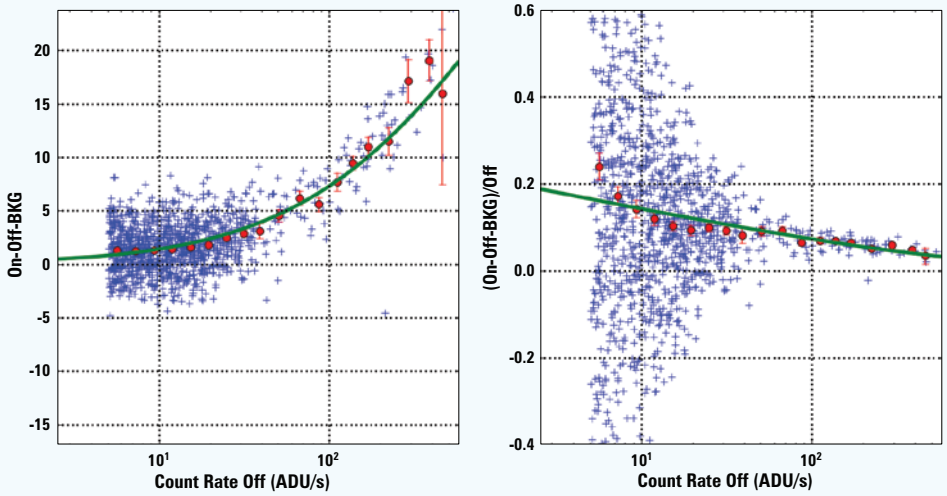

Figure 4: The absolute (left) and relative (right) difference between count rates with the lamp on and off, as a function of the lamp-off count rates, on a pixel-by-pixel basis (+ symbols) for NIC1 and F110W filter. The red circles are averages of points binned in 30 equal logarithmic steps of the lamp-off count rate. The green line shows the fitted nonlinearity function.

In the archive, we found observations from Cycle 7 with NIC2 and the F110W filter, taken with the lamp on and off. They show the same amplitude of nonlinearity as today. This is one of the few NICMOS characteristics that does not depend on temperature. (When astronauts installed the cryo-cooler in 2002, the temperature changed from the 66 K of Cycle 7 to the current 77.1 K.)

We are beta testing a PYTHON script to correct the anomaly for NICMOS imaging. The size of the correction depends on the filter and the brightness of the objects. (The relation is not very tight and is more uncertain at the faint end.) For best results, it is important to include all sources of light onto a pixel, including those of extended background objects or the sky background.

We have used the provisional script to estimate the scientific impacts of the new nonlinearity on various kinds of observations.

As a first example, consider the images of the star cluster NGC 1850 in Figure 3, from the lamp-on/off test. Figure 5 shows the difference in aperture photometry before and after correction. Using the standard pipeline, stars fainter than about the 12th AB-magnitude (the brightness of our standard stars) would be measured as too faint, and brighter stars—if there were any, but there are not—would have been measured as too bright. The field is crowded enough that faint stars can sit on top of the faint tails of the

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point-spread functions of brighter objects. In that situation, the faint stars require less correction, because the local count rate is higher. There is a hint of turnover at about 19 AB-mag due to the diffuse background of fainter stars in the cluster field. On a dark sky background, this turnover might not occur until about 22 AB-mag, resulting in maximum corrections of about 0.25 mag for F110W and 0.12 mag for F160W for NIC1 and NIC2.

The Hubble Ultra Deep Field (HUDF) provides a second example of scientific impacts. In the HUDF, all galaxies are below the level of the sky background, and only the central parts of the brightest stars are brighter than the sky level. Therefore, all HUDF objects—except for the brightest stars—have about the same anomaly correction, determined by the count rate of the sky background (Figure 6). Almost all objects require a correction of 0.16 mag in F110W and 0.04 mag in F160W. These are the maximum corrections expected for NIC3, given that the HUDF was observed with low sky background conditions. These maximum corrections are smaller than for NIC1 and NIC2 because NIC3 is still out of focus; therefore the contrast between the standard stars and the low sky background is smaller for NIC3.

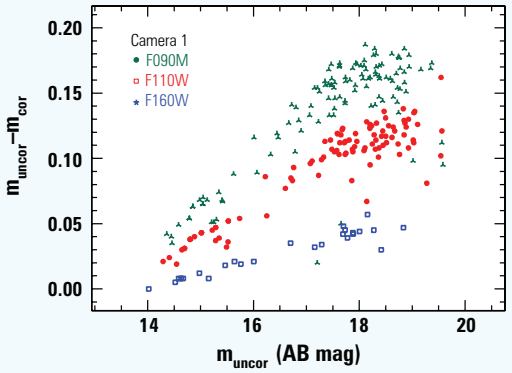

Figure 5: The difference in magnitude, before and after correction, for objects in NGC 1850, as function of uncorrected magnitude.

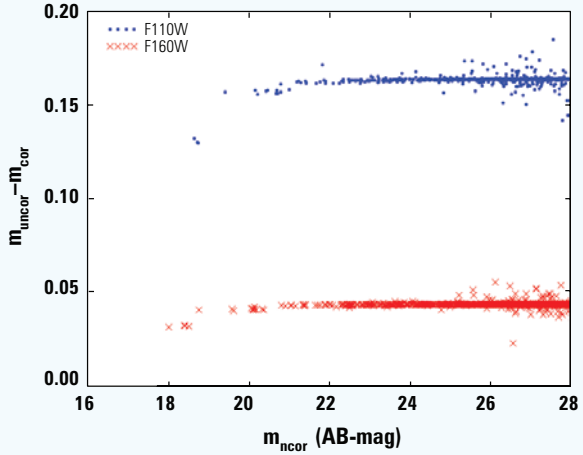

Figure 6: The difference in magnitude, before and after correction, for objects in the HUDF, as function of uncorrected magnitude.

