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NEWSLETTER

Space Telescope Science Institute

Image Credit: The Hubble Heritage Team of astronomers celebrated its five-year anniversary with the release of the picturesque Sombrero galaxy, one of the largest *Hubble* mosaics ever assembled.

The Cycle 13 Proposal Peer Review

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Overview

Under an accelerated schedule, which has significantly shortened the time between proposal submission and observations, the Time Allocation Committee (TAC) and 11 discipline panels met in Baltimore at the end of March to evaluate the 949 proposals that were submitted in late January for Cycle 13 of *Hubble* observations and archival research. As Cycle 12 observations draw to a close this summer and Cycle 13 observations begin in July, publication and citation metrics point to the ever-increasing scientific productivity of *Hubble*. This in part reflects the high productivity of its mature instruments: the Advanced Camera for Surveys (ACS), Space Telescope Imaging Spectrograph (STIS), and Near Infrared Camera and Multi-Object Spectrometer (NICMOS). *Hubble*'s scientific success also reflects the intense competition for observing time—the Cycle 13 oversubscription in requested orbits was 5.5 to 1—and the care and consideration of the TAC and its panels in recommending the best proposals for selection.

When the Cycle 13 *Call for Proposals* (*CP*) was initially released in late summer of 2003, it was thought that the next *Hubble* servicing mission would install the Cosmic Origins Spectrograph (COS) and Wide Field Camera 3 (WFC3) near the end of the cycle. NASA Administrator O'Keefe's decision in January 2004 to cancel all further Shuttle servicing missions to the *Hubble* precluded not only the installation of COS and WFC3, but any likely visits to *Hubble* for replacement of existing components for at least 3–4 years. All observations for Cycles 13–15 will almost certainly be performed using the existing *Hubble* instruments.

One novel feature of the Cycle 13 TAC process was transparent to the community: it was essentially paperless. Every step—from issuance of the *CP* to submission/receipt of proposals, to their dissemination and evaluation by the panelists, to the notification of Principal Investigators (PIs)—was performed electronically. The Institute did offer to provide the necessary resources to any Cycle 13 panelist who wished to have paper copies of proposals to review, but only one out of one hundred panelists insisted on it. An electronic process requires much less time from start to finish.

Cycle 13 also utilized a more robust Astronomer's Proposal Tools software package, with which many PIs had gained some familiarity. The process of proposal writing and submission went smoothly for the vast majority of PIs and Co-Is.

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SUMMER [2004]

Living among the Stars

Steven Beckwith, *svwb@stsci.edu*

I was flying from Berlin to Washington, changing planes in Munich. Before boarding in Munich, there was a second layer of security, the gate agents ever vigilant for terrorists flying to America.

"Step over to the lady on your right," said the ticket agent, "She will ask you a few questions."

I stepped to the right and prepared to state that I had packed my own bags, they never left my side, I never take gifts from strangers, and I was not carrying large sums of money, agriculture products, or small animals. It needed to be quick. I did not yet have a boarding pass, and the passengers were beginning to board. The woman took my passport, noted the number of stamps, countries, and visas and asked in heavily accented English,

"Are you a scientist?" Good guess on the first try. Scientists travel a lot, a fact she knew, but something else must have given me away. Time for a shave.

"Yes," I answered. Keep it short, I thought.

"What kind?"

"I am an astronomer." My answer elicited a broad smile from my interrogator.

"Oh, how nice," she said. "Tell me, can you see back in time?"

My colleagues and I had just released the Ultra Deep Field two months earlier, so I was well prepared for this question. I explained how light took time to travel over large distances, and we can look far back in time by observing the light from objects far away, a kind of cosmic time machine—the sound bite popping out before I could squelch it.

"How far back can you see?" she pressed.

"About 13 billion light years," and I said it again in German to avoid confusion with the American use of billion.

She was immediately taken with this line of thought and spent the next few minutes asking me questions about the early universe, did I believe in black holes, did I think there was life out there, and if we Americans would save the *Hubble Space Telescope*. Usually at ease with this kind of conversation, I was nervously watching the other passengers board, convinced that these questions were not in the manual provided by United Airlines. Nevertheless, I was not going to argue with security. Finally, she capped the conversation by saying, "You astronomers are so lucky. You live among the stars, not among the people."

I gratefully accepted this graceful metaphor for our scientific passion, thanked her, and she let me go, having neglected to ask if I had packed my own bags (I had).

In a taxi in Berlin that morning, my driver had struck up a conversation with me in broken German—he was obviously a recent immigrant as I had also been in the same country 13 years ago. It did not take him long to discover I was an astronomer.

"What is happening to the *Hubble Space Telescope*?" he asked. "Is it going to die?"

"Not yet," I replied. "But it will not last more than a few more years without a visit."

"Why are the Americans so afraid," he asked again, "that they don't want to fly to *Hubble*?" This question has become a common theme abroad, the incredulity at the *Hubble* decision unfortunately enhanced by the unrelated, but prominent, events in Iraq.

All over the world, people know *Hubble* and ask me about it as soon as they learn my profession, usually before they have any hint of my deep connection to the telescope. *Hubble* has penetrated the public consciousness to an unprecedented degree for an astronomy project. There have been other times in history when a scientific idea, experiment, or practitioner became part of popular culture—the Theory of Relativity, the explosion of the first atomic bomb, and Carl Sagan, come to mind—but this happens infrequently. We are fortunate that one of our own astronomical projects, the *Hubble Space Telescope*, has become a modern icon of the progress of civilization. Even correcting for my obvious bias as an ardent *Hubble* hugger, there is little doubt that my experience mirrors those of most of my readers. *Hubble* connects us with the world at large.

NASA is now looking hard for means of keeping *Hubble* alive without risking the lives of astronauts. The only realistic way to extend *Hubble*'s life much beyond 2007 is to visit it again, changing batteries and gyroscopes and, hopefully, installing the two new focal plane instruments. NASA has to visit *Hubble* again just to strap on a de-orbit module. Doing a bit more is a logical way to accomplish two goals with one mission. Without astronauts, we will have to send robots. The team at Goddard Space Flight Center, with support from the Institute, is working out ways to do just that: send robots to add new battery packs, gyroscopes, and, yes, install the new instruments, too.

My colleagues ask often if such a mission is plausible. I have seen the laboratory demonstrations of one such system and asked a group of Institute experts to review the technical feasibility. One of our experts, David Hunter, held a series of high-level positions in the Canadian Space Agency building robots for the International Space Station, including the Special Purpose Dexterous Manipulator arm (SPDM). David's assessment is that a servicing mission using SPDM is a challenge but that all the tasks are doable. That's my assessment, too.

It is good news for all of us that NASA is looking favorably on a comprehensive robotic servicing mission, especially with installation of two new scientific instruments, which would keep *Hubble* scientifically productive for another eight years or so. It will be challenging, it will be expensive, and it will not be as tried and true as the servicing missions with astronauts, but it may achieve all of our scientific goals, and it certainly will not risk any lives in the process. This special challenge is just the kind of work that has brought NASA kudos in the past as a can-do agency.

I am optimistic that we can service *Hubble* by some method one more time in late 2007, extending its life another five or six years. The *Hubble* team has faced similar challenges in the past. Each time, the team has achieved every goal. Right now, we are living very much among people doing the hard work of putting together an entirely new kind of servicing mission so that our users can continue living among the stars. Ω

Cycle 13 Review from page 1

Peer Review Process

As reported in the Fall 2002 *Newsletter*, an external review of the Institute's TAC process in summer 2002 affirmed the basic integrity and effectiveness of the *Hubble* peer review.[1] Nevertheless, it recommended certain changes, which were implemented in the Cycle 12 TAC process. Among these recommendations were relaxing conflict-of-interest rules governing panelists' evaluation of proposals submitted from their own institutions and providing reviewer comments to PIs communicating the panel assessment.

The procedure by which the peer review panels identify the best *Hubble* proposals has evolved since its inception, although it has experienced relatively minor changes in recent cycles. It has distinctive features that are driven by the needs to evaluate a large number of proposals in each cycle and to make cross-disciplinary comparisons between proposals. These features include the following.

Two-Tiered TAC & Panel Evaluation. Proposals are divided into two categories depending upon the level of observing time and resources requested: Large (>100 orbits), Treasury, and Archival Legacy. General Observer proposals are first reviewed by the appropriate discipline panel, then evaluated and ranked by the interdisciplinary TAC, which consists of the chairs of the 11 discipline panels plus the TAC Chair. The Director normally assigns ~1/3 of the available observing time to these larger programs. The remaining ~2/3 of observing time is devoted to smaller programs, which are evaluated exclusively by the individual discipline panels and recommended for observing time and funding.

Proposal Triage. Each proposal is read by all panelists, and reviewed by one primary and two secondary reviewers with research expertise in that field. We make reviewer assignments by maximizing keyword matches specifying proposal subject and panelists' research areas. Grades are tallied before the meeting, and the lowest-ranked 1/3 of the proposals are triaged out of the process. Nevertheless, the request of a single panelist can fully reinstate any triaged proposal back into the evaluation process.

Mirror Panels. Except for the solar system panel, each discipline is covered by at least two "twin" panels, which enables proposal assignments on the basis of maximizing expertise and minimizing conflicts of interest. This feature has also led to an acceptance rate for proposals on which panelists are PIs that is the same as that for non-panelist PIs.

Progressive Orbit Subsidy. In order to encourage panels to resist the tendency to favor smaller programs because of the greater number that can be approved for the limited orbits available to a panel, the Institute subsidizes the cost in orbits charged to the panel for all proposals approved for more than 15 orbits. For each orbit approved for scheduling above that number, an increasing fraction of the orbits is

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[1] http://www.stsci.edu/resources/tac_assessment

Cycle 13 from page 3

charged against a pool of orbits held in reserve. The resulting incentive for moderate-sized programs (between 15–100 orbits) has succeeded in producing a more uniform distribution of program sizes.

Proposal Feedback

We provide comments that reflect the panel discussion and assessment of each proposal to the PI. The primary reviewers are responsible for combining the three reviews with a synopsis of the panel discussion. The secondary reviewers, the panel support scientist (an Institute scientist), and the panel chair review the comments before they are sent to the PIs.

Coordinated Observations

Cycle 13 continued the collaboration between the Institute, the National Optical Astronomy Observatories, and the Chandra X-ray Center to provide for observing time on the *Hubble* and either *Chandra* or NOAO telescopes. Under this program, proposers for *Hubble* observing time may also receive observing time on the other facilities as necessary for the science objectives of the *Hubble* proposal, up to a maximum of 400 ksec on *Chandra* and 20 nights on NOAO telescopes.

Future Cycles

The Institute considers the proposal review process to be one of its most important activities, and we remain open to suggestions for improvements to the current process. Although we do not anticipate major changes to our procedures, we are aware that *Hubble*'s capabilities may change if it is not serviced in the near future. In particular, we are concerned that gyro failures or power limitations may diminish performance. We are working with the community to address how best to maximize the science under the various operational scenarios. These considerations could conceivably impact the manner of proposal evaluation in upcoming cycles.

As we approach the first observations of Cycle 13, we are appreciative of the excellent work of the Cycle 13 TAC, the panels, and especially TAC Chair Wendy Freedman. Their efforts should result in another year of outstanding science from *Hubble*. Ω

Hubble Refines Distance to Pleiades Star Cluster

Astronomers using NASA's *Hubble Space Telescope* have helped settle a mystery that has puzzled scientists concerning the exact distance to the famous nearby star cluster known as the Pleiades, or the Seven Sisters.

The mystery began in 1997, when the European Space Agency's satellite *Hipparcos* measured the distance to the Pleiades and found it is 10 percent closer to Earth than traditional estimates, which were based on comparing the Pleiades to nearby stars. If the *Hipparcos* measurements were correct, then the stars in the Pleiades are peculiar because they are fainter than Sun-like stars would be at that distance. This finding, if substantiated, would challenge our basic understanding of the structure of stars.

But measurements made by the *Hubble Space Telescope*'s Fine Guidance Sensors show that the distance to the Pleiades is about 440 light-years from Earth, essentially the same as past distance estimates and differing from the *Hipparcos* results by more than 40 light-years.

