Hubble vs. New Ground-Based Optics

The Hubble Space Telescope (HST) represents an historic leap forward for optical and ultraviolet astronomy. However, the aberration in the HST’s primary mirror has led many to claim that powerful new ground-based telescopes will equal or surpass HST's performance. On the other hand, when optically corrected after the Servicing Mission in late 1993, the sensitivity of HST to very faint objects will increase by about 10 times. Each type of telescope offers astronomers unique strengths. Astronomy will make its mark on history with a combination of advanced ground-based systems and the restored Hubble Space Telescope.

How are new technologies improving the performance of ground-based telescopes? What science can only Hubble do?

Two features of telescope design are crucial in comparing the capability of ground-based telescopes: resolving power and light gathering power. Location also is a key factor which in many cases outweighs the differences in resolving power and light gathering power of telescopes.

Keck I’s 10-meter surface is an array composed of a mosaic of 36 hexagonal segments, which are operated in unison (photo 1). [Cutaway drawing by Steven Simpson courtesy of Sky and Telescope.] After servicing late in 1993, the Hubble Space Telescope (photo 2) will have its chance to capture faint objects far out and back in time when the universe was in infancy.

Light Gathering Power

One measure of a telescope's capability is light gathering power. The bigger the area of a lens or mirror, the more light from an object that can be captured and focused to make a brighter image. For cameras, it’s the f-stop which controls how much area of the lens is available: The more area (lower f-numbers), the shorter the exposure needs to be to form an image. Because astronomers study very faint objects in the sky, they need telescopes with as big an area as possible to collect and concentrate light into an image.

The most light-hungry instruments are the spectroscopes which take the incoming light and split it into an array, like colors of the rainbow, called a spectrum. With these spectra scientists can tell what kinds of atoms and molecules are found at very great distances or far back in time and how hot and how fast they are moving.

The world’s largest telescope, the W. M. Keck telescope in Mauna Kea, Hawaii, instead of one mirror, is made of many individually controlled, hexagonal mirror segments. Keck’s multi-mirror array has a 110-meter (33-foot) aper-
The WASP
Volume 25, Number 12 — December 1993

Published by:
Warren Astronomical Society, Inc.
P.O. Box 1505
Warren, Michigan 48090-1505

1993 OFFICERS

President: Robert Halsall 781-6784
1st Vice President: Marty Kunz 477-0546
2nd Vice President: Jeff Bondono 731-4706
Secretary: Nancy Rowe 544-9081
Treasurer: Mike O'Dowd 268-7125
Librarian: Louis Namee 777-0742

The Warren Astronomical Society, Inc. is a local, non-profit organization of amateur astronomers. The Society holds meetings on the first and third Thursdays of each month, starting at 7:30 p.m.

General meeting on first Thursdays:
Cranbrook Institute of Science
500 Lone Pine Road
Bloomfield Hills, Michigan

Business meeting on third Thursdays:
Macomb Community College
South Campus, Building B, Room 209
14500 Twelve Mile Road
Warren Michigan

MEMBERSHIP AND DUES
Membership in the Society is open to all. Annual dues are:

Student $12.00
College $17.00
Individual $25.00
Additional Family Members $ 5.00 per person
Senior Citizen $15.00

Among the many benefits of membership are:

- Discount magazine subscriptions:
  Astronomy $16.00 (12 monthly issues)
  Sky and Telescope $18.00 (12 monthly issues)
- Free copy of each WASP newsletter.
- Free use of Stargate Observatory.
- Special interest subgroups. (See subgroup chairpersons.)
- Call list - don't miss unexpected events.
- Free membership in Astronomical League.
- Free copy of Reflector (Astronomical League newsletter).
- Free use of W.A.S. library. (See Librarian.)
- Rental telescopes. (See Observatory Chairperson.)

Send membership applications and dues to:
Mike O'Dowd 268-7125
4734 Brockham Way
Sterling Heights, Michigan 48310

WARREN ASTRONOMICAL SOCIETY PAPER
The WASP is the official monthly publication of the Society. Each new issue of the WASP is made available at the Macomb meeting on the third Thursday. Non-members will be charged $1.00 for each new issue. Back issues, when available, are free. Requests by other clubs to receive the WASP and other correspondence should be addressed to the editor.

Articles for inclusion in the WASP are strongly encouraged and should be submitted to the editor on or before the first Thursday of each month. For further information on contribution, see the "Instructions for Authors" box on page 4 of Volume 23, Number 5.