We have created a web site with the latest information on the nonlinearity: **http://www.stsci.edu/hst/nicmos/performance/anomalies/nonlinearity.html**. Users can download the beta-test version of the correction script, along with instructions on how to use it. All NICMOS users who require photometry accurate to better than ~20%, especially at the shorter wavelengths, are strongly encouraged to apply this correction. The NICMOS group at the Institute is currently implementing the correction in the standard pipeline.

We have not yet found a physical explanation for the new nonlinearity in NICMOS. Effects like charge trapping and persistence seem unable to explain the power law behavior over such a wide dynamical range. Also, those explanations would predict a lower amplitude in very long exposures, which has not been observed. The wavelength dependence and temperature insensitivity provide further clues. Nevertheless, the explanation has remained elusive. Ω

Discovery and Repair of the Anomaly in WFPC2's WF4

J. Biretta, *biretta@stsci.edu*

In October 2005, we discovered a serious electronic anomaly in the Wide Field 4 (WF4) channel of the Wide Field and Planetary Camera 2 (WFPC2). The detector occasionally produced blank images, and its photometric counts were sometimes too low by as much as a factor of three. In February 2006, we repaired the problem and returned WF4 to near-normal operations. We have also derived a preliminary photometric correction for impacted data. The following summarizes the history, analysis, repair, and correction of the WF4 anomaly.

The characteristic of the anomaly is a low and unstable bias level or electronic zero point. The likely cause is a slowly failing component in the CCD amplifier. At first glance, users might think the affected images are perfectly normal, since the calibration pipeline automatically removes the bias level. However, a closer look reveals that the photometric counts are low, and the background exhibits elevated noise in the form of weak horizontal streaks. If the bias level falls to zero, the images are blank, although very bright sources and cosmic rays are sometimes visible.

The anomaly is confined to the WF4 CCD; the other three CCDs in WFPC2 are fine.

We can trace evidence of the anomaly as far back as March 2002, around the time of Servicing Mission 3B, when the bias levels of occasional images were a few counts below the normal value of 311 DN (data number). The anomaly grew slowly over the following years and bias levels drifted lower. By early 2004, some images showed bias levels < 280 DN (Figure 1) and photometry that was 5% low. In February 2005, the first zero-bias, blank images occurred. By late 2005, about 15% of all images appeared blank, and the photometry of remaining images was reduced by 5% to 70%.

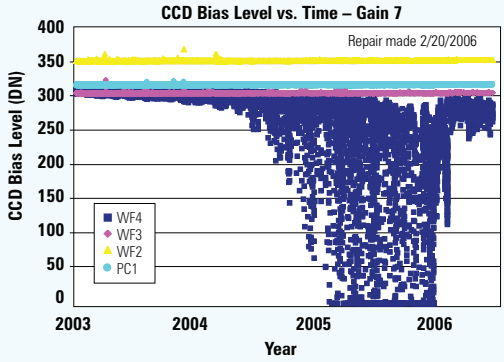

Figure 1: Historical bias levels at gain 7 in all four CCDs of WFPC2. The development of anomalous bias levels in WF4 is apparent. Near-normal bias levels were restored in February 2006.

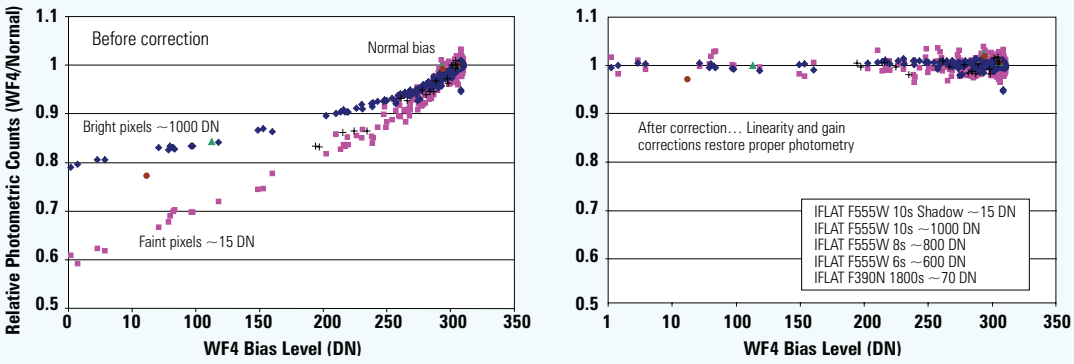

Figure 2: Ratio between anomalous WF4 photometric counts and normal counts as a function of bias level for pixels of various brightness at gain 7. The upper panel is before correction; the lower panel is after preliminary correction.

We found a strong correlation between episodes of low bias and spikes in the temperature of a circuit board in camera head of WF4. The spikes occurred every four to six hours, when the camera head reached its lower temperature limit and heaters switched on. The solution was to lower and narrow the range of the operating temperature of WFPC2, from the original 10.9–14.9°C to 10.0–11.3°C. Since February 2006, bias levels have been nearly normal, and blank images have disappeared. The largest adverse effect is a half-pixel shifting between the CCDs, which could affect chip-to-chip astrometry. The image quality remains normal.

