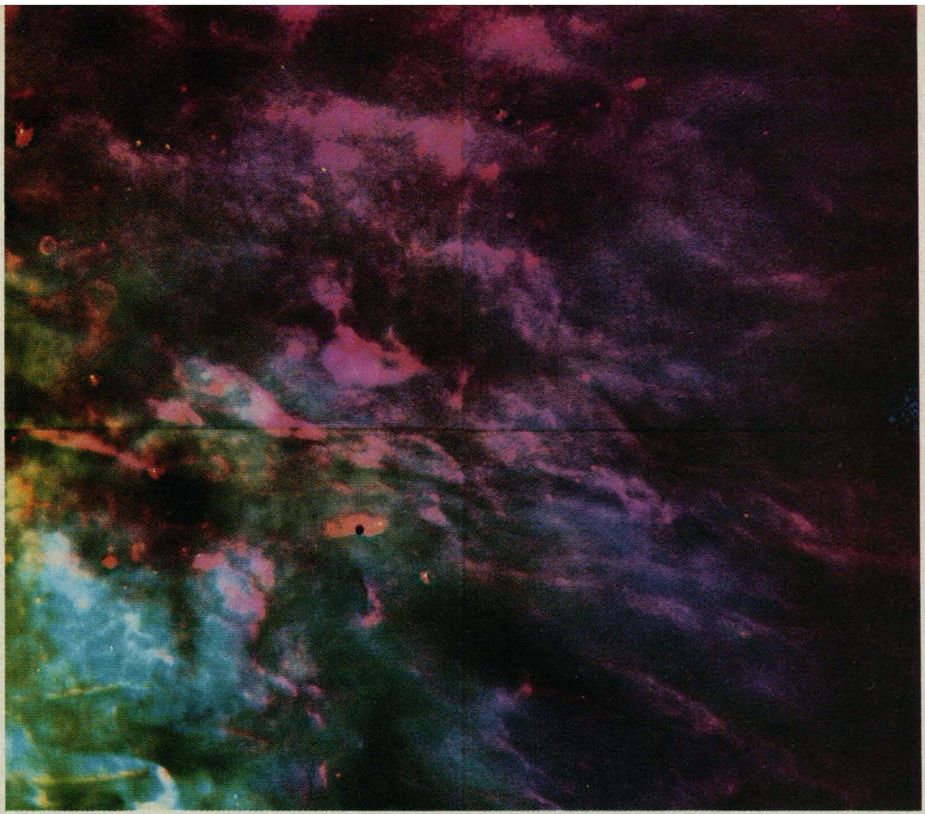


NASA

▶ **Tendrils and knots.** *A close-up of the glowing gas in Orion.*

Slowly, Hubble Begins To Do Science

It certainly hasn't been easy, but the telescope is gradually making good on its promise.

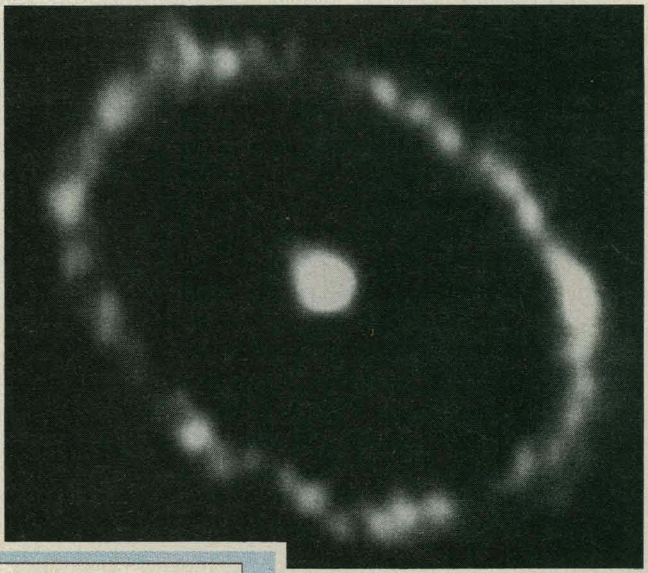
FOR MORE THAN HALF A YEAR NOW, EVEN AS the Hubble Space Telescope's ground controllers have been guiding the spacecraft through its checkout phase, astronomers have been slowly learning how to use the fuzzy-eyed telescope to do some real research. And at a special Hubble session at the recent mid-January meeting of the American Astronomical Society in Philadelphia, it was clear that their efforts are beginning to bear fruit. A portfolio of images and other data from that session is reproduced here.

The most obvious concern for everyone on the project is the telescope's notorious optical aberration, which surrounds every star image with a spidery fuzz. Nonetheless, say the astronomers, with heavy computer processing Hubble can still produce pictures of many objects with almost 10 times the clarity achievable from the ground.

A particularly vivid illustration of that clarity is the close-up (shown above) of the famous "Great Nebula" in Orion, which marks a region of vigorous star formation in an interstellar gas cloud located about 1500 light-years from Earth. Taken late last year by the telescope's Wide Field Planetary Camera (WF/PC), the image shows unprecedented detail in the wisps and knots and tendrils of the agitated gas, along with several newborn stars that had never been observed before.