Send articles to the editor:
Douglas E. Goudie (313) 680-0434
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Troy, Michigan 48083-2405
Internet: cl771@cleveland.freenet.edu

Disclaimer: The articles presented herein represent the opinions of their authors and are not necessarily the opinions of the Warren Astronomical Society or this editor. The WASP reserves the right to edit or deny publication of any submissions.

STARGATE OBSERVATORY
The observatory is owned and operated by the Society. Located on the grounds of Camp Rotary on 29 Mile Road, 1.8 miles east of Romeo Plank Road, Stargate features a 12.5 inch f/17 club-built Cassegrainian telescope under a steel dome. The observatory is open to all club members in accordance to the "Stargate Observatory Rules:" Those wishing to use the observatory must call the Observatory Chairperson (2nd Vice President) by 7:00 p.m. on the evening of the session.

LIBRARY
The Society maintains a library of astronomy-related books and periodicals at the Macomb County Community College meeting room. See the Librarian for rules or to check out a book.

SUBGROUPS
Special interest subgroups exist for those interested in specialized areas of astronomy. Contact the chairperson of each subgroup for more information on that group.

Computers: Larry Kalinowski 776-9720
Deep Sky: Doug Bock 750-0273
Lunar / Planetary: Riyad Matti 548-7511
Solar: Marty Kunz 477-0546

Telescope making:

CALL LIST
The Call List is a list of people who wish to be alerted of spectacular and unexpected astronomical events. Anyone who notices such an event calls the next person on the call list. That person in turn calls the next person, etc. A call list member can restrict callings to certain available times. Any Society member is welcome to join the call list.

To join the call list, please notify Marty Kunz at 477-0546,
Computer Chatter
By Larry F. Kalinowski

The last meeting at MCCC produced a new stepping stone in the annals of the Warren Astronomical Society. Thanks to Paul Strong, five IBM computers were turned on and all the members present had the chance to watch or operate an astronomical program. The first WAS computer lab was a success. The program demonstrated was my pride and joy, the LFK Messier Observer’s Guide. It was the first of a series of software demonstrations that members of the society will present over the next year. Our Cosmohood, Deep Space, Dance of the Planets, Skyglobe, The Sky and Astro I. P. are only a few of the programs the computer lab will play host to in the upcoming months. The role of the computer is becoming evermore important in our understanding and execution of everyday events, from typing a letter to grasping the universe.

There’s a new shareware program out from the author of Skyglobe called CircumSpace. If you haven’t seen it, you’re in for another treat, especially you Trekkies. It allows the user to travel through space to the 7,000 or so stars nearest the Earth and at warp speed, if you wish. If you’re one that thinks certain types of people all look the same, wait until you travel between the stars in this program. Sameness takes on a new meaning here. It shows the difficulty involved with determining where you are and where you’re going in the vastness of space. CircumSpace is a take-off of Michigan’s (the author’s home state) Circumspice - "If you seek a pleasant star system, look about you."

Speaking of Trekkies, Paramount announced a new cable network based on the Star Trek television franchise. The network will go into operation for a few hours a day, much like the Fox network. A new program called Star Trek Voyager will be introduced.

Channel 32 in Ontario (just across the border) is showing a new series of Bits and Bytes, a computer introduction program, on Saturdays at 11:30 a.m. There are six half-hour segments and each one is complete on the topic it covers. It’s not on every week, so keep checking your IV Guide for the next program.

I have a 1200 baud Hayes (Smartmodem) external modem for sale. I’m asking $20.00 for the unit. You’ll need to buy the cables to get it running. That’ll be another $12.00 or so. You’ll also need a 25 pin to 9 pin cable for AT type computers and a telephone line with modular connectors. A power supply is included with the modem. I’ll even throw in a modem program if you need one. Sorry, there’s no manual. If you’ve ever wanted to "connect to the world" this is a low cost way to do it (I use a modem to send these WAS articles to our editor.) Call me at 776-9720 after 6:00 p.m.

Don’t forget the lunar eclipse during the evening / morning of November 28 - 29. The Moon enters the umbra of the Earth at 11:40 p.m. EST of the 28th, with totality beginning at 1:02 a.m. and ending at 1:50 a.m. Lunar eclipses are always worth observing, even if you just peek at it from your bedroom window. If you’re a photographer, don’t miss it.

NEC seems to have another significant improvement in CD ROM drives. It’s bragging about the new three speed Multispin model 3XP. It boasts a 450 kilobyte per second transfer rate and a 250 millisecond access time. Constant data transfer is accomplished with a 256 kilobyte cache. Catalog price from Tiger Software Company in Coral Gables, Florida is $455.