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The science impact of the anomaly has been modest. Most WFPC2 pointed targets are placed either on the PC1 or WF3 CCDs, which are unaffected. And

WFPC2's WF$
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in general, WFPC2 utilization has decreased since the installation of ACS. Nonetheless, there are still some science programs with very large targets and parallel surveys, where the added field-of-view contributed by WF4 is significant.

We are developing a photometric correction for WF4 data obtained with low bias levels. Figure 2 illustrates preliminary results (see Instrument Science Report WFPC2 2005-02, **http://www.stsci.edu/instruments/wfpc2/Wfpc2_isr/wfpc2_isr0502.html**/). Based on special on-orbit calibrations, we are striving to refine the correction. We expect that most WF4 data will be rectified with only a modest degradation in signal-to-noise ratio and photometric accuracy. Fortunately, the number of zero-bias or blank images—which cannot be remedied—is small. Even though WF4 is now operating at near-normal bias levels, we expect those levels will trend downward as the underlying hardware failure progresses. We will make additional temperature adjustments in the future, as necessary. Extrapolating the recent trend, we estimate that WF4 can operate several more years in this manner, until some lower temperature limit is reached.

We will post updates and new information on the WFPC2 website as they become available (**http://www.stsci.edu/instruments/wfpc2/wfpc2_top.html**/). Ω

Aladin Replacing the VTT

K. Peterson, *peterson@stsci.edu*

In Cycle 16 we will replace the VISUAL TARGET TUNER (VTT) in the ASTRONOMER'S PROPOSAL TOOL (APT) with a new tool for previewing *Hubble* observations against sky images. The new tool will be based on the popular ALADIN SKY ATLAS interface, which was developed by the Centre de Données astronomiques de Strasbourg (**http://aladin.u-strasbg.fr**/). This change gives us more options for future enhancements, and brings a variety of benefits to users:

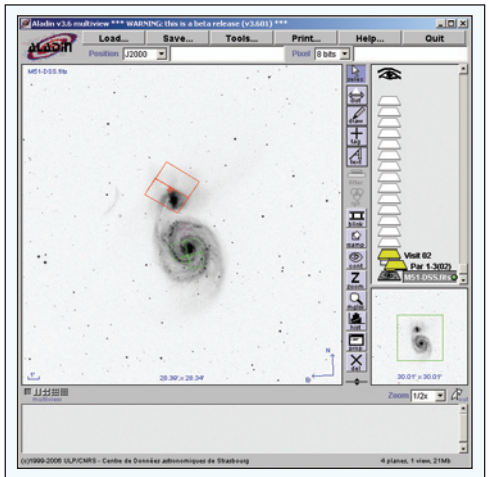

Figure 1: ALADIN screenshot.

Wider Access. ALADIN can query a wide variety of image and catalog data through one uniform interface, including all images in the Multimission Archive at Space Telescope and all catalogs in VIZIER. ALADIN can also query any service registered with the Virtual Observatory (VO).

More Power. ALADIN has many more capabilities for displaying and manipulating images than VTT. For example, you can load multiple images of the same area of the sky and easily switch between them. You can also compare several images at once, with side-by-side, blinking, and color options.

Improved Proposal Support. As with the VTT, ALADIN allows you to move exposures around to experiment with different placements in a proposal. Further, it allows you to review and approve proposed changes throughout the proposal, instead of being forced to confirm or discard changes as you move from exposure to exposure.

Interoperability. ALADIN already works with other VO tools, either directly, like VOPLOT (general plotting; **http://vo.iucaa.ernet.in/~voi/voplot.htm**/) and VOSPEC (spectral data display and analysis; **http://esavo.esa.int/vospecapp**/), or by sharing tabular data with ALADIN (TOPCAT; **http://www.star.bristol.ac.uk/~mbt/topcat**/).

ALADIN is becoming a common denominator for many astronomical activities, which now will include proposal preparation for *Hubble*. We hope this will make the learning curve easier. If you would like to take part in the pre-Cycle 16 testing of ALADIN in its APT application, please contact me. Ω

James Webb Space Telescope: The Next Great Observatory

H. B. Hammel, *hbh@alum.mit.edu*, and the *Webb* Science Working Group

As scientific stewards for the *James Webb Space Telescope*, the members of the Science Working Group (SWG) are striving to ensure this facility meets the diverse needs of the astronomical community. We want to share with you a number of aspects of *Webb* that may not be fully appreciated by those outside the immediate project.

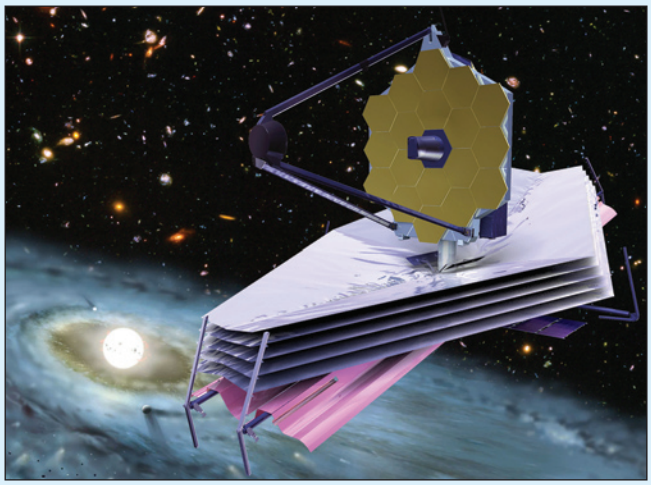

Figure 1: The current *Webb* design projected against a portion of the Hubble Ultra Deep Field and David Hardy's painting of the disk surrounding Fomalhaut (*NASA/STScI*, © David A. Hardy/**www.astroart.org/PPARC**).