An equally dramatic example of Hubble's ultrahigh resolution is the bull's-eye image shown at bottom right: a close-up of Supernova 1987A taken late last year by the European Space Agency's Faint Object Camera. The blob at the center is astronomers' first direct glimpse of the supernova's incandescent shell of explosion debris. The tattered ring appears to be the remnants of gas and dust ejected from the supernova's precursor star thousands of years before it exploded. According to Duccio Macchetto of the Space Telescope Science Institute in Baltimore, principal investigator for the Faint Object Camera, a careful analysis of how the light of the explosion was reflected from the ring back to Earth has allowed him and his colleagues to estimate the ring's true diameter—1.37 light-years—and its true distance from Earth: 169,000 light-years, plus or minus 5%. That is a significant improvement over previous estimates, says Macchetto, and should allow astronomers to use the supernova as a reference point for refining the cosmic distance scale to objects much farther away.

Hubble scientists are also elated by the performance of the telescope's two spectrographs, which they expect to yield much more detailed information about the motions and compositions of celestial objects. In Philadelphia, Kenneth Carpenter of the Goddard Space Flight Center illustrated the improvement with the comparison shown at the bottom of page 522, which pits the Goddard High Resolution Spectrograph on Hubble against an older and smaller spec-



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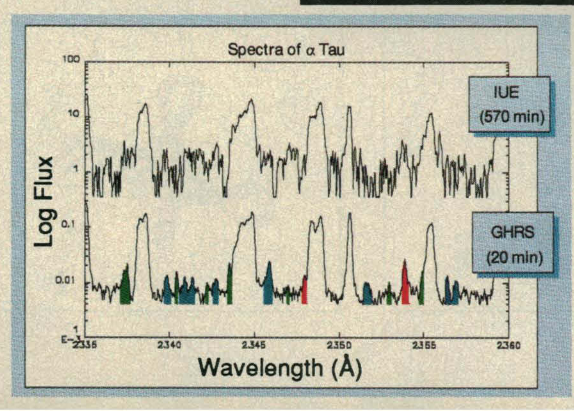

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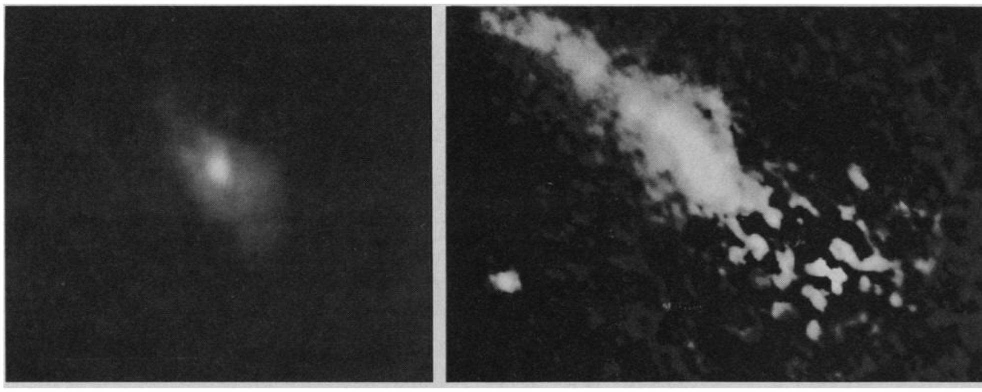
▶ **An old star and a dead star.** *Hubble reveals a host of new spectral lines from the old red giant star Aldebaran* (left). *And a ring of glowing gas surrounds Supernova 1987A* (above).



Mysteries. *A ragged galactic core* (left) *and a braided jet* (right).

trographic spacecraft known as the International Ultraviolet Explorer (IUE). The target in both cases was the bright red star Aldebaran, or Alpha Tauri. With just 20 minutes of exposure, said Carpenter, the Hubble spectrograph turned up 17 new spectral lines (highlighted in color) that IUE couldn't pull out of the background noise even after 9.5 hours of exposure.