We’re still in need of replacement computer parts for the observatory computer. If you have any hardware that will help us upgrade one of our XT’s to a 286 or 386 configuration, please contact me at the phone number above. At the present time, the computer meeting for November is uncertain. It looks as though 111b be working the second shift during the Thanksgiving time slot, the week before and the week after. I’ll see that an announcement is made at the Macomb meeting.

Officer Elections

The Warren Astronomical Society held its annual officer election at the October 21, 1993 Macomb Community College meeting as scheduled. Nominations for officers were closed and member voting resulted in the following:

President - Jeff Bondono
1st Vice President - Marty Kunz
2nd Vice President - Riyad Matti
Secretary - John Herrgott
Treasurer - Mike O'Dowd

The term for new officers begins January 1, 1994. Congratulations and good luck to all the new officers! And thanks to all outgoing officers, too!
Hubble vs. Ground-based...

(Continued from page 1)

ature. This colossus has 17 times more light collecting area than HST's 2.4 meter (seven-foot) mirror. Consequently, Keck's "lightbucket" is significantly faster at collecting faint starlight. This makes the Keck telescope a powerful instrument for performing spectroscopic studies of faint objects; it could gather spectral data from astronomical sources much more quickly than Hubble.

Resolving Power Resolving power or resolution is the ability to yield sharp, detailed images. An optometrist calls this "visual acuity." In theory, a telescope's resolving power improves as the diameter of the telescope's mirror or lens increases. However, the blurring of starlight by Earth's atmosphere prevents telescopes from realizing their theoretical potential.

Ground based telescopes can resolve detail about 60 times better than the human eye. Keck's larger mirror array is limited by the atmosphere to a resolving power of about 0.5 arc second. HST, located high above the Earth's atmosphere, has a resolving power that is five to 10 times better. This means that the HST can concentrate starlight into much smaller spots and separate objects that are much closer together than the Keck can. Resolving power is measured in terms of arc seconds. One arc second is 1/3600 of a degree (the angular separation of car headlights at 300 miles). HST, for example, has a resolving power of one tenth arc second (the separation of car headlights 3,000 miles away).

Resolution Improvements in Ground-Based Telescopes

Although HST will remain the premier observatory for high resolution studies of astronomical objects, new techniques are being used with ground-based telescopes that will allow them to compete with HST even in resolving power. However, these techniques only work for bright star-like objects. They also work only for small patches of sky, a few arc seconds across, near the center of the telescope's field of view. This means that these techniques will not work for studies of extended targets such as star-forming nebulae.

Active Optics, Adaptive Optics

If you look at a star on any clear night, it appears to twinkle. Light from the star passing through the turbulent atmosphere is shifted slightly by parcels of air moving to and fro thousands of times per second. By the time the light reaches the eye, or the telescope, the dancing of the light causes the image to blur into a spot about one arc second wide.

New technologies can sharpen these stellar images by distorting a telescope's mirror to compensate for blurring, or by extracting the blurring later using image processing. In active optics, the shape of the telescope mirror is adjusted hundreds of times per second to cancel the distortions caused by the atmosphere. In adaptive optics, the telescope mirror is moved thousands more times per second to follow the dancing image of the star and keep it focused into a small spot. This technique requires a reference source, either a bright star located in the vicinity of the celestial target or an "artificial star" created by reflecting a laser off selected layers in the atmosphere.

By contrast, Hubble's images and other data are optically stable so that astronomers can revisit a target at any time of year and expect the same quality data. This assures a repeatability that is not possible with adaptive optics on ground-based telescopes. An enormously complex ground-based system would be required to match HST performance. Such a system does not currently exist, and could be a decade away - beyond the working lifetime of HST.

Speckle Interferometry

By taking many short exposures in succession rather than one long-time exposure, the effects of atmospheric turbulence can be "frozen." A computer combines each image by shifting it to a common center. This subtracts the blurring effects and recovers the telescope's best resolving power. For ground-based Mt. Palomar's 200-inch mirror this is an improvement from 0.4 at best to 0.02 arc seconds.
Location
Because HST is a space-based observatory, it is the only telescope that can view any celestial target located anywhere in the sky unhindered by either the Earth, Moon or Sun. Keck is located at an ideal observing spot near Earth’s equator, allowing it to observe most of the celestial sphere. However, stars and galaxies located near the north and south celestial poles (below 30 degrees altitude from Hawaii) are inaccessible.

The ultraviolet region is a gold mine. The most common elements in the universe - hydrogen, helium, carbon, nitrogen, oxygen and silicon - all leave spectral signatures in the ultraviolet. Ultraviolet light typically radiates from extremely hot, dynamic phenomena, such as cores of active galaxies, quasars, energetic stars, and vast disks of dust around black holes. For those looking through HST's ultraviolet window, a wealth of science about many mysterious sources of energy is open.