A premier space facility in the coming decade

Webb—a 6.5-meter, segmented, infrared telescope—will be optimized for imaging and spectroscopy from 0.6 to 27 microns wavelength. The telescope will be passively cooled to about 45 K by a sunshield, and will carry four instruments: a near-infrared camera, a near-infrared multi-object spectrograph, a mid-infrared instrument, and a tunable-filter imager.

In the spirit of the Great Observatories, *Webb* will be a versatile engine of astronomy. It will be open to all astronomers through a peer-reviewed General Observer (GO) Program, which will be allotted more than 85% of the observing time. After its launch in 2013, *Webb* will serve thousands of astronomers from worldwide institutions both large and small, just as *Hubble*, *Chandra*, and *Spitzer* serve their significant communities of funded researchers today.

Based on experience with *Hubble* and the other Great Observatories, *Webb*'s GO program will engage the best minds of the astronomical community, and will produce unexpected discoveries and fundamental breakthroughs. The amazing science produced by *Webb* will be achievable because of the considerable capabilities planned for the observatory through its instrumentation and operating model.

Exploring of all fields of astronomy

Webb's four timely and compelling science themes span the breadth of astronomy. They examine every phase of cosmic history: from the first glows after the Big Bang to the formation of galaxies; from the formation of stellar systems—some capable of supporting life on planets like Earth—to the evolution of planets in the solar system. The SWG is ensuring that the observational needs of these themes guide the development of the observatory.

First Light. After the Big Bang, the first galaxies probably formed as groups of very massive stars. When those stars finished their lives as supernovae, elements—like carbon, oxygen, and iron—formed and were blown into space to seed future generations of stars. *Webb* will find and study the most luminous early stellar groups, their bright but rare supernovae, and the earliest luminous black holes.

Galaxy Assembly. Large galaxies were probably assembled through mergers of smaller ones, but current sensitivities and wavelength coverage limit our study of this process across the major epoch of galaxy formation. With its broad wavelength coverage, *Hubble*-like image quality, and high sensitivity, *Webb* will observe millions of galaxies at all stages of development. These results will provide a complete picture of galaxy assembly from the epoch of First Light through the present.

Birthplace of Stars. Though hidden from our view at visible wavelengths, stars and planetary systems form within nearby dust clouds, which hide the details of this process. *Webb*, observing in the near- and mid-infrared, will penetrate the dusty shrouds, revealing the interiors of these stellar nurseries and discovering the conditions for forming planetary systems.

Planets and Life. *Webb* will study the evolution of planetary systems, including factors related to the possibility of life. It will explore the distribution of organic molecules and water in the Solar System, identify planetary signatures around other stars, image young planets in nearby systems, and study the atmospheres of planets as they transit parent stars.

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Technology development on track

Because of strong, up-front investment in technology development during the formulation phase, the *Webb* Project will soon demonstrate the readiness for flight development of all critical technologies. The design of essential flight hardware is now complete and construction has begun. All the segments of *Webb*'s primary mirror have been fabricated, and the production line is figuring and polishing them. *Webb*'s approach to wavefront sensing has been successfully demonstrated at the Keck Observatory.

All enabling technologies for the *Webb* mission are on track to meet test requirements for a NASA readiness assessment in January 2007. An independent Special Review Team has just examined all elements of the *Webb* Project and concluded that the technical content is complete and sound, and that the *Webb* team is experienced and effective.

Scientists from dozens of national and international institutions are directly involved in the *Webb* development phase. Three of its four instruments involve major international participation, and the European Space Agency will launch *Webb* on an Ariane 5 rocket. The *Webb* Project also has a broad U.S. industrial base, with contractors in 24 states.

The Next Great Observatory

The general public recognizes NASA's Great Observatories as the superb, general-user astronomical facilities they are. The *Hubble* pictures, long adorning classroom walls and personal websites across the nation, are these days being joined by images from *Spitzer* and *Chandra*. *Webb* will provide *Hubble*-quality resolution and sensitivity at near- and mid-infrared wavelengths, and will continue to expand our understanding of the universe long after these current observatories are gone.

An international, blue ribbon committee—the Science Assessment Team—recently reaffirmed the scientific value of *Webb*. It stated that since the formulation of the program in 1999, the scientific case for the telescope and its unique capabilities has grown in strength and significance. With launch in 2013 and operations until at least 2018, *Webb* will be the workhorse for the astronomy community in the next decade.

We on the SWG are designing *Webb* for you, our fellow astronomers. The *James Webb Space Telescope* will be your telescope. We encourage you to contact us with your ideas and with any questions you have about *Webb*. The SWG roster is on our website: **http://www.jwst.nasa.gov/**. Ω

Webb Status

P. Stockman, *stockman@stsci.edu*

In late January, the *Webb* project passed its Systems Definition Review (SDR). This involved two teams independently analyzing the quality and completeness of the mission profile—including system architecture, operational concepts, requirements, performance goals, and verification plan. Both teams were impressed and pronounced the *Webb* program ready to move towards a Preliminary Design Review (PDR) in 2008. The SDR milestone indicates that the design of the observatory is sound and that no further significant changes in scope are expected.