Image Credit: NASA, ESA and AURA/Caltech

Cycle 13: TAC and Panel Members

Member	Institution
TAC Chair	
Wendy Freedman	Carnegie Institution of Washington
Solar System Panel Members	
Michael A'Hearn	University of Maryland
Fran Bagenal	University of Colorado at Boulder
Nicolas Biver	Observatoire de Paris - Section de Meudon
Michael Brown (Chair)	California Institute of Technology
John Clarke	Boston University
Richard French	Wellesley College
Bill Merline	Southwest Research Institute
Anne Verbiscer	The University of Virginia
Diane Wooden	NASA Ames Research Center
Galactic Panel Members	
Tom Ayres	University of Colorado at Boulder
Martin Barstow (Chair)	University of Leicester
Gisella Clementini	Osservatorio Astronomico di Bologna
Stephanie Cote	Dominion Astrophysical Observatory
Pierre Cox	Institut d'Astrophysique Spatiale
Giuseppe Cutispoto	INAF - Catania Astrophysical Observatory
Francesca D'Antona	INAF - Osservatorio Astronomico di Roma
Helene Dickel	University of Illinois at Urbana - Champaign
Andrea Dupree (Chair)	Smithsonian Institution Astrophysical Observatory
Suzan Edwards	Smith College/University of Massachusetts
Cesara Esteban	Instituto de Astrofisica de Canarias/Universidad de La Laguna
Rob Fesen (Chair)	Dartmouth College
Pete Garnavich	University of Notre Dame
Doug Gies	Georgia State University Research Foundation
Alice Harding	NASA Goddard Space Flight Center
Falk Herwig	Los Alamos National Laboratory
David Hollenbach	NASA Ames Research Center
Steve Howell	National Optical Astronomy Observatories
Chris Howk	University of California - San Diego
Ed Jenkins	Princeton University
James Liebert	University of Arizona
David Meyer	Northwestern University
Tony Moffat	Université de Montreal
Siobahn Morgan	University of Northern Iowa
Jon Morse	Arizona State University
Bob O'Dell	Vanderbilt University
George Pavlov	The Pennsylvania State University
Daniel Pequignot	Observatoire de Paris - Section de Meudon
Elana Pian	INAF - Osservatorio Astronomico di Trieste
Edward Robinson	University of Texas at Austin
Roger Romani	Stanford University
Robert Rood	The University of Virginia
Abhijit Saha (Chair)	National Optical Astronomy Observatories
Bradley Schaefer	Louisiana State University & Agricultural & Mechanical College
H.M. Schmid	Eidgenossiche Technische Hochschule (ETH)
Regina Schulte-Ladbeck (Chair)	University of Pittsburgh
Allen Shafter	San Diego State University
John Thorstensen	Dartmouth College
Alan Tokunaga	University of Hawaii
Kim Venn	Macalester College/University of Minnesota - Twin Cities
Bruce Wilking	University of Missouri - Saint Louis
Lee Anne Willson	Iowa State University
Frank Winkler	Middlebury College
Guy Worthey	Washington State University
Robert Zinn	Yale University

Member	Institution
Extragalactic Panel Members	
Itziar Aretxaga	Instituto Nacional de Astrofisica, Optica y Electronica
Lee Armus	California Institute of Technology
Jack Baldwin	Michigan State University
Andrew Blain	California Institute of Technology
John Blakeslee	The Johns Hopkins University
Allesandro Capetti	Osservatorio Astronomico di Torino
Chris Carilli	National Radio Astronomy Observatory
Stephane Charlot	Max-Planck-Institut für Astrophysik/CNRS, Institute d'Astrophysique de Paris
Jane Charlton	The Pennsylvania State University
Chris Conselice	California Institute of Technology
Frederic Courbin	Université de Liege
Sandra Faber	University of California - Santa Cruz
Andrew Fabian (Chair)	University of Cambridge
Jack Gallimore	Bucknell University/Space Telescope Science Institute
Karl Gebhardt	University of Texas at Austin
Rosa Gonzalez Delgado	Instituto de Astrofisica de Andalucia (IAA)
Richard Green (Chair)	National Optical Astronomy Observatories
Christine Jones (Chair)	Smithsonian Institution Astrophysical Observatory
Guinevere Kauffmann	Max-Planck-Institut für Astrophysik
Charles Keeton	University of Chicago
Jean-Paul Kneib	Observatoire Midi-Pyrénées/California Institute of Technology
Steve Kraemer	Catholic University of America/NASA Goddard Space Flight Center
Francesca Matteucci	INAF - Osservatorio Astronomico di Trieste
Patrick McCarthy (Chair)	Carnegie Institution of Washington
Brian McNamara	Ohio University
Avery Meiksin	University of Edinburgh, Institute for Astronomy
Leo Metcalfe	XMM-Newton Science Operations Centre
Heather Morrison	Case Western Reserve University
Julio Navarro	University of Victoria
Michael Pahre	Smithsonian Institution Astrophysical Observatory
Rosalba Perna	Princeton University
Patrick Petitjean	CNRS - Institute d'Astrophysique de Paris
Jason Prochaska	University of California - Santa Cruz
Alice Quillen	University of Rochester
Brigitte Rocca-Volmerange	CNRS - Institute d'Astrophysique de Paris
Larry Rudnick	University of Minnesota - Twin Cities
John Salzer	Wesleyan University
Rita Sambruna	George Mason University
David Sanders	University of Hawaii
Craig Sarazin	The University of Virginia
Joe Shields	Ohio University
Daniel Stern	Jet Propulsion Laboratory
Pieter van der Kruit (Chair)	Kapteyn Astronomical Institute
Joachim Wambsganss	Astrophysikalisches Institut Potsdam
Liliya Williams	University of Minnesota

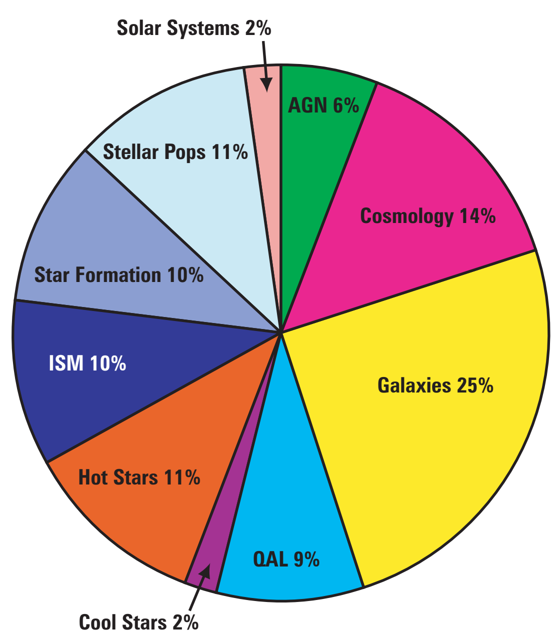
Proposals By Country

Country	Submitted	Approved
Australia	13	2
Austria	1	0
Belgium	3	2
Brazil	2	1
Canada	6	2
Chile	3	0
France	13	2
Germany	29	5
Greece	2	0
India	1	0
Ireland	3	0
Israel	3	1
Italy	22	2
Japan	1	0
Korea	1	0
Mexico	3	0
Poland	1	0
Russia	3	1
South Africa	1	0
Spain	8	2
Sweden	5	0
Switzerland	6	1
The Netherlands	11	4
United Kingdom	55	9
Venezuela	1	0
United States	752	175
ESA Countries	169	31

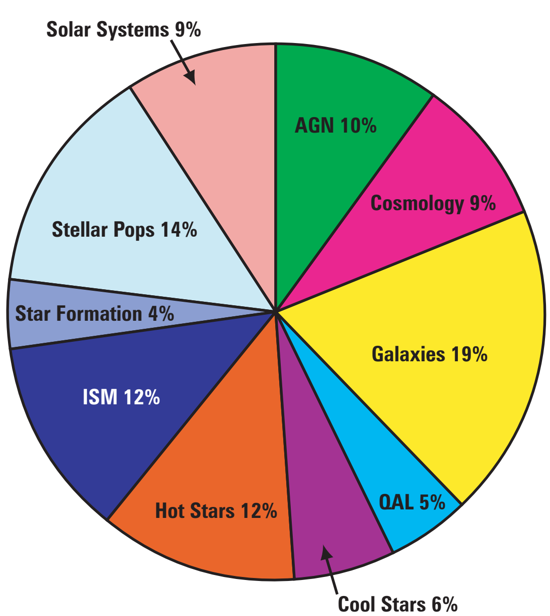
Summary of Cycle 13 Results

Proposals	Requested	Approved	% Accepted	ESA Accepted	ESA % Total
General Observer	739	144	19.5%	28	19.4%
Snapshot	82	21	25.6%	3	14.3%
Archival Research	89	31	34.8%		
AR Legacy	6	1	16.7%		
Theory	33	12	36.4%		
Total	**949**	**209**	**22.0%**	**31**	**18.8%**
Primary Orbits	17257	3111	18.0%	489	15.7%

Orbit Results By Science



Proposal Results By Science



US Proposals By State

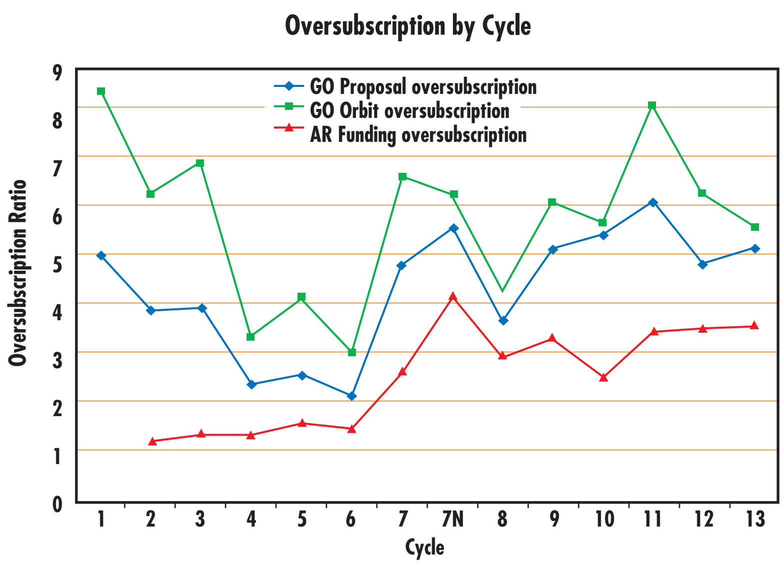
State	Submitted	Approved
AL	8	0
AZ	56	11
CA	114	33
CO	36	9
CT	6	4
DC	27	4
DE	5	0
FL	12	0
GA	8	1
HI	12	2
IL	15	6
IN	5	0
KY	4	3
LA	5	1
MA	47	10
MD	147	36
MI	19	4
MN	8	1
MO	5	0
NC	1	0
NH	3	1
NJ	12	4
NM	11	2
NY	36	5
OH	16	4
OK	1	1
OR	1	0
PA	49	12
RI	1	0
SC	4	1
TN	5	0
TX	34	11
VA	12	2
WA	13	5
WI	10	1
WY	4	1

Instrument Statistics

Instruments	Mode	Requested Orbits	%	Approved Orbits	%
ACS/HRC	Imaging	1714	7.9%	267	
ACS/HRC	Spectroscopy	11	0.1%	0	
ACS/SBC	Imaging	141	0.6%	6	
ACS/SBC	Spectroscopy	12	0.1%	7	41.9%
ACS/WFC	Imaging	8114	37.2%	1413	
ACS/WFC	Spectroscopy	96	0.4%	0	
FGS	POS	366	1.7%	0	
FGS	TRANS	29	0.1%	29	0.7%
NIC1	Imaging	363	1.7%	37	
NIC2	Imaging	1412	6.5%	373	18.7%
NIC3	Imaging	1652	7.6%	346	
NIC3	Spectroscopy	74	0.3%	0	
STIS/CCD	Imaging	375	1.7%	29	
STIS/CCD	Spectroscopy	835	3.8%	273	
STIS/FUV	Imaging	54	0.2%	18	
STIS/FUV	Spectroscopy	2790	12.8%	532	30.1%
STIS/NUV	Imaging	22	0.1%	7	
STIS/NUV	Spectroscopy	1625	7.5%	355	
WFPC2	Imaging	2119	9.7%	344	8.5%
Total		**21804**		**4036**	

Orbits include coordinated parallel usage
Excludes Pure Parallel and Snapshot programs

Proposal Acceptance Ratio



Name	Institution	Type	Title
Extragalactic Programs			
Aaron Barth	California Institute of Technology	GO	Stars versus Gas: A Direct Comparison of Black Hole Mass Measurement Techniques
Misty Bentz	Ohio State University	GO	ACS/NICMOS Imaging of Bright Lyman Break Galaxy Candidates from SDSS
Joel Bregman	University of Michigan	GO	The Masses of the Ultraluminous X-ray Sources
Michael Corbin	Space Telescope Science Institute	GO	Ultracompact Blue Dwarfs: Galaxy Formation in the Local Universe?
Michael Drinkwater	University of Queensland	SNAP	Cluster Archeology: The Origin of Ultra-Compact Dwarf Galaxies
Xiaohui Fan	University of Arizona	GO	Low-Ionization BALs: Evolution or Orientation?
Gary Ferland	University of Kentucky	AR	Numerical Simulations of Outflows in Quasars: The Microphysics of BAL Winds
Rajib Ganguly	Space Telescope Science Institute	AR	Searching for Quasar-intrinsic Absorption through Time Variability
Igor Karachentsev	Russian Academy of Sciences, Special Astrophysical Obs.	GO	Dark vs. Luminous Matter in the CenA/M83 Galaxy Complex
Leon Koopmans	Kapteyn Astronomical Institute	SNAP	Dark-matter Halos and Evolution of High-*z* Early-type Galaxies
Claudia Kretchmer	The Johns Hopkins University	GO	Tracing the Emergence of the Hubble Sequence among the Most Luminous and Massive Galaxies
Bradley Peterson	Ohio State University	GO	Structure of the Accretion Disk in the NLS1 NGC 4051
Daniel Proga	University of Colorado at Boulder	AR	Outflows from Seyfert Galaxies: A Challenge to Current Models
Andrew Robinson	Rochester Institute of Technology	GO	The Nuclear Scattering Geometry of Seyfert Galaxies
Joseph Shields	Ohio University	GO	A Fundamental Test of Accretion Physics with NGC 4203
Isaac Shlosman	University of Kentucky	AR	Formation of Structure in AGN Accretion Disk Winds: Theory and Observational Implications
William Sparks	Space Telescope Science Institute	SNAP	Infrared Snapshots of 3CR Radio Galaxies
Clive Tadhunter	University of Sheffield	GO	What Drives the Outflows in Powerful Radio Galaxies?
Farhad Yusef-Zadeh	Northwestern University	AR	The Distribution of Stars around the Massive Black Hole at the Galactic Center
Farhad Yusef-Zadeh	Northwestern University	GO	A Coordinated NICMOS and XMM Experiment to Observe the Variability of Sgr A*
Nahum Arav	University of Colorado at Boulder	GO	Abundances in AGN Outflows: Putting Real Numbers into Quasar Feedback Scenarios
Aaron Barth	California Institute of Technology	GO	A Multiwavelength Study of POX 52, a Dwarf Seyfert Galaxy with an Intermediate-mass Black Hole
Mariangela Bernardi	Carnegie Mellon University	SNAP	The Most Massive Galaxies in the Universe: Double Trouble?
John Biretta	Space Telescope Science Institute	GO	*HST/Chandra* Monitoring of a Dramatic Flare in the M87 Jet
Christopher Conselice	California Institute of Technology	GO	The Origin of Dwarf Galaxies and Steep Luminosity Functions in Clusters
Derek Fox	California Institute of Technology	GO	Solving the Mystery of the Short-hard gamma-ray Bursts
Jack Gabel	University of Colorado at Boulder	GO	Radial Velocity Variability in the Mass Outflow in the Seyfert 1 Galaxy NGC 3783
Paul Goudfrooij	Space Telescope Science Institute	GO	Globular Cluster Systems of Giant, Post-starburst Shell Ellipticals
Andres Jordan	Rutgers, the State University of New Jersey	GO	The ACS Fornax Cluster Survey
Chien Peng	University of Arizona	GO	The Coevolution of Supermassive Black Holes and Galaxies at $z \sim 3$
Norbert Pirzkal	Space Telescope Science Institute	AR	Morphological Analysis of $z = 5.7$ Lyman alpha Sources in the GOODS/UDF Fields
Thomas Puzia	Space Telescope Science Institute	GO	Resolving Globular Clusters in NGC 1399
James Rhoads	Space Telescope Science Institute	GO	Probing the Surroundings of a Highly Luminous Redshift 6.5 Galaxy
Jessica Rosenberg	University of Colorado at Boulder	GO	The Size and Shape of a Spiral Galaxy's Gaseous Halo
Anil Seth	University of Washington	AR	The Globular Cluster Systems of Low-mass Spiral Galaxies
Charles Steidel	California Institute of Technology	AR	The Physical Nature of Galaxy Morphology during the Peak Epoch of Galaxy Formation

