# NASA's eye in the sky promises exciting discoveries

On 28 April an extraordinary news conference was in progress at the US National Aeronautics and Space Administration (NASA) in Houston. Five crew members of space shuttle *Discovery*, on a mission code-named STC-31, were describing from space, their adventure of deploying NASA's heaviest payload ever, the Hubble Space Telescope (HST). The space telescope is now in earth orbit and it will be a few weeks before its instruments are checked and it is readied for actual observation.

HST is named after the great astronomer Edwin Hubble, who propounded the theory of an expanding universe. The idea of a space telescope dates back to 1926, when Hermann Oberth, a German rocket pioneer, pointed out the advantages of astronomical observation from space. The foundation of HST was laid in the work of Lyman Spitzer, Jr, in 1946. As the project grew, the Space Telescope Science Institute was established to design and operate the space telescope.

With its 2.4-metre mirror HST is not very big compared to many ground-based telescopes. It has only one-sixth the collecting area of the 6-metre Soviet Bol'Shoi Teleskop and one-fourth the collecting area of the 5-metre Hale telescope on Mount Palomar. But due to its location 611 km out in space, much above the earth's atmosphere, it offers many advantages. Ground-based telescopes cannot produce images with a resolution better than one second of arc (arcsecond) owing to the perturbing effect of the turbulent atmosphere. The HST, above the atmosphere, can produce images limited in resolution only by diffraction effects. Its mirror is expected to produce images with a full width at half the maximum intensity equal to 0.08 arcsecond at 632.8 nm. This is the wavelength of the helium – neon laser light used to test the accuracy of the mirror's surface. HST will be able to observe over a wide range of the electromagnetic spectrum from ultraviolet (1150Å) through infrared (11,000 Å). An earth-based telescope simply cannot achieve this as the earth's atmosphere only transmits radiation in the radio and visible regions and absorbs the rest. Background light makes it difficult to get good observing sites on earth. The orbital sky provides a black sky with very little or practically no scattered light at all. This, along with the HST's ability to produce sharp images, makes it capable of detecting stars even 30 times fainter than those that can be seen by the 5-metre Hale telescope.

To exploit the advantages of space-based astronomy, the team that put together HST turned to many new developments. The design of stable support systems to hold the telescope precisely in the pointed direction during observation was a great challenge. At present, HST is expected to have a pointing accuracy of 0.01 arcsecond with a pointing jitter of around 0.007 arcsecond. HST also has a powerful astrometric capability and can measure positions of stars with an accuracy of 0.003 arcsecond.

The orbiting telescope carries five major instruments in the focal plane of the telescope's mirror: faint-object camera, faint-object spectrograph, Goddard high-resolution spectrograph, wide-field and planetary camera, and high-speed photometer. These detect, record and measure the focused radiation.

The faint-object camera intensifies incoming light from faint stars by 100,000 times. This enables recording of each individual photon collected by the telescope. The camera gives more than 25,000 picture elements (pixels) in a field of view 11 arcseconds wide and 22 arcseconds long and can detect stars that are $6 \times 10^8$ times weaker than the faintest capable of being seen by the naked eye from earth. The two spectrographs complement each other in their capabilities. While the Goddard high-resolution spectrograph incorporates high resolution the other has a wider bandwidth and hence higher sensitivity. The Goddard high-resolution spectrograph can resolve features in spectra lines as narrow as one-hundred-thousandth of a wavelength in the ultraviolet region. This is very close to the intrinsic width of interstellar absorption lines. The wide-field camera has a field of view of 154 inches × 154 inches and a light-detecting array of eight charge-coupled device elements. Each pixel is 15 microns wide and is arranged in an 800 × 800 format. The high-speed photometer has an array of 23 filters covering the spectral region 1200 – 7000 Å. It can detect very rapid brightness changes in stellar objects.

Three important astrophysical programmes are earmarked for HST's first year in orbit. They are: to calibrate the cosmic distance scale and, in particular, obtain a precise value of the Hubble constant; to survey a few random locations in the sky; and to study high-red-shift quasars. Among the many proposals, from observatories and laboratories worldwide, approved for the first phase of HST's operation is one from the Tata Institute of Fundamental Research (TIFR), Bombay. It concerns the detection of the so-called cyclotron emission in the ultraviolet frequency range from a specific star that is known to be an X-ray source.

Even with the successful launch and the expected bright future, there are many controversies. Many are unhappy about the long time that elapsed between the start of the project and the launch. This has resulted in a telescope for 1990 with many designs frozen in 1970 – 72. Another controversy is the choice of a low orbit compared to that of the International Ultraviolet Explorer (IUE) launched in 1978. Earth obscures only 2% of the sky as seen by IUE but a very large fraction as seen by HST. Escalation of cost from the expected $ 400 million to roughly $ 2 billion has brought in a spate of criticisms. Periodic space shuttle missions are expected to service and upgrade HST's instruments and keep the telescope alive for more than 15 years. But, many scientists feel that they could get a lot more science for the money in the future if NASA just forgot about the servicing.

It is hoped that HST will uncover many new phenomena not yet imagined. If it does, it will not merely add to the present ideas of the universe but profoundly modify basic concepts. This was what Spitzer wrote way back in 1946. Soon, HST may fulfill this promise.

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