Detailed design has begun in several areas, and construction has started on long-lead items. Axsys is machining or figuring 16 of the 18 beryllium segments of the primary mirror. Tinsley has started polishing two of the segments. All four instrument projects have passed their PDRs. The instrument teams are constructing high-fidelity engineering versions to use in the initial integration of the science payload and pathfinder optical tests.

The *Webb* project is moving rapidly to prove the readiness of the new technologies in the *Webb* design (Table 1). A technology is "ready" when engineering models demonstrate the required performance, including cryogenic temperatures, vacuum, cosmic rays, and micrometeorites, in an environment similar to L2. Two of *Webb*'s advanced technologies—the material for the multi-layer sunshield and the near-infrared detectors—have achieved ready status. Meanwhile, Ball Aerospace is testing each step of the telescope alignment and wavefront sensing and control using a one-sixth scale model of the telescope. In summer 2006, a team with members from Northrop Grumman, NASA, and the Institute will begin testing the stability of a backplane segment at cryogenic temperatures and with ten-nanometer accuracy. In December 2006, the mechanical cooler for the mid-infrared instrument will be the last technology to be verified. The project will

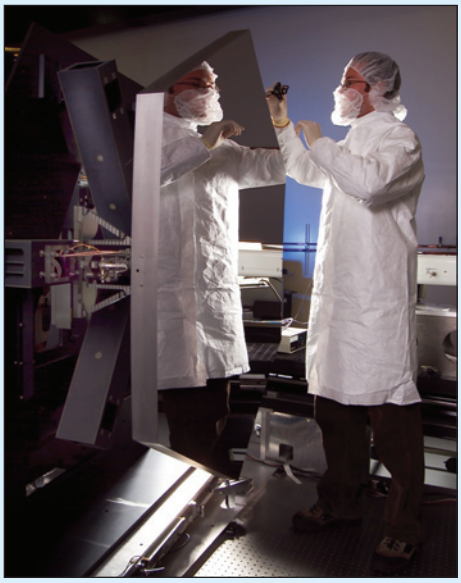


Figure 1: The polished engineering pathfinder for the *Webb* Be primary mirror segments (Ball Aerospace).

present the results of these readiness tests at a Technical Non-Advocate Review in January 2007. At that time, after a successful review and with the early manufacture of the beryllium optics, the Project will have retired the major technical risks in the development of *Webb*.

Webb Budget

In February 2006, the announcement of the President's budget for FY07 and later years brought cries of anguish from the astronomy community. Several important missions were significantly delayed or canceled. Funding for Research and Analysis (R&A) was slashed. Although the FY07 budget for *Webb* did not rise above the previously approved level, the fact it didn't decrease as for other missions—and the expectations of some that future *Webb* costs could increase—concerned many scientists. This spring, the *Webb* project discussed these issues with NASA's major advisory bodies, including the recently constituted Astronomy and Astrophysics subcommittee of the NASA Advisory Committee. The project foresees no significant change in scope. It believes adequate reserves will be available for testing and preparing for launch in FY10–FY13. Nevertheless, in the near term, the project is concerned that the levels of uncommitted reserves are low for meeting the challenges of reaching PDR in FY08 and starting the construction of the remaining mission elements. It is instructive that the *Chandra* program successfully met a similar challenge at the peak of its development.[1] Ω

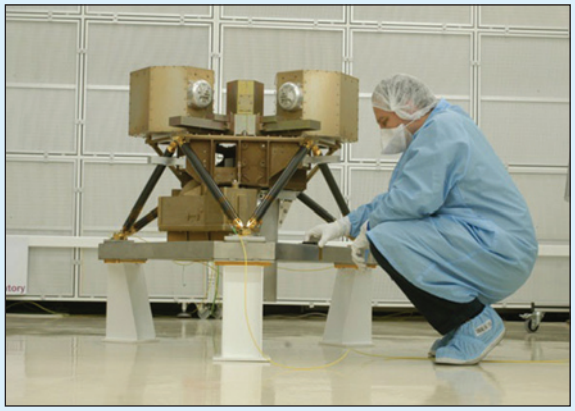


Figure 2: The structural-thermal model of the Mid Infrared Instrument for *Webb* after completing testing at the Rutherford Appleton Lab (RAL).

2006 Technology Test Schedule

Near-infrared detectors	April	Completed
Sunshield materials	April	Completed
Primary mirror segment assembly	June	Completed
Mid-infrared detectors	July	Completed
Cryogenic detector readout electronics (ASICs)	August	
Microshutter arrays for NIRSpec	August	
Cryogenic heat switches	September	
Large, precision, cryogenic structures	November	
Wavefront sensing and control	November	
Cyrocooler for MIRI	December	

[1] Hefner, K. & Davidson, G. 2004, "2004 Performance as Promised: the Chandra X-ray Observatory," AIAA-2004-5935 Space 2004 Conference and Exhibit, San Diego, California, Sep. 28–30, 2004.