Name	Institution	Type	Title
Nicole Vogt	New Mexico State University	GO	Mass Distributions of $z \sim 1$ Galaxies: Probing Substructure and Dynamical Evidence for Bulges in Velocity Profiles
Rachel Webster	University of Melbourne	GO	Microarcsecond Imaging of a Gravitationally Lensed QSO: 2237+0305
Lin Yan	Jet Propulsion Laboratory	AR	Extremely Red Galaxies at $z > 1$ in the COSMOS Field
Almudena Alonso-Herrero	Instituto de Estructura de la Materia	GO	Star Formation in Luminous Infrared Galaxies: Giant HII Regions and Super Star Clusters
C. Carollo	Eidgenossiche Technische Hochschule (ETH)	GO	Bulges or Disks in the Centers of Late-type Spirals?
Seth Cohen	Arizona State University	AR	Structural Evolution of Galaxies with GOODS and the Ultra Deep Field
Frederic Courbin	Université de Liege	GO	The Nature of Quasar Host Galaxies: Combining ACS Imaging and VLT Integral Field Spectroscopy
Arlin Crotts	Columbia University in the City of New York	GO	Accurately Mapping M31's Microlensing Population
Donald Garnett	University of Arizona	GO	The Star Formation History and Metallicity Evolution of M33: A Comprehensive Study of Disk Evolution
Armando Gil de Paz	Carnegie Institution of Washington	AR	Determining the Formation Epoch of Dwarf Galaxies Using the *HST*/ACS Ultra Deep Field
Karen Leighly	University of Oklahoma Norman Campus	GO	Where is the Wind in 1H0707–495?
Jodie Martin	The University of Virginia	AR	Archival Study of Merger-induced Populations in Early-type Galaxy Cores
Hagai Netzer	Tel Aviv University - Wise Observatory	GO	Can Narrow-line Regions in Luminous AGN Be Enormously Large?
Christopher O'Dea	Space Telescope Science Institute	SNAP	The Co-Evolution of Star Formation and Powerful Radio Activity in Galaxies
Jason Prochaska	University of California - Santa Cruz	GO	Star Formation in Damped Ly-alpha Galaxies: Testing the Connection with the Lyman Break Population
Douglas Richstone	University of Michigan	GO	The Masses of the Quasar Relics
Rachel Somerville	Space Telescope Science Institute	AR	Constraints on Galaxy Formation Models from Size Evolution of Galactic Disks and Spheroids
Thaisa Storchi-Bergmann	Universidade Federal do Rio Grande do Sul	GO	STIS Follow-up Spectroscopy of Seyfert Galaxies from Cycle 11 near-UV Imaging Survey
Bradley Whitmore	Space Telescope Science Institute	GO	In-Depth Study of the Antennae with NICMOS and ACS
Wei Zheng	The Johns Hopkins University	AR	Windows of the Early Universe beyond Redshift 7
Narciso Benitez	Instituto de Astrofisica de Andalucia (IAA)	GO	NICMOS Observations of A1689
Megan Donahue	Michigan State University	SNAP	A Snapshot Survey of a Complete Sample of X-ray Luminous Galaxy Clusters from Redshift 0.3 to 0.7
Richard Ellis	California Institute of Technology	AR	The Assembly History of Disks and Bulges out to $z = 1$
Christopher Fassnacht	University of California - Davis	GO	ACS Observations of the Gravitational Lens B1608+656: Characterizing the Einstein Ring
David Kirkman	University of California - San Diego	AR	The Astrophysics of the Intergalactic Medium at Intermediate Redshifts
George Miley	Universiteit Leiden	GO	Imaging a Protocluster at $z = 3.1$: Effects of Environment and Evolution on Galaxy Populations in the Early Universe
Priyamvada Natarajan	Yale University	AR	Probing the Nature of Dark Matter Using Cluster Lensing
Jason Rhodes	California Institute of Technology	AR	Connecting Mass to Light in the GOODS Fields
Regina Schulte-Ladbeck	University of Pittsburgh	AR	Discovery of Two Star-forming Galaxies Causing Strong Quasar Absorption Lines
David Turnshek	University of Pittsburgh	GO	Probing the Outer Regions of M31 with QSO Absorption Lines
David Tytler	University of California - San Diego	GO	Doubling the Data on the HeII Re-ionization of the Intergalactic Medium
Scott Anderson	University of Washington	SNAP	UV Confirmation of New Quasar Sightlines Suitable for the Study of Intergalactic Helium
Romeel Dave	University of Arizona	AR	SLACR: The Simulation Lyman alpha Comparison Repository
Richard Ellis	California Institute of Technology	GO	Characterizing the Sources Responsible for Cosmic Reionization
Christopher Fassnacht	University of California - Davis	AR	Properties of Moderate-redshift Galaxy Groups Associated with Gravitational Lenses
Marijn Franx	Universiteit Leiden	GO	Morphologies of a New Class of Rest-frame Optical Selected High-redshift Galaxies
Nickolay Gnedin	University of Colorado at Boulder	AR	Confronting *HST* Observations of Dwarf Spheroidals with Theory
Caryl Gronwall	The Pennsylvania State University	AR	The Morphology of Ly-alpha Emission Galaxies at $z = 3.11$ in the GOODS-S Field

Name	Institution	Type	Title
Christine Jones	Smithsonian Institution Astrophysical Observatory	GO	Dark Matter Constraints from the Merging Cluster 1E0657–56
Smita Mathur	Ohio State University	GO	A Combined *HST/Chandra* Study for Finding the Baryons in the Low-redshift Universe
Nicholas Morgan	Yale University	GO	Probing a Damped Lyman-alpha System along Two Lines of Sight
Roser Pello	Observatoire Midi-Pyrénées	GO	Morphology of $z \sim 7$–10 Galaxies Viewed through Gravitational Telescopes
Regina Schulte-Ladbeck	University of Pittsburgh	GO	The Connection between Star-forming Galaxies and Low-redshift Quasar Absorption Line Systems
Tommaso Treu	University of California - Los Angeles	GO	Co-Evolution of Spheroids and Black Holes
R. Tully	University of Hawaii	GO	Groups of Dwarf Galaxies: Pools of Mostly Dark Matter?
Wei Zheng	The Johns Hopkins University	GO	Tracing the Reionization History of Intergalactic Helium out to Redshift 3.8
Galactic Programs			
Scott Anderson	University of Washington	GO	The Formation Histories and Dynamical Roles of X-ray Binaries in Globular Clusters
Gary Ferland	University of Kentucky	GO	Physical Processes in Orion's Veil: A High Resolution UV Absorption Study of the Line of Sight toward the Trapezium
Robert Fesen	Dartmouth College	GO	Imaging the Chemical Distribution in Type Ia SN Ejecta
Boris Gaensicke	The University of Warwick	SNAP	Toward a Global Understanding of Accretion Physics: Clues from an UV Spectroscopic Survey of Cataclysmic Variables
Edward Guinan	Villanova University	GO	Toward an Accurate Calibration of the Galactic Cepheid P-L Zero Point
Paul Kalas	University of California - Berkeley	GO	Multi-color *HST* Imaging of the GJ 803 Debris Disk
Anthony Moffat	Université de Montreal	GO	Weighing the Most Luminous Main-sequence Star in the Galaxy
Mark Morris	University of California - Los Angeles	AR	Accreting White Dwarfs and Neutron Stars near the Galactic Center
Edmund Nelan	Space Telescope Science Institute	SNAP	Resolving OB Binaries in the Carina Nebula, Resuming the Survey
George Pavlov	The Pennsylvania State University	GO	Ultraviolet Spectrum of the Binary Millisecond Pulsar J0437–4715
Seth Redfield	University of Texas at Austin	SNAP	A Snapshot Survey of the Local Interstellar Medium: New NUV Observations of Stars with Archived FUV Observations
Letizia Stanghellini	Space Telescope Science Institute	GO	Planetary Nebulae in the SMC: A Study of Stellar Evolution and Populations in an Extremely Low-metallicity Environment
Ben Sugerman	Space Telescope Science Institute	GO	Evolution of Light Echoes of SN 1993J
Daniel Welty	University of Chicago	GO	A Mini-Survey of Interstellar Abundances in the Magellanic Clouds
Matthew Bobrowsky	Space Telescope Science Institute	AR	Departures from Axisymmetry in Planetary Nebulae
You-Hua Chu	University of Illinois at Urbana - Champaign	GO	Resolving the Thermal Conduction Front in the Bubble S308
Geoffrey Clayton	Louisiana State University & Agricultural & Mechanical College	GO	The Shadow Echoes of the Unique R Coronae Borealis Star, UW Cen
Scott Friedman	Space Telescope Science Institute	GO	Constraining Models of Galactic Chemical Evolution and Mixing by Measuring the Spatial Variability of D/H in the Interstellar Medium
Douglas Gies	Georgia State University Research Foundation	GO	Wind Accretion and State Transitions in the Black Hole Binary Cyg X-1
Carole Haswell	Open University	GO	IY UMa: A Literal Probe of Accretion Disc Structure
Robert Kirshner	Harvard University	GO	SAINTS: Supernova 1987A INTensive Survey
James Lauroesch	Northwestern University	GO	Prospecting for Rare Elements in the Interstellar Medium
Stephen Lawrence	Hofstra University	AR	The SN 1987A/LMC "Deep Field"
Charles Proffitt	Catholic University of America	SNAP	STIS Snapshot Survey of Boron Abundances in Early-B Stars
Thomas Rauch	Dr.-Remeis-Sternwarte, Bamberg	GO	On the Evolutionary Status of Extremely Hot Helium Stars: Are the O(He) Stars Successors of the RCrB Stars?
Richard Shaw	National Optical Astronomy Observatories	SNAP	Snapshot Survey of SMC Planetary Nebulae
Stephen Smartt	University of Cambridge	GO	Direct Imaging of the Progenitors of Massive, Core-collapse Supernovae
Danny Steeghs	Smithsonian Institution Astrophysical Observatory	GO	Accretion in the Closest Binary Systems Known

