Hubble Managers Start to Survey the Damage

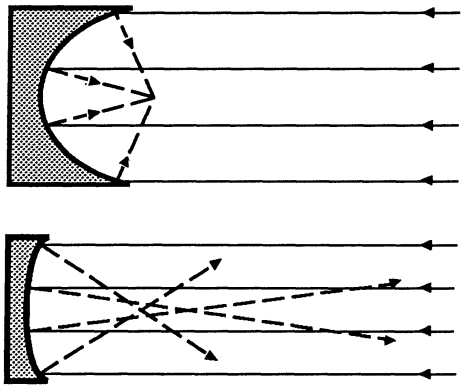
A first report on the $1.6-billion telescope's optical flaw and the prognosis for doing science

THE AWFUL RECOGNITION DAWNED during the weekend of 23–24 June, as ground controllers at NASA's Goddard Space Flight Center outside of Washington, D.C., were trying to figure out the Hubble Space Telescope's finicky refusal to come into perfect focus. Pointing the telescope at a convenient star field, they first commanded it to go completely out of focus. Then they systematically brought it back step by step—and were appalled to realize that the shifting patterns of light were revealing a textbook example of spherical aberration, an optical defect that causes every star image to be surrounded by a fuzzy halo of light.

By 26 June, Hubble project managers were reporting the word to NASA headquarters: the defect, which is caused by incorrect curvature in one or both of the spacecraft's mirrors, cannot be fixed from the ground. It will be years before the $1.6-billion telescope can achieve the ultra high resolution images it was designed for, if ever. Voyager-like pictures of the planets, the first faint glimmer of newborn galaxies, the true size and age of the universe—all will have to wait until space shuttle astronauts can bring up a new set of cameras with corrective optics.

And, they added, NASA itself will have to own up to a human error in creating the mirrors, which were made under agency supervision by the Perkin-Elmer Corporation (now Hughes Danbury Optical Systems). It is still unclear whether the deviant curvature is in Hubble's 2.4-meter primary mirror or in the much smaller secondary mirror, which takes the starlight collected by the primary and bounces it down into the cameras and other instruments. But either way, said deputy project manager Jean Olivier during a hastily called press conference on 27 June, the distortions are too symmetric, too perfect to be a random deviation caused by the stresses of launch. "We suspect that the methods used to measure the figure of the mirror during manufacture, which are very complex, resulted in the mirror being very precisely made," he said—"but to the wrong figure."

For astronomers, of course, the first and most urgent priority was to figure out how the flaw will affect Hubble's scientific output. From a first quick survey, it seems that roughly half of what they want to do with the telescope will be unaffected. In particular, the poor focus takes nothing away from Hubble's ability to peer deep into the ultraviolet part of the spectrum, which is completely screened from the ground by Earth's atmosphere. So one of Hubble's key targets—the ultraviolet spectral signature of embryonic galaxies and intergalactic gas clouds backlit by quasars—should proceed as planned.



Aberrant behavior. *A perfect parabolic mirror will reflect every ray of starlight to a single focal point (top). But Hubble's mirror isn't perfect, the rays do not cross at a single point, and so there is no perfect focus (bottom).*

Nor will the poor focus spoil the steadiness of Hubble's images, especially now that engineers are bringing the earlier problems with spacecraft stability under control. Free from atmospheric turbulence, Space Telescope will still be able to look for the subtle back-and-forth motions that might indicate that a star has planets.

The bad news, however, is that about half the science proposals *will* be affected, most notably those that rely upon Hubble's workhorse Wide Field/Planetary Camera (WF/PC). Even with a degraded focus its images are still somewhat better than those from ground-based telescopes: it focuses about 20% of the light from a star into a bright "core" about 0.1 arc second across, with the remainder spreading out into the aberrant halo. (The best ground-based images are about 1 arc second across.) But the astronomers on the WF/PC team are having to face a brutal question: are those images *so* much better that they are worth taking precious observing time away from less-affected instruments?

Until they can obtain some trial images of real scientific targets, that's going to be a tough question to answer. But if decision is no, then the current WF/PC may never be used at all. "We don't want to use Space Telescope for non-unique science," says Edward J. Weiler, Hubble program scientist at NASA headquarters. "If that means turning WF/PC off, then so be it."

As bleak as that sounds, NASA officials and astronomers alike say they are hopeful that the imaging experiments can eventually be resurrected. NASA designed Space Telescope so that shuttle astronauts could extract its old scientific instruments and replace them with new ones as needed. Indeed, an upgraded WF/PC is already well under way at the Jet Propulsion Laboratory. In principle, says Weiler, it should be straightforward to modify the internal optics of future instruments and remove the telescope's distortion entirely. JPL engineers are now studying how to accelerate the WF/PC-2 development, and NASA headquarters, which long ago penciled in a shuttle flight to revisit Hubble in 1993, is looking for ways to reschedule it sooner.

If such a fix could be implemented, says Weiler, then the net result will not be a loss of Hubble science, but a rearrangement of that science, with most of the currently planned imaging being done after 1993. In the interim, he says, astronomers have already submitted more than enough top-quality proposals to keep Hubble busy. "Can we do unique and important science? *Yes*," he vows—"100% of the time."

Meanwhile, within a day of hearing the news, top NASA officials asked JPL director Lew Allen to chair a formal board of inquiry into the mirror fiasco. The question is obvious: How this could have happened—especially given the hundreds of people who checked and cross-checked the mirror-making process every step of the way. The curvature error, which amounts to about half a wavelength of visible light or about 1/50 the width of a human hair, would have easily been detectable by the laser interferometers used to test the mirrors. No such errors were ever seen. But then, as Olivier admits, the mirrors were only tested individually, never as a complete optical system. In principle, there was no reason to expect the assembly to introduce such an aberration. And in any case, carrying out such a test would have cost hundreds of millions of dollars. But at the moment, this seems the most logical place to start looking for the mistake. ■ **M. MITCHELL WALDROP**