Gravity's Relentless Pull: An interactive, multimedia, E/PO website on black holes

R. van der Marel, *marel@stsci.edu*, **D. Schaller,**[1] and **G. Verdoes Kleijn**[2]

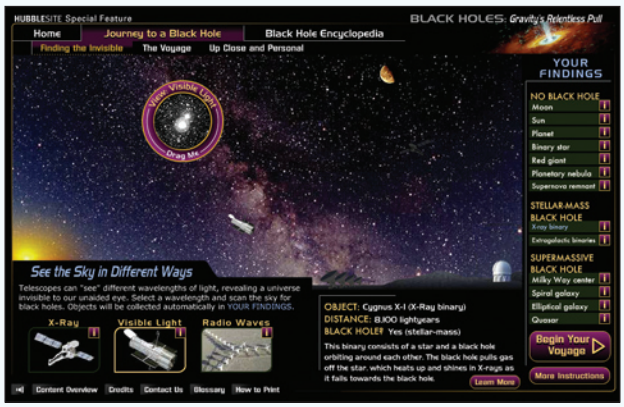


Figure 1: At the first module, a viewfinder can be moved across the sky to find and collect night sky objects. The objects can be viewed at different wavelengths, and a text box indicates whether or not a black hole has been found. The "Learn More" button provides access to a wealth of background information.

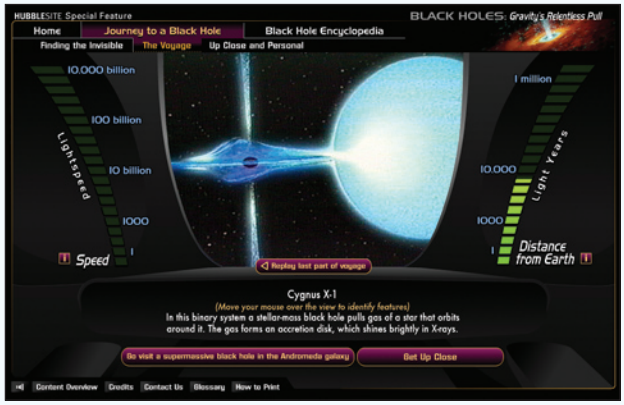


Figure 2: At the second module, the user undertakes a trip in an animated starship to a nearby black hole, encountering many intriguing objects along the way. The cockpit dials show the current speed and distance traveled. Here, the traveler has arrived at Cygnus X-1 and witnesses how a stellar-mass black hole accretes mass from its binary companion star.

Some of the *Hubble Space Telescope*'s most ground-braking discoveries have been about black holes, which are arguably the most extreme and mysterious objects in the universe. As a result, black holes appeal to a general audience in a way that almost no other scientific subject does. Unfortunately, most people have little idea of what black holes actually are, and they are more likely to associate them with science fiction than with science. These circumstances recommend black holes as a natural topic for an education and public outreach (E/PO) activity. To this end, we have created a website called "Black Holes: Gravity's Relentless Pull," which serves as the E/PO component of several *Hubble* observing projects. The new website is part of HubbleSite, the Internet home of all *Hubble* news (**http://hubblesite.org/go/blackholes**/).

Many sites on the Internet already explain black holes in one way or other. Most are encyclopedic, offering detailed text and graphics. By contrast, our site emphasizes user participation, and it is rich in animations and audio features. This approach was facilitated by the availability of powerful software for authoring multimedia content. The result is a website where scientific knowledge, learning theory, advanced technology—and pure fun—all converge.

The Website

The opening animation at our website introduces the basic concept of a black hole. It shows how one could turn the Earth into a black hole, if only one could shrink it to the size of a marble. By connecting enigma and commonplace, this scenario lends black holes a seeming familiarity.

The core of the website consists of three sequential, interactive modules, of which "Finding the Invisible" is the first. It shows the night sky with a viewfinder that can be dragged around to discover images of about a dozen objects, including some that should be familiar to the user (the Sun, Moon, and Saturn) and others that only an astronomer might recognize (Betelgeuse, Crab nebula, Cygnus X-1, Andromeda galaxy, and quasar 3C273). The user can select the wavelength range of the viewfinder: visible light, radio waves, or X-rays. The goal is to teach which types of objects contain black holes and which do not. Interested users can move to pages that explain the various objects, the telescopes used to observe them, and the features in the images at different wavelengths that indicate the presence of a black hole. In this way, the user not only learns about black holes, but also about their relation to other objects in the universe and about the methods that astronomers use to study them.

When the user has found one or more black holes, he or she can choose to go to the second module, "The Voyage," which offers a multimedia trip in an animated starship to a nearby black hole—either a stellar-mass black hole (Cygnus X-1), or a supermassive black hole (in the center of the Andromeda galaxy). The viewer traverses the Solar System as well as our own Milky Way galaxy. Various intriguing objects are encountered along the way, including many of the objects previously encountered in the first module. A goal is to connect the two-dimensional, projected

view of the night sky to the actual three-dimensional structure of the universe. In the process, the user learns about the distance scale and the layout of the local universe.

After the spaceship has arrived at the black hole, the user can proceed to the third module, "Get Up Close." Orbiting around a black hole, the sky outside the spaceship window looks strangely distorted, because of the strong gravitational lensing of distant starlight. The module discusses this and many other fascinating phenomena to be encountered near black holes.