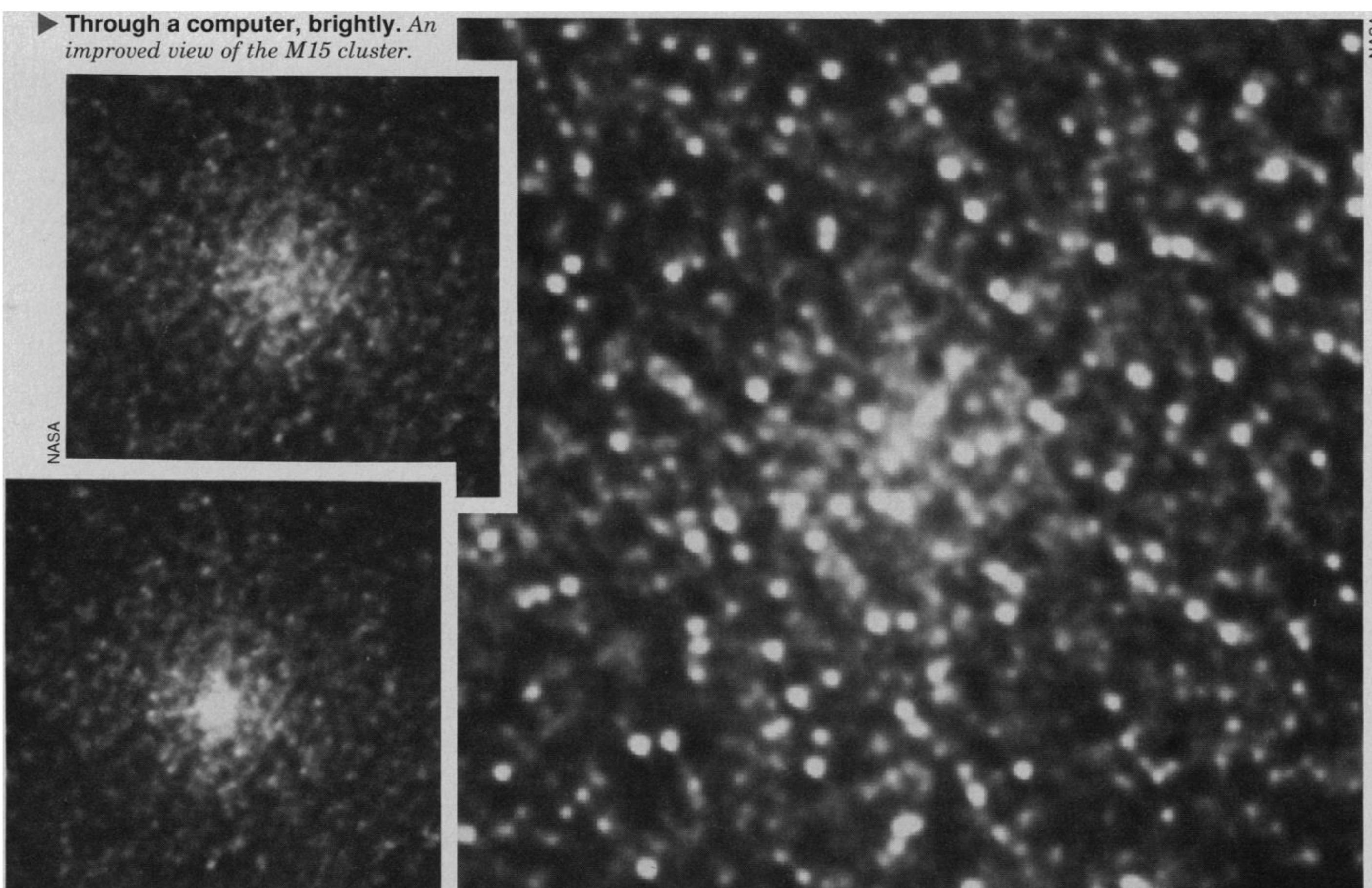
Whether Hubble is producing high-resolution imagery or spectroscopy, astronomers have every reason to hope for surprises and mysteries. And they have not been disappointed. At upper left, for example, a WF/PC image shows the core of NGC 1068, a "Seyfert" galaxy that has an abnormally bright nucleus. A dense knot of stars can be seen at the very center of the galaxy, where they may be clustering around a giant black hole. But no one yet knows what to make of the blotchy halo of stars around the center.

To the right of NGC 1068, the Faint Object Camera depicts another mystery: a 10,000 light-year-long jet of hot plasma coming from the core of the galaxy 3C 66B, which is also thought to be the site of a massive black hole. This jet has been seen before—but other images did not show that it is braided into a kind of twisted ladder. And no one understands that structure either. Finally, as a prime example of virtuoso image processing, consider the WF/PC views at page bottom, which show the tightly packed stars at the center of a globular cluster known as M15. In looking at M15 the WF/PC team was trying to find out whether massive black holes also form in the middle of globular clusters like this one. Unfortunately, says Tod Lauer of the California Institute of Technology, it was hard to tell at first. The large picture shows WF/PC's original image, after correction for the aberration. What's actually going on in the center is obscured by M15's brightest stars. So Lauer and his colleagues simply had a computer remove those stars, yielding a much improved view (top inset) of the distribution of the dimmer and more typical stars. And that shows that the stars have not coalesced into a black hole. If they had, the cluster would show a bright core, as in the computer simulation shown in the bottom inset.

What seems to have happened instead, says Lauer, is that the cluster center originally formed lots of close binary stars, which orbit around each other at a furious rate. Their whirling gravitational interactions would have kicked other stars outward, stopping any inward collapse—in effect stirring the cluster like cosmic egg-beaters.

One bittersweet question that remained after this dazzling array of cosmic images: If a myopic Hubble could produce such a display, what would an instrument with perfect eyesight have produced?

■ M. Mitchell Waldrop



Through a computer, brightly. *An improved view of the M15 cluster.*