Name	Institution	Type	Title
Todd Tripp	University of Massachusetts	AR	Fundamental Properties of Gas in the Distant Galactic Halo and Leading Arm of the Magellanic Stream
Alycia Weinberger	Carnegie Institution of Washington	GO	Imaging of Ices in Circumstellar Disks
Mark Wyatt	Royal Observatory Edinburgh	GO	Coronagraphic Imaging of eta Corvus: A Newly Discovered Debris Disk at 18 pc
Silvia Zane	Mullard Space Science Laboratory	GO	Optical Identification of Two Nearby Isolated Neutron Stars through Proper Motion Measurement
John Bahcall	Institute for Advanced Study	GO	Observing the Next Nearby Supernova
Luciana Bianchi	The Johns Hopkins University	GO	A Search for gamma Cas Analogs at Low Metallicity
Adam Frank	University of Rochester	AR	The Astrophysics of Heterogeneous ("Clumpy") Stellar Outflows
Robert Hynes	University of Texas at Austin	GO	A UV Survey of Quiescent Black Holes and Neutron Stars
GianLuca Israel	INAF, Osservatorio Astronomico di Roma	GO	Unveiling the Nature of the 321s Orbital Period Binary RXJ0806.3+1527
Edward Jenkins	Princeton University	AR	A Comprehensive Study of Interstellar Depletions
Charles Keyes	Space Telescope Science Institute	GO	Multi-wavelength Observations of Symbiotic Stars in Outburst
Christian Knigge	University of Southampton	GO	A Deep Far-UV Search for the Interacting Binary Population in M80
Claus Leitherer	Space Telescope Science Institute	SNAP	A Lyman-alpha Snapshot Survey of FBS and SBS Galaxies
Blair Savage	University of Wisconsin - Madison	GO	Origins of the Highly Ionized Gas toward the X-ray Bright BL Lac Object Mrk 421
Glenn Schneider	University of Arizona	GO	Solar Systems in Formation: A NICMOS Coronagraphic Survey of Protoplanetary and Debris Disks
Roberto Soria	University College London	GO	ACS/HRC Imaging of Two Very Bright Ultra-Luminous X-ray Sources (ULXs)
Paula Szkody	University of Washington	GO	Determining the Instability Strip for Accreting White Dwarfs
Nolan Walborn	Space Telescope Science Institute	GO	Critical STIS Spectroscopy and ACS Imagery at the Top of the IMF
Alycia Weinberger	Carnegie Institution of Washington	GO	Spatially Resolved Spectroscopy of HR 4796A's Dust Ring
Daniel Welty	University of Chicago	GO	HD 62542: Probing the Bare, Dense Core of an Interstellar Cloud
Klaus Werner	Universitat Tübingen, Institut für Astronomie und Astrophysik	GO	UV Spectroscopy of the Hot Bare Stellar Core H1504+65
David Zurek	American Museum of Natural History	GO	A New Class of Bright Ultraviolet Variable Sources in the Globular Cluster NGC 1851
Jay Anderson	Rice University	GO	Astrometric and Photometric Study of NGC 6397 for Internal Motions, Dark Binaries, and X-ray Sources
Thomas Ayres	University of Colorado at Boulder	GO	The Deep Lamp Project
Charles Bailyn	Yale University	GO	The Core Dynamics of the Dense Globular Cluster NGC 6752
Luigi Bedin	Universitá di Padova	GO	Solving the Problem of the White Dwarf Cooling Sequence End in M4: An Efficient Approach
Andrew Cole	Kapteyn Astronomical Institute	GO	Pre-History of a Starburst: Deep Imaging of IC 10
Kelle Cruz	University of Pennsylvania	GO	Resolving a Binary System that Straddles the L/T Transition
Richard de Grijs	University of Sheffield	GO	Our Galaxy's Most Promising Super Star Cluster Candidate, Westerlund 1: Tip of the Iceberg?
Michael Endl	University of Texas at Austin	GO	Detecting the Elusive Low-mass Companion around epsilon Indi
Edward Guinan	Villanova University	GO	Lyman-alpha FUV Observations of the Sun in Time and Effects on Planetary Atmospheres
William Harris	McMaster University	GO	The Most Massive Star Clusters: Supermassive Globular Clusters or Dwarf Galaxy Nuclei?
Suzanne Hawley	University of Washington	AR	Investigation of M Dwarf Atmospheres Using Archival STIS Data
Gregory Herczeg	University of Colorado at Boulder	GO	Uncovering the Unknown Ly-alpha Flux in Classical T Tauri Stars
Donald Hoard	California Institute of Technology	SNAP	A Never-before Explored Phase Space: Resolving Close White Dwarf/Red Dwarf Binaries
John Huchra	Smithsonian Institution Astrophysical Observatory	GO	Star Clusters and Stellar Populations in M81
Henry Kobulnicky	University of Wyoming	GO	Resolving the Distance Ambiguity for the Galactic Open Cluster Westerlund 2
Weidong Li	University of California - Berkeley	SNAP	A Snapshot Survey of the Sites of Recent, Nearby Supernovae

Name	Institution	Type	Title
Kevin Luhman	Smithsonian Institution Astrophysical Observatory	GO	Searching for the Bottom of the Initial Mass Function
Dean McLaughlin	Space Telescope Science Institute	AR	Origin of the Globular Cluster Fundamental Plane
I. Reid	Space Telescope Science Institute	SNAP	Ultracool Companions to the Nearest L Dwarfs
Raghvendra Sahai	Jet Propulsion Laboratory	AR	The Hydrodynamics of Collimated Flow Interactions around Dying Stars
Ricardo Schiavon	The University of Virginia	GO	Spatially Resolved Mid-UV Spectra of the Centers of Local Group Galaxies
Nathan Smith	University of Colorado at Boulder	GO	An ACS H-alpha Survey of the Carina Nebula
Gerardo Vazquez	Space Telescope Science Institute	AR	Photo- and Spectro-Chemical Evolution Models for Starburst Galaxies
Michael West	University of Hawaii	GO	Ages and Metallicities of the Intergalactic Globular Cluster Population in Abell 1185
Przemyslaw Wozniak	Los Alamos National Laboratory	SNAP	Probing the Dynamics of the Galactic Bar through the Kinematics of Microlensed Stars
Charles Alcock	University of Pennsylvania	SNAP	Systemic Proper Motions of the Magellanic Clouds from Astrometry with ACS: II. Second Epoch Images
Jay Anderson	Rice University	GO	Improving the Astrometric Calibration of ACS/WFC for the Most Useful Filters
Howard Bond	Space Telescope Science Institute	GO	Post-AGB Stars in the Halo of M81
Wolfgang Brandner	Max-Planck-Institut für Astronomie - Heidelberg	GO	NICMOS Differential Imaging Search for Planetary Mass Companions to Nearby Young Brown Dwarfs
Thomas Brown	Space Telescope Science Institute	GO	The Formation Mechanisms of Extreme Horizontal Branch Stars
Rupali Chandar	Space Telescope Science Institute	AR	Evolution of Stars and Stellar Systems. I. The Initial Size Distribution of Clusters
Robin Ciardullo	The Pennsylvania State University	GO	Determining the Origin of Virgo's Intracluster Stars
Gordon Drukier	Yale University	AR	Theoretical Studies of the Cores of Globular Clusters
Annette Ferguson	Max-Planck-Institut für Astrophysik	GO	Probing the Formation and Evolution of M31's Outer Disk and Halo, Part II
Karl Gebhardt	University of Texas at Austin	AR	Central Surface Brightness Profiles of LMC Globular Clusters
Dean Hines	Space Science Institute	GO	Imaging Polarimetry of Young Stellar Objects with ACS and NICMOS: A Study in Dust Grain Evolution
Elliott Horch	University of Massachusetts - Dartmouth	GO	The Astrophysical Parameters of Very Metal-poor Halo Binaries
Roberta Humphreys	University of Minnesota - Twin Cities	GO	The 3D Morphology of the Extreme Red Supergiant VY CMa
Alex Lobel	Harvard University	GO	A Critical Test for Radiatively Driven Hot Winds in Cool Stars
James Neff	College of Charleston	GO	Are Dust Disks and Circumstellar Gas around Young A Stars Unrelated Phenomena?
Antonella Nota	Space Telescope Science Institute	GO	Current Star Formation in Young, Compact Clusters in the Small Magellanic Cloud
Edward Olszewski	University of Arizona	GO	The 3-D Shape of the SMC: Is It Tidally Distorted?
Slawomir Piatek	New Jersey Institute of Technology	GO	Space Motions for the Draco and Sextans Dwarf Spheroidal Galaxies
Raghvendra Sahai	Jet Propulsion Laboratory	SNAP	When Does Bipolarity Impose Itself on the Extreme Mass Outflows from AGB Stars? An ACS Snapshot Survey
Christopher Sneden	University of Texas at Austin	GO	Probing the Nucleosynthesis Products of the First Stars
Schuyler Van Dyk	California Institute of Technology	AR	The Local Environments of Supernovae
Alfred Vidal-Madjar	CNRS, Institute d'Astrophysique de Paris	GO	Physical Parameters of the Upper Atmosphere of the Extrasolar Planet HD209458b
Solar System Programs			
Michael A'Hearn	University of Maryland	GO	Rotation of Comet Tempel 1
William Borucki	NASA Ames Research Center	GO	ACS and WFPC2 Stellar Photometry in the Kepler Mission Target Field
John Clarke	Boston University	GO	Saturn's Auroral Energy Deposition Coordinated with Cassini UVIS
Lori Feaga	Space Telescope Science Institute	AR	The Distribution and Variability of Io's SO_2 Atmosphere

Name	Institution	Type	Title
Paul Feldman	The Johns Hopkins University	GO	The Gas Environment of Comet 9P/Tempel 1 During the Deep Impact Encounter
Denis Grodent	Université de Liege	GO	Identification of a Magnetic Anomaly at Jupiter from Satellite Footprints
Amanda Hendrix	Jet Propulsion Laboratory	AR	An Analysis of *HST* and *IUE* Spectra to Investigate the Effects of Space Weathering at Ultraviolet Wavelengths
Erich Karkoschka	University of Arizona	GO	Jupiter's Upper Stratospheric Hazes Probed with Ganymede
Ralph Lorenz	University of Arizona	GO	Titan: Huygens Probe Entry Fireball and UV Seasonal Change
Tariq Majeed	University of Michigan	AR	Jovian Upper Atmospheric Dynamics and Thermal Structure from STIS Observations of Auroral Emissions
William Merline	Southwest Research Institute	GO	Determination of Orbits and Colors for Two New Binaries in the Koronis Asteroid Family
Kathy Rages	SETI Institute	SNAP	Atmospheric Variability on Uranus and Neptune
Mark Showalter	NASA Ames Research Center	GO	The Moons, Rings and Arcs of Uranus: Discovery and Dynamics
John Spencer	Southwest Research Institute	GO	The Relative Roles of Volcanism and Sublimation in Supporting Io's Atmosphere
Peter Tamblyn	Southwest Research Institute	AR	Deep Archival Search for Trans-Neptunian Objects
Laurence Trafton	University of Texas at Austin	AR	Electron Impact Simulations of Io's Atmosphere
David Trilling	University of Pennsylvania	GO	Recovery of Three Faint Kuiper Belt Objects Discovered with *HST*
Jody Wilson	Boston University	AR	The Escape of Oxygen from Mars
Michael Wong	University of California - Berkeley	GO	Fresh Ammonia-ice on Jupiter: The Northern Equatorial Region
Large Programs			
Jill Bechtold	University of Arizona	AR	The Legacy *HST* Data Set of IGM Spectroscopy
Thomas Brown	Space Telescope Science Institute	GO	The Formation History of Andromeda
Marc Davis	University of California - Berkeley	GO	The Evolution and Assembly of Galactic Disks: Integrated Studies of Mass, Stars, and Gas in the Extended Groth Strip
Alex Filippenko	University of California - Berkeley	GO	Toward a Comprehensive Understanding of Type Ia Supernovae: The Necessity of UV Observations
J. Howk	University of California - San Diego	GO	Testing the Warm-hot Intergalactic Medium Paradigm
Shrinivas Kulkarni	California Institute of Technology	GO	Unveiling the Progenitors and Physics of Cosmic Explosions
Matthew Malkan	University of California - Los Angeles	GO	The NICMOS Grism Parallel Survey
Adam Riess	Space Telescope Science Institute	GO	PANS: Probing Acceleration Now with Supernovae
David Silva	European Southern Observatory - Germany	SNAP	The Next Generation Spectral Library
Inseok Song	University of California - Los Angeles	GO	Coronagraphic Survey for Giant Planets around Nearby Young Stars
Treasury Programs			
Massimo Robberto	Space Telescope Science Institute	GO	The *HST* Survey of the Orion Nebula Cluster

Status of the Hubble 'Two-Gyro' Mode

R. Doxsey, *doxsey@stsci.edu*

Throughout *Hubble*'s 14-year lifetime, the longevity of the gyros used by the Pointing Control System (PCS) has been a concern. Gyros have been replaced on several servicing missions, and there was a 6-week period in 1999 when observations were suspended because the available complement of working gyros dropped below three, the number required for normal operations. The tragic *Columbia* accident in February 2003 led to the realization that the next planned servicing of *Hubble* would likely be delayed beyond the projected lifetime of the current complement of gyros. In response, the *Hubble* project at Goddard Space Flight Center (GSFC) and the Institute began developing the capability to carry out science operations using two rather than three gyros. The availability of such a mode will provide 12 to 18 months of additional observing time with *Hubble*.

In early summer 2004, the technical work required to implement the two-gyro pointing mode is progressing well. The PCS engineers and flight software group at GSFC are well into the design, implementation, and testing of the mode, which requires using other sensor data to replace the 'missing' third gyro of normal operations. The replacement data comes from the magnetometers, Fixed Head Star Trackers (FHSTs), and Fine Guidance Sensors (FGSs). The first changes to the flight software, implementing new processing of magnetometer and FHST data, were uplinked to *Hubble* in May and are performing well. Two further incremental installations are planned, one in the fall and one in January 2005, when full flight test of the two-gyro mode will be conducted.

The pointing information from the magnetometers and FHSTs is much less accurate than that from a gyro. As a result, the pointing errors after slews and occultations of the target by the Earth will be much larger than at present: 3 to 10 degrees compared with 5 to 25 arcsec. The major challenge of developing the two-gyro mode is designing and implementing the steps necessary to correct this error to the level where the FGSs can acquire guide stars. Because these steps will have a large impact on the process of scheduling observations, we have been making major changes to our scheduling systems to accommodate the two-gyro mode.

The two-gyro mode will increase the pointing jitter of the telescope line of sight. Current estimates are that the jitter pattern will go from a 5 to 7 milliarcsec circle to an approximately 10 by 30 milliarcsec oval. The PCS engineers will be carrying out high-fidelity simulations of the performance of the mode over the summer, which Institute instrument scientists will assess in terms of the scientific impact on the various instrument modes.

The Institute has started posting information for observers about the two-gyro mode on the web (**http://www.stsci.edu/hst/HST_overview/TwoGyroMode**), which we will update regularly. By fall, we will have a handbook on the two-gyro mode, which will cover all the relevant material.

Based on the current predictions of gyro lifetime, there is a possibility that we will need to begin using the two-gyro mode sometime during Cycle 14. For this reason, we will modify our procedures for soliciting and selecting proposals to accommodate this possibility. These changes will be reflected in the Cycle 14 *Call for Proposals*, which will be released in October. Proposers for Cycle 14 will be required to provide information in their Phase I proposals regarding the suitability of their program under two-gyro mode as well as the normal three-gyro mode. Ω

Scheduling with Two-Gyro Pointing

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M. Reinhart, *reinhart@stsci.edu*, **R. Doxsey,** *doxsey@stsci.edu*

As a deliberate feature of its design, *Hubble* can normally view a very large portion of the sky. At any time, the only forbidden area is a 50-degree radius circle around the Sun. Even targets in the ecliptic plane are available ~250 days each year. This design provides a great deal of flexibility, both for observers and for schedulers of the telescope. Observers take advantage of the flexibility by specifying specific orientations for their observations or specific times or time intervals for their observations. Schedulers take advantage of it by distributing observations evenly across the year, avoiding 'fat' or 'lean' weeks in the schedule.