Five interactive experiments are offered to explore specific issues. "Create a Black Hole" allows the user to study the evolution of stars of different masses by trying to create a black hole, rather than a white dwarf or neutron star. "Orbit around a Black Hole" plots relativistically correct orbits around a black hole, showing how it is possible to orbit a black hole without being sucked in. "Weigh a Black Hole" shows how to use observations of a black hole in a binary system to calculate its mass. This illustrates learning without seeing. "Drop a Clock into a Black Hole" explains time dilation and redshift. Mysteriously, an outside observer never sees a falling clock disappear beyond the event horizon, which highlights the principle of relativity. The last experiment, "Fall into a Black Hole," allows the viewer to take the final plunge and witness how one's body gets stretched by tidal forces. With this, the user's journey is complete—from the backyard view of the night sky to a personal encounter with a singularity.

Learning Theory

Our motivations for adopting a strongly interactive website were grounded in specific learning theories—"constructivism" in particular. Constructivism holds that learning is not merely an addition of items into a mental data bank, but rather requires a transformation of concepts in which the learner plays an active role making sense out of a range of phenomena. Research has shown that people use various learning styles to perceive and process information. For these reasons, we structured the scientific content in multiple ways at our website, to engage a range of learners in a variety of meaningful ways.

Novices and children often prefer interactive learning experiences, which can motivate them to stay engaged until they achieve some payoff. The interactive modules and experiments of the black hole website are tailored for this audience. They offer goal-based scenarios to motivate learning and a sense of accomplishment when completed. By contrast, experts and adults often prefer formal organization and ready access to information that they already know about and just want to locate. To reach this audience, the site also contains an encyclopedia of FAQs—frequently asked questions—about the physics and astronomy of black holes, as well as a detailed glossary.

Continued page 26

Website on Black Holes Wins Top Pirelli Prize

Roeland van der Marel (left) accepted the Top Pirelli prize for the website "Black Holes: Gravity's Relentless Pull" in Rome on May 16, 2006. Riccardo Giacconi (right), member of the international jury, winner of the 2002 Nobel Prize in physics, and former Institute director, presented the award.

The website "Black Holes: Gravity's Relentless Pull" won the top prize in the 2005 competition for the Pirelli INTERNETional Awards. This prestigious award recognizes excellence in the communication of science and technology using the Internet or other multimedia tools. Launched in 1996, the award is sponsored by the same Italian company that makes Pirelli tires.

Roeland van der Marel, who led the team that created the website, accepted the award at a ceremony in Rome. The winning team also includes Gijs Verdoes Kleijn, formerly of the Institute and now at the University of Groningen in the Netherlands, and Educational Web Adventures of St. Paul, MN, led by David Schaller, which was responsible for the design and development of the website.

Pirelli awards are given in five categories: physics, chemistry, mathematics, life sciences, and information and communications technology. An international jury selects winners from some 1,000 entries from more than 50 countries. The black hole website not only won the physics category, but also beat out the other category winners to claim the top prize of the competition.

Black Holes from page 25

We are currently working on a modified version of the website that can be used as a kiosk exhibit in museums, science centers, and planetaria. This will further broaden the audience of the project to include those people who do not have access to the Internet, or who typically do not use it to broaden their knowledge.

Current Science

The entire site is based on the most recent scientific knowledge. Recent results and ongoing projects are highlighted where possible. We will continue to update the site as new discoveries emerge.

Astronomical images from state-of-the-art telescopes are used in abundance, with a particular focus on *Hubble*.

Extensive links are provided to other websites on the Internet, which allows users to explore specific subjects in more detail.

Even with its sharp focus on black holes, our site strives to teach much more. We illustrate how humans can understand the universe by detailed observations of the night sky. We teach basic concepts, like light and gravity. We show how different perspectives can enrich our understanding of nature. We illustrate the many wonders of our universe, and demonstrate its scale by alerting the user to what is really near and what is really far away. And we highlight the many things about black holes—and our universe—that we still do not understand.

In the broadest sense, our goal has been to show that even the most mysterious of things can be understood with the combined application of human thinking and powerful technology. We hope to convey the importance of scientific thought and to instill an appreciation for learning and an interest in science, especially in the younger generation of users. Ω

1 Educational Web Adventures
2 University of Groningen

2006 Fall Mini-Workshop

B. Rothberg, *rothberg@stsci.edu*

Fall Mini-Workshop

DAY 1
- Setting the stage: mergers and the Red Sequence/Blue Cloud.
- Stellar evolution models & observations: Can you get from the Blue Cloud to the Red Sequence?
- Galaxy assembly: making predictions and testing (or breaking) the models.

DAY 2
- Low-*z* mergers and end products: merger dynamics, history of assembly and evolution, E+A galaxies.
- High-*z* progenitors: early mergers (same, similar, or different?) emergence of the Hubble Sequence.

DAY 3
- Feedback, quenching, and truncated star formation: AGNs and other mechanisms for stopping star formation.
- Final session: interactive workshop forum.

Recent deep surveys have vivified the link between star formation and galaxy evolution, driven by the process of interactions and mergers between galaxies. However, these results have also raised questions about the epoch at which the brightest and most massive galaxies formed. To promote discussion of the results and foster debate on their meaning, we will hold a mini-workshop at the Institute on October 4–6, 2006, entitled "Galaxy Mergers: from the Local Universe to the Red Sequence."

The spectroscopic and imaging surveys have found enough "red and dead" early-type galaxies to form the Red Sequence as far back as redshift $z \sim 1$. A flurry of papers on these results suggest that non-dissipative or "dry" mergers are the key to forming massive early-type galaxies, and that gas-rich or "wet" mergers cannot account for the most massive red and dead galaxies. Numerical simulations provide some support for this view.