An Advantage of Space-Based Ultraviolet Astronomy
A broad range and variety of objects in the universe radiate energy at ultraviolet wavelengths, including the atmospheres of most stars, the surfaces of stars far more massive than our Sun, white dwarfs and hot regions of interstellar gas. However, Earth’s atmosphere absorbs almost all the ultraviolet light arriving from other celestial bodies. A telescope in space, equipped for ultraviolet observations, is therefore necessary for the study of objects detectable in this important region of the spectrum. In particular, HST is the most powerful telescope ever launched for ultraviolet astronomy.

Hubble Investigates Comet on a Collision Course with Jupiter
By Sarah Keegan, Headquarters, Washington, D.C.; Jim Elliott, Goddard Space Flight Center, Greenbelt, Maryland and Ray Villard, Space Telescope Science Institute, Baltimore, Maryland

October 18, 1993 - NASA's Hubble Space Telescope has provided the most detailed look yet at the comet hurtling toward a July 1994 collision with the giant planet Jupiter.

Hubble's high resolution images shows that the approximately 20 objects that make up comet P/Shoemaker-Levy 9 - giving it the appearance of a string of pearls - are much smaller than originally estimated from observations with ground-based telescopes.

"The Hubble observations show that the cometary nuclei are probably no bigger than three miles across, as opposed to earlier estimates of nine miles," explains Dr. Harold Weaver of the Space Telescope Science Institute (STScI), Baltimore.
Collision Course...

(Continued from page 5)

The new Hubble data show that the impacts will unleash only 1/10th to 1/100th as much energy as thought previously. However, even with these new size estimates, the impacts will be comparable in strength to the collision of a large asteroid or comet with Earth 65 million years ago. This cosmic catastrophe is suspected to have caused the extinction of the dinosaurs and hundreds of other species between the Cretaceous and Tertiary periods.

Weaver and a team of co-investigators are announcing their analysis of the Hubble observation at the 25th annual meeting of the Division for Planetary Sciences of the American Astronomical Society being held in Boulder, Colorado.

Since the comet's discovery last March, there have been widely varying estimates of how energetic the collisions with Jupiter will be. The force of the collision depends not only on the relative speed of the impacting bodies, but their mass as well.

Measuring the sizes of the nuclei is very difficult because each nucleus is surrounded by a haze of dust, called a coma. "Most of the light being observed is due to scattering by dust in the coma," Weaver says.

Relative to ground-based images, the Hubble image provides improved contrast between the nuclei and their comae, thereby allowing a better estimate of the sizes. However, "even the current Hubble image does not allow a clear separation of nucleus and coma, so its size estimates are still probably only upper limits to the true nuclear sizes," according to Weaver.

Fortunately, the definitive answer might be available soon. During the December Hubble Servicing Mission a new camera called Wide Field and Planetary Camera 2, with corrective optics to compensate for aberration in Hubble's primary mirror, will be installed on the telescope. "The Hubble repair should provide images with much better contrast than the current images, and if the nuclei are close to the sizes we now think they are, then they should really pop out in the new Hubble images," Weaver says.

Hubble's sharp resolution shows that one bright knot in the comet stream is really four fragments close together. Two of the pieces have an apparent separation of only 700 miles. The Hubble image also shows that most of the visible nuclei have comparable sizes.

Weaver says that the close match in size among the chunks suggests they might be the primordial "building blocks" of comets. According to calculations, the parent comet broke apart when it passed close to Jupiter in July 1992.

"Jupiter's gravity might have disassembled the comet back into the primordial objects, called planetesimals, that were present when our sun formed 4.5 billion years ago," Weaver says. "However, since the current Hubble observations cannot detect nuclei much smaller than about 124 miles (two km), the size distribution of the planetesimals is still indeterminate. Once Hubble's optics are fixed, we should get a better handle on the range of sizes within the planetesimal population."

Comet or Asteroid?

Though commonly referred to as a comet, some astronomers think P/Shoemaker-Levy 9 might be an asteroid. In this case, it would have come from the asteroid belt between the orbits of Jupiter and Mars, rather than from a hypothetical comet belt beyond Pluto's orbit.

However, no one has ever seen an asteroid break apart, so it is difficult to predict how asteroids should behave under these circumstances. Likewise, since there are few detailed studies of comets as far away as Jupiter (1/2 billion miles or 805,000 km), it's hard to know how a comet should behave at Jupiter's distance.