As the development of two-gyro mode has progressed, the Institute has studied the impact on scheduling, where flexibility will be considerably reduced. While details may change as the mode is completed, the basic implications for scheduling are now understood. In this article, we present a summary of those impacts. Details can be found at **http://www.stsci.edu/hst/HST_overview/TwoGyroMode**, which will be updated with new information as it is available.

Hubble pointing is remarkably accurate, even when the Fine Guidance Sensors (FGSs) are not used for guiding. The pointing drifts are only ~5 arcsec during the ~40 minutes when a target is occulted by the Earth. The pointing error after a large slew of the telescope is generally < 50 arcsec. These small errors make it relatively easy to acquire, or re-acquire, guide stars.

The foundation of *Hubble*'s high pointing precision is the use of three gyros. Loss of one of the gyros will result in much larger pointing errors—of order degrees—after occultations and slews. In the two-gyro mode, the Fixed Head Star Trackers (FHSTs) will compensate for this loss of accuracy, using a step-by-step process (see Figure 1). The need to use the FHSTs for extended periods, of order 20 minutes, is the factor that makes scheduling more difficult, and reduces flexibility.

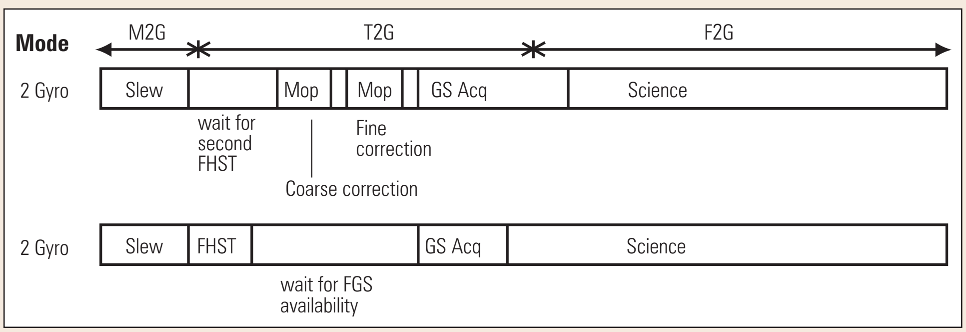

Figure 1: The lower timeline shows the use of FHSTs for three-gyro operations. At most, a short, five-minute FHST update is needed at any time between the end of the slew and the start of the guide-star acquisition. The upper timeline shows the use of FHSTs for two-gyro mode. Magnetometers and two gyros are used for the slew itself (M2G). At the end of the slew, one FHST is used to zero-out the drift rates. When a second FHST is available, it is used to take a map of the star field, to determine and correct the pointing error, which can be as much as 10 degrees. A second map is required, and the FHSTs are used to stabilize the telescope while the guide stars are found. The total time when FHSTs are required is shown with the 'T2G' bar.

The FHSTs do not see the sky in the direction that the telescope is pointing, but instead they point aft, in nearly the opposite direction. There is a requirement that the sightlines of the FHSTs be clear of the Earth prior to the view-direction of the telescope being clear. Satisfying this requirement eliminates many of the observing times available in three-gyro mode (see Figure 2). A narrated animation showing how the sky availability changes through the year is available at **http://www.stsci.edu/hst/HST_overview/TwoGyroMode/2GyroMovies**.

In two-gyro mode, targets at low declinations can be viewed about half the year, generally in one contiguous period. Targets at high declinations, including the continuous viewing zones, will have periodic availability, governed by the 56-day precession of the *Hubble* orbit. All parts of the sky will be accessible at some time during the year. The number of days per year when any target can be observed in two-gyro mode is about half that in three-gyro mode (see Figure 3). We are developing graphics for the

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website to compare the three- and two-gyro cases for specific target locations, to allow observers to take these factors into account when designing future observing programs.

As a part of our scheduling studies, we evaluated the impact of some of the parameters changing as the development of the two-gyro mode proceeds. We found that changes in timing and viewing restrictions had only small impacts on the overall scheduling situation. We are confident that the general character of the scheduling situation will be as described here. Ω

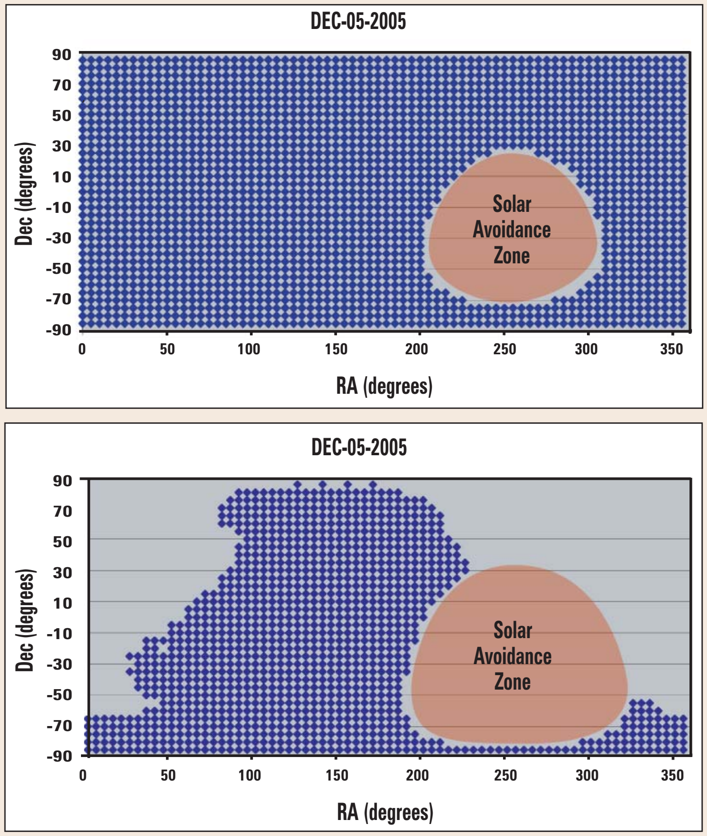

Figure 2: The upper panel shows sky availability for three-gyro mode for a date in December 2005. The only unavailable area is the 50-degree radius region around the Sun. The lower panel shows the sky availability on the same day for the two-gyro mode. Only points with the blue symbols are available for scheduling on this day. Portions of the sky about to pass through the Sun are not available, while those following the Sun are available. The Solar Avoidance zone is also 10 degrees larger than in three-gyro mode.

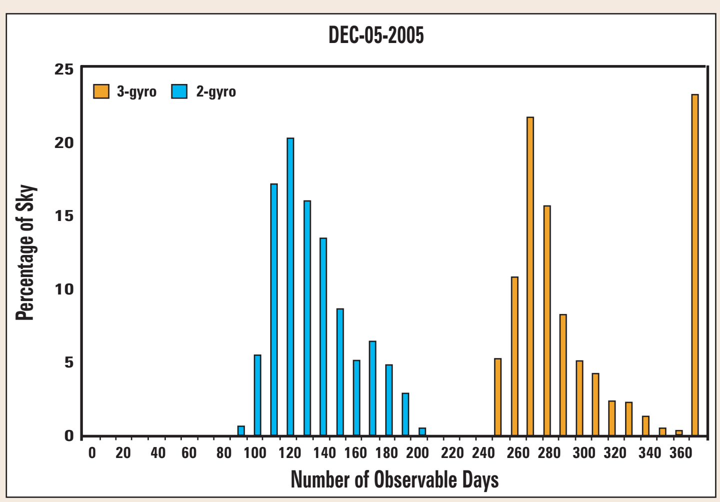

Figure 3: Comparison of sky availability in two- and three-gyro modes. Sky availability in two-gyro mode is reduced by about half from the availability in three-gyro mode.

Advanced Camera for Surveys News

R. van der Marel, *marel@stsci.edu*

Recent science results with the Advanced Camera for Surveys (ACS) continue to show its power for deep imaging and studying the early universe.

On March 9th, in the presence of Maryland Senator Barbara Mikulski, Institute Director Steven Beckwith unveiled the Hubble Ultra Deep Field (UDF). It provides the deepest view into the universe to date. The UDF used the ACS Wide Field Channel (WFC) for 400 orbits in the filters F435W, F606W, F775W, and F850LP to reach to about 30th magnitude and detect more than 10,000 objects.[1] The observations were obtained using Director's Discretionary time, and the data were made available to the astronomical community without a proprietary period. Complementary imaging with the Near Infrared Camera and Multi-Object Spectrometer (NICMOS) further increases the value of this dataset. There is no doubt that the UDF will be a unique resource for a wide range of scientific investigations for many years to come. Information on the UDF and data products is available at **http://www.stsci.edu/hst/udf**.

No distant supernovae were found in the UDF data. By contrast, a team led by A. Riess found 42 supernovae in the data from the ACS Great Observatories Origins Deep Survey (GOODS) program, which is a shallower survey of a wider field than the UDF. The GOODS sample includes six of the seven most distant supernovae known.[2] The apparent brightnesses of the supernovae give cosmologists a way to measure the expansion rate of the universe at different times in the past. The results confirm and refine previous evidence that the cosmological expansion is accelerating due to a strange phenomenon called 'dark energy,' the nature of which remains unknown. It could be the energy of empty space, represented by Einstein's cosmological constant, or it could be the effect of a changing energy field dubbed 'quintessence.' Future observations with Hubble/ACS will undoubtedly provide further insight into the properties of dark energy and the universal expansion.

Observations of distant clusters yield insight into the formation and evolution of galaxies over a broad range of cosmic time. [3] John Blakeslee and his team observed the massive cluster RDCS 1252.9–2927 and inferred that its galaxies formed the bulk of their stars at redshifts $z > 3$. George Miley and his collaborators uncovered, for the first time, a proto-cluster of 'infant galaxies' at $z = 4.1$. This cluster is so young that its member galaxies are still actively forming stars. These findings are consistent with the cosmological paradigm wherein clusters form from the merger of many sub-clusters in a universe dominated by cold dark matter. However, clusters of galaxies had not previously been observed to exist this early in the age of the universe.

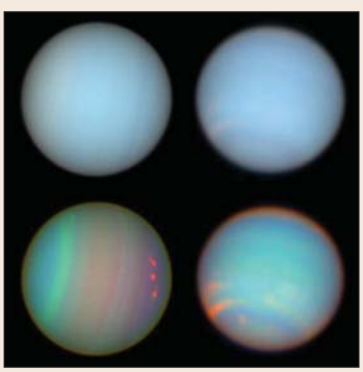

Figure 1: Uranus and Neptune observed by ACS and STIS in a variety of filters. The top panels show the planets in their natural colors, and the bottom panels use an enhanced color representation to highlight atmospheric features. (**http://hubblesite.org/newscenter/newsdesk/archive/releases/2004/05/**)

A team led by Jean-Paul Kneib used ACS to observe the much nearer galaxy cluster Abell 2218. In their images they found a distant galaxy that is gravitationally lensed by the foreground cluster into a pair of strikingly similar images. [4] The arrangement and color of these images indicate a very distant object with a redshift in the range $z = 6.6$ to 7.1. Spectroscopy with the Keck Observatory places the redshift of the galaxy in the upper end of that range, which may make it the most distant object yet discovered. Due to the magnification of 25 afforded by the foreground cluster, these observations provide a rare glimpse of the very early universe. The galaxy, observed when the universe

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was barely five percent of its current age, may be typical for the type of young stellar systems that ended the cosmological 'dark ages.'

M. Brown (Caltech) and his team used the High Resolution Channel (HRC) on ACS to image Sedna, the farthest known object in the solar system, seeking evidence of a satellite. They had recently discovered Sedna at Mt. Palomar and named it after the Inuit goddess of the ocean. Based on the long rotational period inferred from light curves—20 to 50 days—the researchers expected to find a satellite, which could slow Sedna's rotation by tides. However, the ACS images show no sign of a companion, which makes the slow rotation even more interesting.[5] The fact that the HRC image of Sedna is unresolved places an upper limit on the object's size of approximately three-quarters the diameter of Pluto.

In another recently completed study, Erich Karkoschka and his team used ACS and the Space Telescope Imaging Spectrograph (STIS) to image Uranus and Neptune. [6] Figure 1 shows the planets both in their natural color and in an enhanced color representation that highlights atmospheric features. Wider-view ACS images of Uranus also reveal its faint rings and several of its satellites.

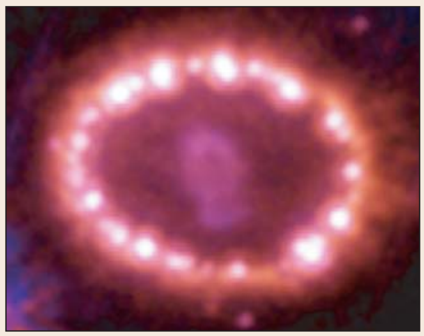

Figure 2: Supernova 1987A was the brightest stellar explosion seen since the one observed by Johannes Kepler 400 years ago. A surrounding ring of gas was in place when the star exploded, probably shed some 20,000 years earlier. This recent Advanced Camera for Surveys image shows many bright spots along the ring of gas, like a 'string of pearls.' They are produced when a supersonic shock wave unleashed during the explosion slams into the gas ring, at more than a million miles per hour.

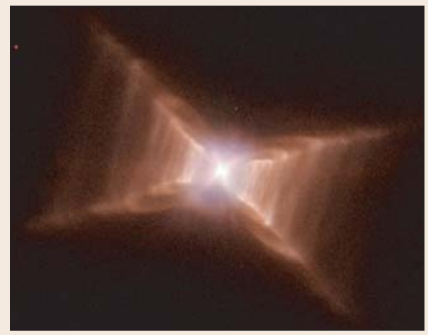

Figure 3: Wide Field and Planetary Camera 2 image of one of the most unusual nebulae known in our Milky Way, HD 44179. The nebula is more commonly called the 'Red Rectangle' because of its unique shape and color as seen with ground-based telescopes. The star in the center of the Red Rectangle began its life as a star similar to the sun, but is now ejecting its outer layers to produce the visible nebula. The X-shaped structure is due to the bi-conical geometry of the outflow. In a few thousand years, when ultraviolet light from the star makes the nebula fluoresce, the object will become a planetary nebula.

