Hubble to be augmented with powerful new infrared observing capability

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Wide Field Camera 3, a new camera for the Hubble Space Telescope, to be installed by astronauts during the upcoming space shuttle servicing mission, will provide astronomers with an unprecedented near-infrared view of the universe.

Astronomical observations at near-infrared wavelengths offer unique opportunities for studying the universe. Important classes of low-temperature objects, such as the lowest-mass stars and brown dwarfs, as well as distant members of our own solar system, are readily detected in this wavelength regime. The penetrating power of infrared radiation for seeing through interstellar dust also permits views of the critical processes of star formation in galactic regions that are too dust-enshrouded for study at shorter wavelengths. Perhaps most important, near-infrared observations permit the detection of distant galaxies and supernovae, seen as they were in early epochs of cosmic time, because the expansion of the universe stretches their light – that was originally emitted at ultraviolet or visible wavelengths – red-shifting it to be detected as infrared radiation when it arrives at Earth.

Space observations are particularly powerful for exploiting the potential of infrared astronomy. Even at near-infrared wavelengths that penetrate the Earth’s atmosphere (which longer wavelength IR radiation does not), space observations have substantial advantages in sensitivity, because the infrared glow of the terrestrial sky, even at night, is thousands of times brighter than the natural astronomical background, the so-called “zodiacal light” (sunlight scattered by dilute grains of dust within our own solar system). This difference in background brightness permits even a modest-sized telescope in space to out-perform the largest ground-based telescopes in infrared imaging.

Wide Field Camera 3 (WFC3), a new camera to be installed onto the Hubble Space Telescope (HST) in its upcoming Servicing Mission 4 this fall, will be the next major step in infrared astronomy. WFC3 (see Figure 1), is a general purpose imager providing a wide wavelength coverage in two channels: a UV/visible (UVIS) channel covering 200–1000nm wavelengths, and an IR channel covering 850–1700nm. While both channels offer dramatic advances in HST capabilities, we focus on the performance of the IR channel here.

HST’s current IR imager, the Near-Infrared Camera and Multi-Object Spectrograph (NICMOS) has made crucial contributions to astrophysical research on topics ranging from extrasolar planets to high-redshift galaxies to the mysterious “dark energy” phenomenon that dominates the energy density of the universe. By taking advantage of recent advances in detector technology, the IR channel of WFC3 will extend this work with a major increase in sensitivity and surveying capability.

Figure 1. The fully-assembled WFC3 instrument, configured for environmental testing at NASA’s Goddard Space Flight Center.

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At the heart of the WFC3 IR channel is a custom focal plane array7–9 (FPA; see Figure 2) developed by Teledyne Imaging Sensors, formerly Rockwell Science Center. The one megapixel FPA (16 times the pixel count of the earlier-generation NIC-MOS sensors) consists of a HgCdTe detection layer hybridized to a silicon multiplexer readout. The HgCdTe has been grown with a special composition tailored to achieve a band gap corresponding to a cutoff wavelength of 1.7 microns. This is a larger band gap/shorter cutoff wavelength than available for previous HgCdTe sensors; it permits the detector to deliver low dark current at a relatively warm operating temperature of 145 K, achievable with WFC3’s passive radiator and thermo-electric coolers, and minimizes the detector’s sensitivity to thermal background radiation from the warm upstream optics in HST, which is not a cryogenic telescope.

WFC3’s IR channel will provide high-resolution imaging (0.13–0.15 arcsec FWHM) over a field of view that is ∼6.4 times larger than the largest NICMOS field of view, with a throughput that is also ∼2–2.5 times greater9. The result will be an increase in HST’s IR survey speed capabilities (time to cover a given area of sky to a given target depth) of 10–30 times or more10. A rich set of broadband filters (for the greatest sensitivity to faint objects), narrowband filters (at the wavelengths of key astrophysical or planetary spectral features), and grisms (for slitless low-resolution spectroscopy) further augments the power of the IR channel.

WFC3 will be installed into HST by space shuttle astronauts (see Figure 3), during the first spacewalk of upcoming Servicing Mission 4, scheduled to be launched in early October. After an initial checkout period, WFC3 will begin a rich and varied program of astronomical observations. The enthusiasm of the astronomical community for the IR channel of WFC3 is manifested by the results of the HST Cycle 17 Time Allocation process, which awarded more than 30% of the total Guest Observer orbits to WFC3/IR observations. These programs will probe the distant universe for early galaxies and the outer reaches of our solar system for faint trans-Pluto (Kuiper Belt) bodies, among many other topics. A new era of infrared astronomy will have begun.

WFC3 has been developed as a facility instrument by the HST Project at NASA’s Goddard Space Flight Center (GSFC). Much of the WFC3 hardware was developed by the principal partner, Ball Aerospace & Technologies Corporation of Boulder, Colorado; system level integration and test was carried out at GSFC. Overall scientific guidance to the project has been provided by the WFC3 Scientific Oversight Committee, chaired by Dr. Robert O’Connell of the University of Virginia.

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References