Nevertheless, other evidence suggests that gas-rich merging is important. This evidence includes: (1) massive disk galaxies with large reservoirs of gas at $z > 1$ and colors that place them on the Red Sequence; (2) nearby giant elliptical galaxies with intermediate-age stellar populations and globular clusters; and (3) merger simulations that suggest gaseous disks at the centers of mergers are needed to achieve the same dynamical properties as elliptical galaxies.

How do these competing concepts of galaxy merging fit into our overall understanding of galaxy evolution? Can the observed color-magnitude diagram be reconciled with the predictions of cold, dark matter cosmology and hierarchical assembly?

The mini-workshop will comprise invited review talks of 30 minutes in length and approximately 20 contributed talks, which will be 20 minutes in length, with an additional 10 minutes set aside for discussion and questions. Abstracts for contributed talks should be forwarded to Quin Gryce (*gryce@stsci.edu*) by August 15, 2006. The submission deadline for poster talks is September 22, 2006. You can register online, at **http://www.stsci.edu/institute/conference/mergers**.

Payment prior to August 31, 2006, will be $230. After August 31, 2006, the registration fee will be $250. Early registration payments must be received at the Institute prior to this date. Payment at the door will be assessed at $250 by check, cash, Visa, or Mastercard only. Make checks payable to

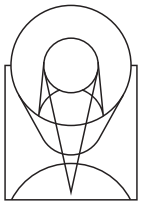
Space Telescope Science Institute. The registration fee covers the opening reception in the evening of October 4, as well as morning and afternoon snacks provided during the conference. Send payment to Quindairian Gryce, Workshop Coordinator, 3700 San Martin Drive, Baltimore, MD 21218.

For more logistical information contact: Quin Gryce, Meeting Coordinator, (*gryce@stsci.edu*, 410-338-4970). For scientific information, please contact Barry Rothberg, (*rothberg@stsci.edu*, 410-338-4835). Ω

Invited Speakers:
Josh Barnes: numerical simulations of mergers, Eric Bell: the Red Sequence/Blue Cloud from $z \sim 1$, Avishai Dekel: feedback processes, Barry Rothberg: dynamical properties of mergers, Scott Trager: stellar populations in elliptical galaxies, Pieter van Dokkum: distant red mergers, Brad Whitemore: mergers in the local universe

Scientific Organizing Committee:
Barry Rothberg, chair, Roelof de Jong, Paul Goudfrooij, John Hibbard (NRAO), Bahram Mobasher, Tom Puzia, Brad Whitmore.

Figure 1: NGC 2623, an advanced merger between two spiral galaxies. The two galaxies have coalesced into a single object with intense star formation. The bright objects within the galaxy are young clusters, which may be proto-globular clusters. Published ground-based observations show that the dynamical properties of this advanced merger remnant are consistent with an elliptical galaxy (Rothberg, B. & Joseph, R. D. 2006, *AJ*, 131, 185). This "true" color image is based on *B*, *V*, and *I* images from the Wide Field Camera of the Advanced Camera for Surveys.



Contact STScI:

The Institute's website is: **http://www.stsci.edu**
Assistance is available at *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:

Martin Elvis (chair), Harvard-Smithsonian CfA, *elvis@cfa.harvard.edu*

David Axon, RIT
Martin Barstow, U. of Leicester
Eric Emsellem, CRAL
Laura Ferrarese, HIA
Mario Mateo, U. of Michigan
Pat McCarthy, OCIW
C. Robert O'Dell, U. Vanderbilt
Regina Schulte-Ladbeck, U. Pittsburgh
Monica Tosi, OAB
Marianne Vestergaard, U. of Arizona
Donald G. York, U. Chicago

The Space Telescope Science Institute Newsletter is edited by Robert Brown, *rbrown@stsci.edu*, who invites comments and suggestions.

Technical Lead: Christian Lallo, *clallo@stsci.edu*
Contents Manager: Sharon Toolan, *toolan@stsci.edu*
Design: Krista Wildt, *wildt@stsci.edu*

To record a change of address or to request receipt of the Newsletter, please send a message to *address-change@stsci.edu*.

ST-ECF Newsletter

The 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.

Richard Hook *(Editor)*

Space Telescope–European Coordinating Facility
Karl Schwarzschild Str. 2
D-85748 Garching bei München
Germany
E-Mail: *rhook@eso.org*

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Fall Mini-Workshop

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Early registration deadline: . . . . . 31 Aug 2006
Registration deadline: . . . . . 22 Sept 2006
Poster submission deadline: . . . . . 22 Sept 2006

ASP Night at the Institute . . . . . 16 Sept 2006
Meeting of the Astronomical Society of the Pacific, Baltimore . . . . . 16–18 Sept 2006
IWPSS (5th International Workshop on Planning and Scheduling for Space) at the Institute, **http://www.stsci.edu/institute/conference/iwpss** . . . . . 22–25 Oct 2006
Webb SWG meeting at GSFC . . . . . 23–24 Oct 2006
Space Telescope Users Committee meeting at the Institute . . . . . 25–26 Oct 2006
Space Telescope Institute Council meeting at the Institute . . . . . 30–31 Oct 2006
Webb Quarterly at Northrop Grumman, Los Angeles, CA . . . . . 28–30 Nov 2006
Workshop "Astrophysics Enabled by the Return to the Moon" at the Institute 28–30 Nov 2006
OPO Ideas Panel Meeting at the Institute . . . . . 29 Nov 2006

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