Other stunning ACS images that were recently released show the 'string of pearls' caused by Supernova 1987A (Figure 2),[7] the light echo around the star V838 Monocerotis,[8] the nearby galaxy NGC 300,[9] and the ring galaxy AM 0644–741.[10]

ACS is not the only camera on *Hubble* providing remarkable views of the cosmos. Although astronomers use the Wide Field and Planetary Camera 2 (WFPC2) less now than over the past decade, its archive contains many undiscovered treasures. Figure 3 shows a recently released image of the Red Rectangle (HD 44179) as an example.[11]

As a result of recent ACS calibration work at the Institute, we have delivered new detector quantum efficiency curves and filter throughput curves for the WFC and HRC. The new curves reproduce the observed count rate of spectrophotometric standard stars, with accuracy better than 1% in all broad-band filters and approximately 1% for narrow-band filters. This is an improvement of 1 to 2% with respect to the curves previously used by the ACS pipeline. The pipeline has used the new files to calibrate all ACS data retrieved from the *Hubble* archive since December 10, 2003. The calibrations only affect the 'photometry keyword' section in the header of the science (SCI) extensions of the calibrated FITS files. The new zero-points and the new values of the keywords are also available at **http://www.stsci.edu/hst/acs/analysis/zeropoints**.

The ACS channels have considerable geometric distortion. This is properly taken into account when observers perform photometry on geometrically corrected, drizzled images, such as the drz.fits images produced by the ACS calibration pipeline. However, there might be instances in which it is preferable to perform photometry on flat-fielded but un-drizzled images, namely the flt.fits, also produced by the ACS calibration pipeline. It should be noted that this choice does introduce additional complexity. When ACS images are flat-fielded by the calibration pipeline, the resultant flt.fits files are flat if the original sky intensity was also flat. However, because the pixel areas on the sky vary around the field, the relative photometry of point sources in flt.fits files is incorrect. We have made new pixel area maps for WFC and HRC available on the web page **http://www.stsci.edu/hst/acs/analysis/PAMS**. When these maps are used according to the instructions, relative point-source photometry will be correct across the field. Also, the same photometric zero-points then apply as for drz.fits images.

Due to the harsh radiation environment in space, the Charge Transfer Efficiency (CTE) of CCD detectors on *Hubble* degrades slowly with time. We make regular calibration observations to monitor this degradation for the ACS CCDs. A. Riess and J. Mack analyzed data of the globular cluster 47 Tuc obtained with the WFC in March 2003, August 2003, and February 2004. The data are consistent with a slow CTE degradation that is approximately linear with time. To read out the charge in a CCD, it has to be sequentially shifted in two separate directions, called 'parallel' and 'serial,' to an amplifier in the corner of the chip. Charge can be lost in either of the two phases. Photometric losses due to imperfect parallel CTE increase with decreasing stellar flux and decreasing background surface brightness. The photometric losses decrease with increasing aperture size, probably due to the ability of large apertures to recapture a fraction of the trapped and emitted charge. There is no evidence for significant serial CTE losses at the present time. A time-dependent global fitting formula is available that allows correction for the parallel CTE losses. For details, see ACS ISR 04-06, available from **http://www.stsci.edu/hst/acs/documents/isrs**.

M. Mutchler and A. Riess (ACS ISR 04-04) analyzed how the CTE depends on detector operating temperature. This study was motivated by the expectation that an aft-shroud cooling system would be installed during Servicing Mission 4, which would have allowed a lowering of the present operating temperature to mitigate the impact of CTE. However, even at the present operating temperature they do not expect CTE degradation to be a showstopper for ACS science. They have used the correction formulae derived from calibration programs to predict the future quality of the parallel CTE. Although such extrapolations are uncertain, they expect that the vast majority of ACS science applications will retain a flux measurement precision of a few percent or better towards the end of the decade.

F. Boffi and her collaborators performed a study of possible contamination buildup on ACS. They performed repeated observations of the star cluster NGC 6681 in ultraviolet light with both the HRC and the Solar Blind Channel (SBC). The results indicate that ACS does not suffer from ultraviolet performance degradation due to contamination. For filters F220W, F250W, and F330W, any sensitivity changes must be less than one percent. By contrast, WFPC2 can show tens of percent degradation of ultraviolet throughput over the course of a month (after which decontaminating the instrument restores the original throughput). These results are not unexpected, since unlike the WFPC2, the ACS does not have a cold external window.

R. Gilliland studied the gain, full-well depth, and linearity of the ACS CCDs (ACS ISR 04-01). The CCDs on ACS can be operated at multiple gain settings. Analysis of calibration and science data yielded corrections to the various gain settings of order 1% or less with respect to the default values. Maps of the full-well depth (where saturation sets in) for both HRC and WFC show spatial variations in excess of 10%. When operated with gains that fully sample the full-well depth, and if one sums over pixels that have been bled into as a result of over-saturation, the CCDs remain perfectly linear (to better than 0.1% in relative counts) to well beyond saturation.

J. Walsh and his collaborators at the Space Telescope European Coordinating Facility (ST-ECF) analyzed the fringing of the ACS CCD detectors (ACS ISR 03-12). Fringing is only a small problem for observations using filters with relatively wide transmission curves. However, it can significantly affect grism observations at red wavelengths. The fringing of CCD detectors occurs because of interference between the incident light and the light reflected at the internal interfaces of the thin layers of the CCD chip. Knowing the construction of the CCD—the layer materials, the variation of their refractive indices variation with wavelength, and their thicknesses—the ST-ECF group calculated the resulting fringe amplitude using geometrical optics. With a simple model for the thickness, they obtained good fits to a series of narrow-band flat fields at wavelengths from 7000 to 10000 Å, which were obtained during ACS ground testing at Ball Aerospace. By applying the model maps of the layer thicknesses to ground or in-orbits flats, the observed fringing in ACS can be reduced by approximately a factor of four, to the level of a few percent rms.

In the first few years of ACS operation, the filter wheels did not always rotate to their nominal position and were sometimes off the mark by one motor step. This was not generally a problem, except for those filters that have small blemishes. A blemish produces an out-of-focus feature in the flat field, which changes position if the filter wheel does not rotate to its nominal position. For a few filter combinations,

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this led to flat-fielding errors that could exceed one percent over a small part of the field of view. We have now addressed this problem through an upgrade to the flight software, which is responsible for all on-board commanding of the instrument. Tests with the new software indicate that the filter wheel is now correctly positioned at all times.

The coronagraphic modes on HRC have presented another problem for flat-fielding. The coronagraphic spots drift randomly over a region that is some five pixels across. This necessitates the construction of a flat field that is tailored to each specific observation date. To enable this, we decompose the flat field into a static part that is applied by the calibration pipeline and a spot flat that must be applied manually. The spot flats are available from **http://www.stsci.edu/hst/acs/analysis/reference_files/hrc_coron_spotflat_list.html**. To apply the spot flat, one must know the spot position, which is monitored regularly and is also tabulated on the aforementioned web page.

The amount of hard disk storage space required for ACS images is considerable. We are therefore investigating ways to achieve significant data compression. Several years ago, Rick White and Perry Greenfield proposed a method of compressing images as floating point arrays, which can achieve considerable size reduction, due to the fact that it is not lossless. In essence, the compression gain is achieved by not storing information that is far below the image noise level. Of course, such methods raise the concern that astronomically important information might be lost. To address this concern, Colin Cox performed an analysis of a variety of ACS images, both with and without compression (ACS ISR 04-02). In the examples tested, compression ratios of about six were obtained with no significant information loss. We are investigating the possibility of making this compression algorithm available to users.

As always, consult the ACS web page at **http://www.stsci.edu/hst/acs/** for the latest information. For questions, send email to the STScI Help Desk at *help@stsci.edu*. Ω

1 **http://hubble.stsci.edu/newscenter/newsdesk/archive/releases/2004/07/**

2 **http://hubble.stsci.edu/newscenter/newsdesk/archive/releases/2004/12/**

3 **http://hubble.stsci.edu/newscenter/newsdesk/archive/releases/2004/01/**

4 **http://hubble.stsci.edu/newscenter/newsdesk/archive/releases/2004/08/**

5 **http://hubble.stsci.edu/newscenter/newsdesk/archive/releases/2004/14/**

6 **http://hubble.stsci.edu/newscenter/newsdesk/archive/releases/2004/05/**

7 **http://hubble.stsci.edu/newscenter/newsdesk/archive/releases/2004/09/**

8 **http://hubble.stsci.edu/newscenter/newsdesk/archive/releases/2004/10/**

9 **http://hubble.stsci.edu/newscenter/newsdesk/archive/releases/2004/13/**

10 **http://hubble.stsci.edu/newscenter/newsdesk/archive/releases/2004/15/**

11 **http://hubble.stsci.edu/newscenter/newsdesk/archive/releases/2004/11/**

The Heart of the Trifid Nebula

The Trifid Nebula, cataloged by astronomers as Messier 20 or NGC 6514, is a well-known region of star formation lying within our own Milky Way Galaxy. It is called the Trifid because the nebula is overlain by three bands of obscuring interstellar dust, giving it a trisected appearance as seen in small telescopes. The Trifid lies about 9,000 light-years (2,700 parsecs) from Earth, in the direction of the constellation Sagittarius.

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

MultiDrizzle in the Hubble Archive Pipeline

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Many *Hubble* observers divide their observations into multiple exposures to facilitate the rejection of cosmic rays, which can affect a large number of CCD pixels. Furthermore, they often use the technique of "dithering," whereby multiple exposures are obtained at slightly different pointings, to provide better subsampling of the *Hubble* point-spread function and to move bad pixels to different locations on the sky. Observers can combine dithered exposures into a single image using the Drizzle program (Fruchter and Hook 2002), which was implemented for the Advanced Camera for Surveys (ACS) by means of the PyDrizzle script. However, PyDrizzle focuses primarily on image registration and combination and does not directly address cosmic-ray rejection.

We developed the MultiDrizzle script (Koekemoer et al. 2002) to provide a single, automated means of aligning images, performing cosmic-ray rejection, and producing a final, cleaned, combined image using Drizzle.

MultiDrizzle is available to observers within IRAF/STSDAS, and, as of August 2004, it is also now incorporated into the *Hubble* archive pipeline. The initial pipeline implementation produces cleaned, combined images for all ACS associations, which are defined as groups of exposures obtained using dither patterns or CR-SPLIT specifications in the Phase II observing file.

MultiDrizzle is run on images that have passed through the essential steps of calibration, which include bias subtraction, flat fielding, and dark current correction. Given a set of input exposures, MultiDrizzle carries out the following steps:

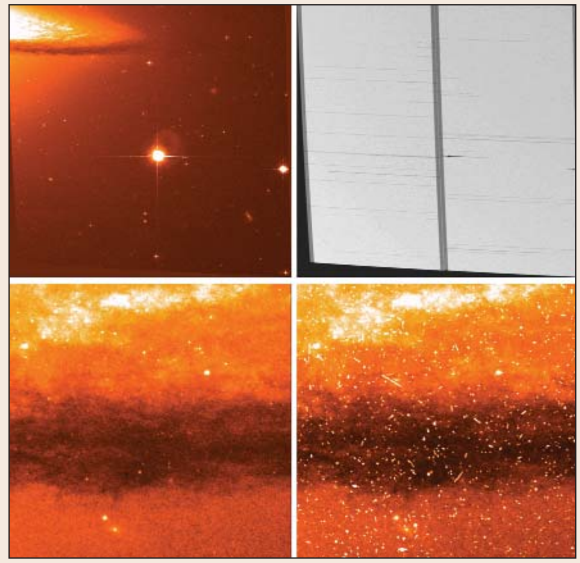

Figure 1: An example of the automatically cleaned MultiDrizzle product, for a four-exposure dithered observation of the nearby galaxy NGC 4594. The top panels show the final, full-frame drizzled and weight images (left and right, respectively). The bottom left panel shows a close-up of the output image from MultiDrizzle, while the bottom right panel shows the same region including all of the accumulated cosmic rays originally present in the exposures.

- Calculate and subtract a background sky value for each exposure;
- Search for additional bad pixels in each exposure, which are occasionally not flagged during calibration;
- Determine shifts from the coordinates in the image headers and apply these shifts in drizzling all the exposures onto a series of separate output images that are registered on a common grid;
- Use the drizzled exposures to create a first-pass cleaned image, which is essentially a sigma-clipped median image;
- Transform the first-pass, clean, median image back to the frame of each original input exposure;
- Compare each input exposure with the clean image to create a cosmic-ray mask;
- Use Drizzle to combine all the input exposures, weighted by their cosmic-ray masks, thereby creating a final cleaned output image.

Figure 1 shows an example of the type of output produced by MultiDrizzle, run with all its default parameters on a four-exposure dithered observation of the galaxy NGC 4594. The image demonstrates the good quality of the automated cosmic-ray removal within MultiDrizzle, along with the accuracy of the registration obtained from the image headers.

The initial implementation of MultiDrizzle in the *Hubble* archive pipeline, for the ACS Wide Field Channel, High Resolution Channel, and Solar-Blind Channel, can be expected to provide useful images for datasets where the standard recommendations on dithering were followed. These recommendations include obtaining at least four images of comparable exposure time and the use of a dither

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pattern or CR-SPLIT to ensure that the exposures are formally associated within the pipeline system. MultiDrizzle will also combine associations with fewer than four exposures, but due to the high rate of incidence of cosmic rays on the CCD pixels, such datasets will generally contain some pixels that are unrecoverable because they have cosmic rays in all the exposures.