At Jupiter's distance, the comet's surface is so cold that the sublimation rate of water ice is very small. Sublimation is the phenomenon in which solid ice changes directly to water vapor without going through the liquid state.

"On the other hand, the breakup of the comet may have released an unusually large number of icy grains, exposing such a large surface area to the sun that the sublimation might become detectable," Weaver says. "Also, there probably are substances present that are more volatile than water ice."

Weaver's team took spectra near the brightest fragment to search for molecules that might have been released from subliming ice. This would provide strong evidence that P/Shoemaker-Levy 9 is a comet, not an asteroid. Spectroscopic observations made with Hubble Faint Object Spectrograph failed to find hydroxyl molecules that would be a clear indicator of cometary origin.

Another way to address this mystery is by watching the evolution of the surrounding coma. A cometary origin would be likely if the coma is continually replenished by gas streaming off the fragments, since comets are more icy than asteroids.

However, if the coma simply spreads out, eventually completely disappearing, the coma just might be dust from a broken-up asteroid. The current Hubble image shows that the coma is apparently not continually replenished, but more observations are needed to further monitor the coma development.

Collision with Jupiter

The Jupiter collision is expected to occur over a six-day period around July 21, 1994. The effect of the impact will depend not only on the size and velocity of the cometary nuclei, but also their composition and structure.

Comets are very porous and thus, might break up high in the atmosphere. For example, on June 30, 1908, a 160-foot (50 meter) wide cometary nucleus or stony meteor is suspected to have disintegrated in Earth's atmosphere at an altitude of five miles (eight km). The resulting explosion leveled hundreds of thousands of acres of forest in Siberia's Tunguska River Valley, Russia.

The Jupiter impacts potentially could produce spectacular phenomena in the giant planet's multicolor cloud tops. The plummeting comet nuclei would turn into gigantic versions of meteors or "shooting stars." Each fireball would blow a hole in Jupiter's atmosphere the size of Texas.

Although the impacts are predicted to occur on Jupiter's far side (not observable from Earth), it's likely that the effect on the atmosphere still will be visible as the impact zone rotates into the Earth's view. (Jupiter's rotation rate is nine hours, 50 minutes.)
Limiting Magnitudes

Most stars shine with constant brightness. However, a number of stars change their light output over time for various reasons and are therefore known as variable stars. These stars can change their brightness either regularly, irregularly or explosively. There are numerous subclasses of variables among these categories.

Variable stars can change brightness from a few tenths of a magnitude to up to 10 magnitudes or more. Regular (periodic) variables can repeat their cycle anywhere from every few hours to up to several years.

Use these star charts to find some variable stars. At right is a detailed chart showing enough stars to "star-hop" to the variables. Inset is a low-scale chart showing the general region of sky. The detailed chart shows the registered magnitude range for the variable, followed with the period of its cycle in days. Variables without a regular cycle are listed as "Irr." Use nearby stars to make your own estimate of magnitude for the variable. Happy viewing!
### Warren Astronomical Society Calendar 1993

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Event</th>
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<tbody>
<tr>
<td>November 19-20</td>
<td>8:30 p.m.</td>
<td>Open House at the 24-inch observatory of MSU; E. Lansing. This is the final open house of the year. For further information, contact Kim Dyer.</td>
</tr>
<tr>
<td>Monday November 29</td>
<td>1:00 a.m.</td>
<td>Informal Get-Together at Stargate to watch the last total lunar eclipse for several years. (Come on out Sunday night) For further information, contact Riyad Matti.</td>
</tr>
<tr>
<td>Thursday December 2</td>
<td>7:30 p.m.</td>
<td>General meeting at Cranbrook Institute of Science.</td>
</tr>
<tr>
<td>Saturday December 11</td>
<td>7:00 p.m.</td>
<td>Star Party at Doug Bock’s house (“Northern Cross Observatory”).</td>
</tr>
<tr>
<td>Thursday December 16</td>
<td>7:00 p.m.</td>
<td>Holiday Banquet at the Warren Chateau. Begins with Social Hour. No Macomb Community College meeting.</td>
</tr>
<tr>
<td>Saturday December 18</td>
<td></td>
<td>Star Party at Doug Bock’s house: (“Northern Cross Observatory”).</td>
</tr>
<tr>
<td>Thursday December 23</td>
<td>8:00 p.m.</td>
<td>Computer Group meeting at Larry Kalinowski’s house.</td>
</tr>
<tr>
<td>Saturday January 8, 1994</td>
<td></td>
<td>Star Party at Doug Bock’s house (“Northern Cross Observatory”).</td>
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