If observers request the calibrated output products for ACS associations, then they will automatically receive the cleaned MultiDrizzle output image along with all the separate exposures and other related files. The output image is drizzled to the same pixel scale as the channel that was used to obtain the data and is generally oriented with north toward the top. There are some cases where observers may wish to re-run MultiDrizzle themselves on the images, perhaps using slightly different parameters in order to produce images that are optimal for particular kinds of science. For example, they may wish to use a finer pixel scale or a different orientation. This can be easily achieved by running MultiDrizzle within their own IRAF/STSDAS environment once they have received the data.

We are continuing efforts to generalize MultiDrizzle to other *Hubble* instruments and to add new capabilities. The off-line version available within IRAF/STSDAS is tested for both ACS and Wide Field and Planetary Camera 2 data; we will eventually include Space Telescope Imaging Spectrograph and Near Infrared Camera and Multi-Object Spectrometer datasets. Other enhancements—for example, the ability to empirically refine the header-based shifts—are also underway and may eventually be incorporated into the pipeline as well as the IRAF/STSDAS off-line version. We hope that the initial implementation of MultiDrizzle for ACS associations in the *Hubble* pipeline constitutes a substantial enhancement to the scientific quality of the pipeline products. Ω

References

Fruchter, A. S. & Hook, R. N. 2002, *PASP* 114, 144

Koekemoer, A. M., Fruchter, A. S., Hook, R. N., & Hack, W. 2002, *HST Calibration Workshop*, ed. S. Arribas, A. M. Koekemoer, & B. Whitmore (STScI: Baltimore), 337

Koekemoer, A. M., et al. 2004, *HST Dither Handbook*, V3.0 (STScI: Baltimore)

Space Phenomenon Imitates Art

This image resembling Vincent van Gogh's painting, "Starry Night," is *Hubble*'s latest view of an expanding halo of light around a distant star, named V838 Monocerotis (V838 Mon). This *Hubble* image was obtained with the Advanced Camera for Surveys on February 8, 2004. The illumination of interstellar dust comes from the red supergiant star at the middle of the image, which gave off a flashbulb-like pulse of light two years ago. V838 Mon is located about 20,000 light-years away from Earth in the direction of the constellation Monoceros, placing the star at the outer edge of our Milky Way galaxy.

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

Ultra-Deep Fields from Hubble to Webb

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On March 9, 2004, the Hubble Ultra Deep Field (HUDF) data were released to the astronomical community. Within 48 hours of the release, the first science paper based on these data appeared on the astrophysical preprint server. What can we learn from the HUDF that might apply to similar observing programs that might be planned for the *James Webb Space Telescope* (*JWST*)?

From a scientific point of view, the HUDF shows that objects at redshift $z > 5$ begin to display substructures when observed with sufficient sensitivity. There are also indications that galaxies at redshift $z > 6$ are rarer than expected on the basis of a simple extrapolation to higher redshifts, at constant co-moving number density, of the luminosity function at $z = 3$. Thus, *JWST* must be capable of very sensitive observations over a wide field of view to find the galaxies at significantly higher redshift than the limit of the HUDF. Indeed, the HUDF result vindicates the present design for *JWST* and its instruments. The present field of view of the Near Infrared Camera (NIRCam) is about the same as that of the Advanced Camera for Surveys (ACS). A smaller field of view for NIRCam would reduce significantly the efficiency of *JWST* to observe deep fields. High sensitivity has always been and remains a very important requirement for *JWST*.

The HUDF was perhaps the most demanding *Hubble* observation to date and provides technical lessons for *JWST*. The final HUDF images from ACS were obtained by combining up to 288 individual images. The ACS Wide Field Camera has a geometric distortion such that the pixels are diamond shaped and change in area by ~10%. The HUDF team profited from an excellent characterization of the geometric distortion of the ACS, which was carried out by J. Anderson and I. R. King for other scientific reasons. By incorporating this characterization in a custom version of drizzle, the HUDF team recovered a point-spread function (PSF) in the final images that is very close to the theoretical limit obtained by convolving the diffraction-limited width with the original pixel size of ACS. In particular, the registration of so many individual images did not result in additional broadening of the PSF.

Figure 1: A comparison of the Hubble Ultra Deep Field (left panel) with a simulated image of an ultra deep field with JWST (right panel, courtesy of Myungshin Im).

The HUDF images, obtained from both the ACS and the Near Infrared Camera and Multi-Object Spectrometer (NICMOS), show an increase in depth compared to past observations that follows the theoretical limit (given by the square root of the total exposure time). Neither ACS nor NICMOS had an original performance requirement to obtain exposures of 300,000-second duration without degradation in signal-to-noise. The fact that they do so is very promising for *JWST*, and indicates that a well-calibrated instrument can follow the theoretical curve well beyond normal expectations and levels that are testable on the ground before launch.

The Institute produced special, high-precision bias, dark, and flat-field calibrations for the ACS to support the HUDF. The large number of reference files needed to produce these calibrations had no impact on observing efficiency, because *Hubble* can obtain bias and dark files in parallel to other observations. Clearly it will be important to be able to do the same with *JWST*.

In the HUDF, the faintest galaxies contribute only 0.025% to the local sky intensity. At this level, flat-field residuals become the dominant systematic error. For the sky flat fields, the HUDF team found that only the data themselves could provide sufficiently accurate information for flat fielding. A critical step in this process was obtaining data at two different orientations, which revealed the presence of residual effects that were orientation

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dependent. For *Hubble*, the contributions from various scattered-light components at very faint levels are such that a sky image with even slightly different pointing, or obtained at a slightly different time, will be slightly different from those at the initial orientation. This effect limits the ultimate accuracy of flat-fielding shallower data sets, but it was not a problem for the HUDF because the data were sufficiently deep to provide adequate flat fielding on their own. The final sky flatness for the HUDF is better than 1% rms. The longer period of the *JWST* orbit and its distance from the Earth and the Moon may provide a more stable sky. In this case, it may be convenient to obtain sky flat-fielding images in parallel with science observations with other instruments, although it is too early to know whether this will be convenient or necessary. We anticipate that 'self' sky flats will become increasingly important at longer infrared wavelengths (>3 microns), where the level of the zodiacal light increases significantly.

While obtaining data for the primary ACS field, the HUDF observations also obtained (in parallel data on two fields with NICMOS) the two deepest near-infrared observations ever made, and on two fields with Wide Field and Planetary Camera 2 (through the F300W filter) the two deepest ultraviolet images ever obtained. By investing one million seconds of ACS time, we obtained 3.5 million seconds of data on the sky by operating all *Hubble* instruments in parallel. Clearly, it would be highly desirable to obtain such leverage by parallel observations with *JWST*. The multiplier could be a factor of four if all instruments could be operated in parallel. However, because of the high costs, such parallel science capabilities are not currently supported on *JWST*.

The glimpse of the $z > 6$ universe revealed by the HUDF reinforces the need for a *JWST* Deep Field, to push the study of galaxy formation and evolution to higher redshifts by probing longer wavelengths. *JWST* will also be able to extend to lower luminosities the study of $z > 6$ galaxies, to get a more complete view of the galaxy population at the end of the cosmic Dark Age. Ω

Progress on the JWST Primary Mirror

M. Clampin, JWST Observatory Project Scientist**,** *mark.clampin@nasa.gov*

The *James Webb Space Telescope* (*JWST*) Optical Telescope Element (OTE) continues to meet its schedule goals as the program begins fabrication of the flight optics. In the last six months we successfully passed mission and OTE requirements reviews, which were key milestones for the project.

Following the selection of beryllium technology for the *JWST* primary mirror segments, the Mirror Review Board recommended a number of additional tests on the demonstration mirror to provide early mitigation of outstanding concerns regarding beryllium. Foremost amongst these tests was a demonstration that the required mirror segment surface error of 20 nm could be achieved on a timescale compatible with the fabrication schedule for the flight mirror. Tinsley and Ball Aerospace were able to meet this additional milestone with the Advance Mirror System Demonstrator, providing a robust demonstration that the technology and process are in place for fabricating the flight-mirror segments.

The *JWST* schedule calls for an Engineering Demonstration Unit (EDU) to serve as a pathfinder for producing the eighteen flight-mirror segments and build confidence that the critical flight-mirror production pipeline will remain on schedule. Brush-Wellman, which fabricates the mirror blanks using a process called hot isostatic pressing (HIP), recently completed the EDU mirror billet and shipped it to Axys Technologies for the first phase of mirror-blank machining. Figure 1 shows the EDU unit on its mount, ready for machining. Ω

Figure 1: The primary mirror segment of the *JWST* Engineering Demonstration Unit, mounted for machining at Axys Technologies.

News from the Multi-mission Archive at STScI (MAST)

R. Somerville, *somerville@stsci.edu*, **on behalf of the MAST team**

As of May 1, 2004, MAST contained 19 terabytes of data. The average ingest rate from February through April was 16.8 gigabytes/day, and the average daily retrieval rate over this period was 59.8 gigabytes/day. There were over 22,000 web-searches of MAST holdings per month in March and April 2004. Median retrieval times have dropped to less than two hours since the installation of DADS 10.2, in December 2003, and in early May 2004, the median retrieval time was under 30 minutes!

DADS Upgrade News

The most recent DADS release occurred on June 1 & 2, 2004. We have completely redesigned the ingest function, with no direct impact to users. A new feature enables users to retrieve proprietary data to the staging disk. We encourage users to take advantage of this feature, especially if they have slow or unreliable connections. This release also features improved Secure Shell File Transfer Protocol (SFTP) transfers, with better error handling. If SFTP is not functioning properly, we can now redirect the requested data to a CD or DVD or to staging. We have improved some messages to users on the web status page to make them easier to understand.

Ultra Deep Field Release

The Ultra Deep Field (UDF) data from *Hubble* were released on March 9, 2004 (see **http://www.stsci.edu/hst/udf** for a description of the UDF program). The raw data and High-Level Science Products (HLSP), including object catalogs, are available at the Institute, the Space Telescope European Coordinating Facility, and the Canadian Astronomy Data Centre, through **http://archive.stsci.edu/prepds/udf/udf_hlsp.html**. Raw data may also be requested on DVD through MAST.

New, Streamlined HLSP Guidelines

Cycle 13 General Observers, especially PIs of Treasury or Large Programs, should note that we have simplified and streamlined the guidelines for contribution of HLSPs to MAST. The new guidelines may be found at **http://archive.stsci.edu/hlsp_guidelines.html**.

Atlas of Re-calibrated *HST*/FOS Spectra of Active Galactic Nuclei and Quasars

An atlas of recalibrated spectra of active galactic nuclei and quasars from the Faint Object Spectrograph, produced by Evans and Koratkar, is now available as a MAST HLSP (**http://archive.stsci.edu/prepds/fos_agn/index.html**).

New, Improved Tools at MAST

We have made improvements to several of our tools at MAST (check the MAST search toolbox at **http://archive.stsci.edu/mast_search_toolbox.html**). The Spectral Data Coplot Utility (**http://archive.stsci.edu/mast_coplot.html**) now has the option of displaying the average of 'like' spectra. Spectra from the *Far Ultraviolet Spectroscopic Explorer* are now included in the MAST Scrapbook (**http://archive.stsci.edu/scrapbook.php**). The VizieR search form now offers the ability to search on astronomical terms defined by NASA's Astronomical Data Center, as well as to perform keyword searches on author's name, catalog title, and catalog description. This allows searching on many object classes.

A new version of VOPLOT is now accessible from the MAST search results pages. VOPLOT is a tool for visualizing astronomical data. VOPLOT is developed in JAVA, and acts on data available in the VOTable format. For more information, see **http://vo.iucaa.ernet.in/~voi/voplot.htm**.

New VOPLOT features include:

- Projection maps for sinusoidal, Aitoff, and Mollweide Projections
- Operator calculator for easy creation of new columns and filters
- Ability to plot data on reverse *X* and *Y* axes
- Reorganization of user interface
- Bug fixes

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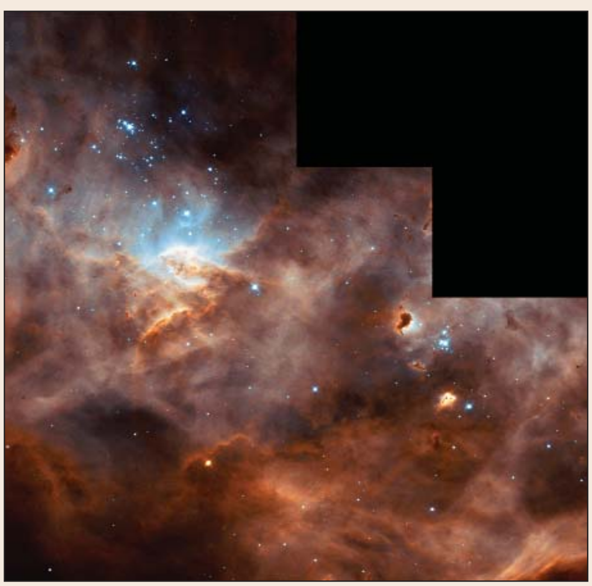
The Virtual Observatory at MAST

A new web page at **http://archive.stsci.edu/vo/** discusses MAST participation in the National/International Virtual Observatory and provides useful VO-related links. Check this site for updates about our ongoing activities. A more general site devoted to VO activities at the Institute is **http://nvo.stsci.edu/**. Some recent VO-related developments at MAST are:

- All MAST mission searches can now be returned in the VOTable format.
- *Hubble* previews are available via the VO Simple Image Access Protocol (SIAP).
- Ultraviolet Imaging Telescope image and preview data are also available via SIAP.
- GOODS Version 1 HLSPs are available via SIAP.
- Early release observations from the *Galaxy Evolution Explorer* and some *Hubble* datasets (the HDF North and South, GOODS, and the UDF) are now incorporated in a SkyQuery prototype (**http://www.skyquery.net/**). SkyQuery is a prototype of a federated database application, implemented using a set of interoperating Web services. This is a demonstration of how typical applications in the Virtual Observatory may look.
- MAST holdings can now be searched simultaneously with data from many other surveys and missions through the Data Inventory Service (DIS) (**http://heasarc.gsfc.nasa.gov/vo/data-inventory.html**), developed for the National Virtual Observatory and hosted at the High Energy Astrophysics Science Archive Research Center. The survey and mission data in the DIS currently include the Sloan Digital Sky Survey, the Two Micron All Sky Survey, the ROSAT All Sky Survey, *Hubble*, *Chandra*, and the *Energetic Gamma Ray Experiment Telescope*. Ω



Hubble Traces Firestorm of Star Formation

The Large Magellanic Cloud (LMC), located only 160,000 light-years from Earth, is the nearest galaxy outside the Milky Way in which stars are actively being formed. With its high resolution, the *Hubble Space Telescope* can study details of star formation in the LMC as easily as ground-based telescopes can study stellar formation within our own Milky Way galaxy. N11 is the second largest star-forming region in LMC. It is only surpassed in the size and activity by "the king of stellar nurseries," 30 Doradus, located opposite N11.

Image Credit: NASA, ESA, the Hubble Heritage Team (AURA/STScI), and HEIC

Hubble Fellowship Program

M. Fall, *fall@stsci.edu*

Hubble Fellowships are awarded annually to outstanding young scientists engaged in research related to the *Hubble* mission. The research may be theoretical, observational (space-based or ground-based), or instrumental. The Fellowships provide three years of salary and other support at U.S. host institutions of the Fellows' choice, subject to a maximum of one new Hubble Fellow per institution per year.

A selection committee met at the Institute in January 2004 to review more than 130 applications for Hubble Fellowships to start in September 2004. The new Fellows are listed in the table shown below.

Hubble Fellows present the results of their research each year in a Hubble Fellows Symposium at the Institute. The most recent Symposium was held on December 9 & 10, 2003.

We plan to select approximately twelve new Hubble Fellows in winter 2004/5 for positions to start in fall 2005. The announcement of opportunity, available at **http://www.stsci.edu/stsci/hubblefellow/ao.html**, provides instructions for the application process. Ω

2004 New Hubble Fellows

Name	*Host Institution*
Gaspar Bakos	Center for Astrophysics
Edo Berger	Carnegie Observatories
Joseph Hennawi	University of California at Berkeley
Kelsey Johnson	University of Wisconsin
Lisa Kewley	University of Hawaii
Anjum Mukadam	University of Washington
Masami Ouchi	Space Telescope Science Institute
Hiranya Peiris	University of Chicago
Scott Sheppard	Carnegie Department of Terrestrial Magnetism
Aristotle Socrates	Princeton University
Joshua Winn	Center for Astrophysics
Zheng Zheng	Institute for Advanced Study

Supernova Blast in Nearby Galaxy

The nearby dwarf galaxy NGC 1569 is a hotbed of vigorous star birth activity which blows huge bubbles that riddle the main body of the galaxy. The galaxy's "star factories" are also manufacturing brilliant blue star clusters. This galaxy had a sudden onset of star birth about 25 million years ago, which subsided about the time the very earliest human ancestors appeared on Earth.

Image Credit: ESA, NASA and P. Anders (Göttingen University Galaxy Evolution Group, Germany)

Hubble Meets the Giant Screen

J. Stoke, *stoke@stsci.edu*, **P. Stanley,** *pstanley@stsci.edu*

As the first high-resolution images from the Advanced Camera for Surveys (ACS) were displayed in the Institute's Office of Public Outreach, we began to ponder the question of how to best display them to the public. A single ACS image contains an IMAX-screen's worth of pixels, and we planned to produce some truly immense pictures by making mosaics of ACS images.

But IMAX? Was it time for the *Hubble Space Telescope* to meet the biggest of movie screens? We had never seriously considered working in this large-format medium, because its production usually costs hundreds of thousands of dollars per minute, far more than our budget could manage. We came up with a rather unconventional idea: a series of trailer-length (under three minutes) explorations of the universe as seen by *Hubble*, to be created almost entirely in-house and offered to the large-format theater community as a public service, at very low cost. With the help of the Maryland Science Center and D. Keighley of DKP/70MM Productions, a subsidiary of IMAX Corporation, we created the series pilot production: "*Hubble*: Galaxies Across Space and Time." DKP/70MM Productions donated the services and materials to create the negative and first print from our digital frames; without their generous contribution, we could not have proceeded.

Figure 1a and **b:** The audience watches the award-winning IMAX film, "*Hubble*: Galaxies Across Space and Time," which won Best Short Feature at the recent LFCA annual conference in Hollywood.

Would large-format theaters support the concept of adding a *Hubble* short to their schedules?

If the response of the Large Format Cinema Association (LFCA) members is any indicator, the answer is a resounding YES! "*Hubble*: Galaxies Across Space and Time" was selected as the Best Short Feature at the recent LFCA annual conference in (where else?) Hollywood, in April 2004.

We debuted the feature at the Maryland Science Center in March, and it will be running there throughout the summer. It is also now showing at the Reuben H. Fleet Science Center in San Diego. Initial feedback from a San Diego console operator at the Planetarium/IMAX dome, when asked about audience reaction, was "The public is responding well to the *Hubble* footage. Their mouths are hanging open." That was our goal! Jaws agape at the splendor of the universe!

We are developing a limited number of prints of our pilot feature while we consider feedback from viewers and theaters on the value of the program. We are also assessing the sustainability of the series by seeking corporate sponsors to subsidize the production costs for new titles. We have received inquiries from many theaters across the country, with some indicating a willingness to pay the relatively modest cost (~$1500) for their own print. That is a real show of support! Ω

It Really IS an Honor to Be Nominated

S. Kakadelis, *stratis@stsci.edu*, **P. Stanley,** *pstanley@stsci.edu*

Many of us have rolled our eyes when hearing an Oscar nominee declare, "It's just such an honor to be nominated." Well, the Institute has joined those ranks! Our HubbleSite was nominated for a prestigious Webby Award in the science category. Presented by the International Academy of Digital Arts and Sciences, a Webby Award is the leading international honor for achievement in web technology, creativity, and individual achievement. Sites undergo a rigorous six-month, three-tiered evaluation process against six criteria on the way to winning the coveted Webby Award.

The fact that HubbleSite made it to the final list of five nominees in the science category is a big honor in the Web world. While we did not win, we can take pleasure in noting that both the 'academy' winner (Exploratorium at **http://www.exploratorium.edu**) and the 'people's voice' winner (How Stuff Works at **http://www.howstuffworks.com**) both link to HubbleSite (**http://hubblesite.org**)! Ω

Figure 1: HubbleSite was honored by a Webby Award nomination in the science category.

Measuring Hubble's Impact in the Classroom

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New York City public schools and Penn State University are among the 312 U.S. school districts and 200 colleges and universities using the Institute's *Amazing Space* online curriculum-support materials as an educational resource.

This finding comes from the first phase of an impact study being conducted by the formal-education team of the Office of Public Outreach. The results so far are based on information compiled from Web-based research. The formal-education team initiated the study to determine which educational institutions are using *Amazing Space* materials and how they are being used.

Amazing Space is a space-science education program designed for K–12 students and teachers, which offers both hard copy and interactive, Web-based activities. Visit us at **http://amazing-space.stsci.edu/**.

Educators in all 50 states are using the curriculum-support material in a variety of ways. One of the largest school districts, Montgomery County in Maryland, has recently incorporated *Amazing Space*'s Hubble Deep Field Academy Activity into its eighth-grade science curriculum. Other school districts are linking *Amazing Space* to state content standards.

At the university level, in colleges of education, professors are using *Amazing Space* activities to train teachers on the principles of integrating technology into science curricula. They also are matching state education standards to *Amazing Space* activities in their education courses.

In the study's next phase, the formal-education team will pursue other methods of research to identify the use of *Amazing Space* activities, including interviewing educators across the U.S. The team is searching for answers to the following questions: How did educators discover *Amazing Space* activities? What were the evaluation criteria for selecting *Amazing Space*? Do the educators plan on continuing to use *Amazing Space*? Are they interested in partnering with the formal-education team to provide additional information about student learning? Ω

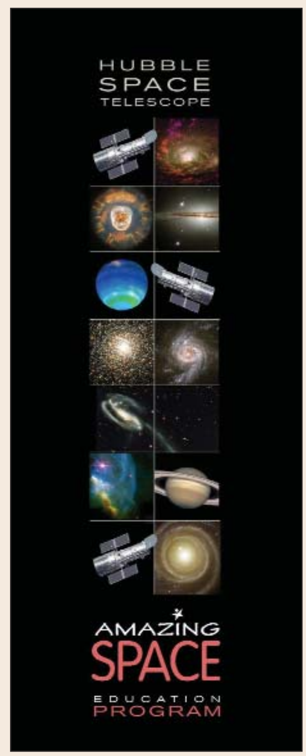


Figure 1: *Amazing Space* provides curriculum-support materials for primary and secondary education. (**http://amazing-space.stsci.edu/**)

May Symposium 2004

M. Livio, *mlivio@stsci.edu*

The Institute hosted the annual May Symposium May 3–6, 2004. The title of the symposium was "Planets to Cosmology: Essential Science in *Hubble*'s Final Years." Approximately 120 participants attended.

As the title implies, the goal was to attempt to identify scientific topics that should be given high priority in *Hubble*'s observation program during the time remaining before the telescope ceases operation. Accordingly, in contrast to the more scientifically focused meetings of previous years, this year's symposium covered a broad range of astronomy. The agenda consisted of sessions devoted to general subjects: planets, star formation, super-massive black holes, the interstellar and intergalactic media, galaxy formation and evolution, the Hubble Ultra Deep Field, and dark energy. In addition to the 32 invited and contributed talks, this symposium included a special panel discussion, in which five experts presented and discussed their perspectives on science priorities for the coming few years.

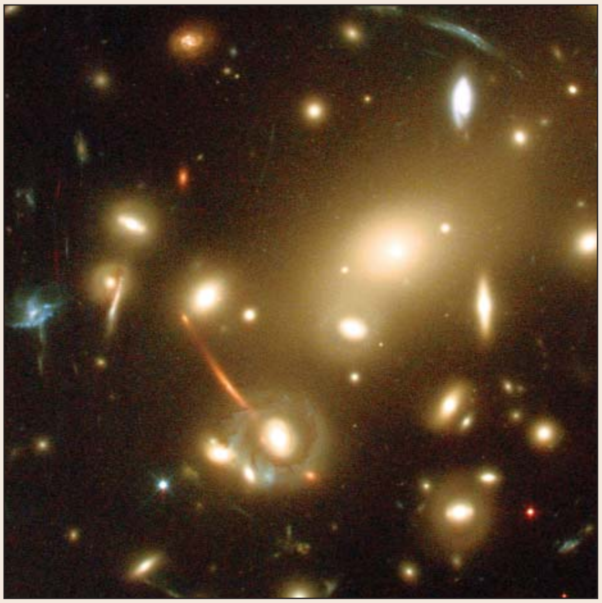
The two topics that stood out are arguably the two most intriguing questions in astrophysics today: (1) what is the nature of the mysterious dark energy that propels the universe into accelerating expansion? and (2) does extraterrestrial life exist? *Hubble* is making—and can continue to make—unique and important contributions on both of these questions.

Currently, *Hubble* observations of supernovae at redshift $z > 1$ place the most meaningful constraints on the equation of state of dark energy. Specifically, the observations show the equation of state is consistent with that expected from Einstein's cosmological constant. Future observations can decrease the current error bars on the parameters of the equation of state by a factor of two.

Only *Hubble* is capable of accurately measuring supernovae in the critical range of redhshifts, where the transition between decelerating and accelerating expansion occurred. This will be true for at least another seven years, until *JWST* is operating.

Hubble is also the only telescope now capable of determining the atmospheric composition of extrasolar planets. For the transiting planet around HD 209458, *Hubble* has already detected the presence of sodium, hydrogen, and oxygen. Because the atmosphere is an important factor in a planet's potential habitability, these measurements are landmark first steps toward the goal of detecting life outside the solar system.

The future servicing of *Hubble* is becoming more realistic. The 2004 May Symposium displayed a strong case for continuing operations based on the outstanding science value of *Hubble* observations yet to be made. Ω



Farthest Known Galaxy in the Universe

An international team of astronomers may have set a new record in discovering what is the most distant known galaxy in the universe. Located an estimated 13 billion light-years away, the object is being viewed at a time only 750 million years after the big bang, when the universe was barely 5 percent of its current age. The primeval galaxy was identified by combining the power of NASA's *Hubble Space Telescope* and CARA's W. M. Keck Telescopes on Mauna Kea in Hawaii. These great observatories got a boost from the added magnification of a natural "cosmic gravitational lens" in space that further amplifies the brightness of the distant object.

Image Credit: ESA, NASA, J.-P. Kneib (Caltech/Observatoire Midi-Pyrénées) and R. Ellis (Caltech)

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: Debbie Elmegreen (chair), Vassar College, *elmegreen@vassar.edu*

David Axon, RIT	C. Robert O'Dell, Vanderbilt U.
Martin Elvis, Harvard-Smithsonian	Regina Schulte-Ladbeck, U. Pittsburgh
Eric Emsellem, CRAL	Lisa Storrie-Lombardi, Caltech
Karen Meech, IfA	Monica Tosi, OAB
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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)*

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"Two-Gyro Pointing" workshop at STScI .17 November 2004
Space Telescope Users Committee meeting at STScI . . . . . .18–19 November 2004
Space Telescope Institute Council meeting at STScI . . . . . . .22–23 November 2004

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