Hubble space telescope instrumentation and scientific discoveries research paper ...

Science

Introduction

When the first crude telescopes grazed the vast space, the 17th century and astronomers such as Kepler and Galileo was already making discoveries of such as the moon craters, the rings of the planet Saturn, and the giant planet Jupiter. These discoveries paved the way for a more extensive exploration of the cosmos, which was ultimately revolutionized by the birth of the Hubble telescope. In April 1990, word's most advanced space telescope named after the astronomer Edwin P. Hubble was launched at 353 miles above the earth's surface with a mission to see deeper into space and beyond. The technological feat of HST was owed from its wide array of engineering technologies that was carefully constructed to achieve its full exploratory potential. This discussion will focus on investigating the instrumentations used in constructing the HST including the scientific discoveries made. In addition, the discussion will also include the vital engineering subsystems such as the Orbital Replacement Units and modular packages that were installed in HST to standardize accessibility for astronauts wearing pressurized suits.

Systems and Instrumentations

The space shuttle Discovery brought the highly trained experts to carry out servicing missions to Hubble on February 1997. Armed with the most sophisticated engineering and advanced space technologies, the STS-82 crew replaced the imaging parts of HST with more advance instruments. The Goddard High Resolution Spectrograph was replaced with Space Telescope Imaging Spectrograph, while the Faint Object Spectrograph was replaced

with the Multi-Object Spectrometer and Near Infrared Camera. The augmented telescope operations also require components such as RWA (Reaction Wheel Assembly), FGS (Fine Guidance Sensor), and SADE (Solar Array Drive Electronics, SSR (Solid State Recorder), E/STR (Engineering/Science Tape Recorder), MSU (Magnetic Sensing Unit), OCE-EK (Optical Control Electronics Enhancement), and DIU (Data Interface Unit). Over the years, the constant servicing mission to the Hubble is becoming more and more challenging due to enormous technical obstacles in order to keep the orbiting observatory optimized for its full capability.

Telescope Configuration

HST was designed with instrumental specifications configured to alternately operate at a given amount of time. The scientific instrumentation elements such as OTA (Optical Telescope Assembly) composed of two mirrors structured to collect light from celestial objects, analyzing devices, SSM (Support Systems Module), and Solar Arrays are referred to as the supporting structures with specified configurations (asd. gsfc. nasa. gov). The OTA for instance is composed of two mirror sets with supporting trusses, and focal plane structure that enables the Hubble to collect as much light as possible from as far as possible. The focused images are analyzed by allowing the incoming light to pass trough the tubular baffle. The 94. 5-in concave mirror will then collect the light and converge it towards the convex secondary mirror, which is only 12. 3-in in diameter. The primary mirror has a 24-in hole in its center to allow the light from the secondary mirror to pass through to the Focal Plane and towards the science instruments for analysis (starchild. gsfc. nasa. gov).

The scientific instruments on the other hand are also composed of numerous components needed to create the image of the light collected by the OTA. There are eight scientific instruments installed in HST in which four are mounted behind the primary mirror aligning them to the telescope’s optical axis. These four axial instruments are mounted perpendicular to the scientific radial instruments such as the WF/PC II (Wide Field / Planetary Camera II and FGS (Three Fine Guidance Sensors) (spacetelescope. org). Faint camera object was part of the telescope brought during the Second Servicing mission held on February 1997 aboard the space shuttle Discovery. The brought telescope is in capable to handle about eight-science instrument categorized into axial science instruments and radial (perpendicular) science instruments. The radial science instruments consist of Wide/Planetary Camera II (WF/PC III) and three Fine Guidance Sensors (FGS). The faint camera object was along with other axial science instruments that include Goddard High Resolution Spectrograph (GHRS), the Corrective Optics Space Telescope Axial Replacement (COSTAR), and the Faint object Spectrograph (FOS).

The telescope and the parts were arranged as see in Figure 1.

The faint object camera puts into archives images and pictures of pale-lighted cosmic objects in space. The faint object camera can be able to take records of images by reflecting the object’s light in one of its two optical pathways. Inside, the light, with the help of a detector, would then be filtered eliminating any excess brightness from other cosmic bodies. The result is a vivid image with a enhanced background. The detector that was been

installed inside the faint object camera will enable to deepen image color and records the enhanced images like in a TV camera. The images that were been logged will be converted into digital files. The files would then be directed to Earth and space science specialists would recreate the imageries taken at the Space Telescope Science Institute (STSsI).

The two telescope components Faint Object Spectrograph (FOS) and Goddard High Resolution Spectrograph (GHRS) helps in the split-up of entering light to different wavelength compositions. In space, the spectrograph had superior proficiency in distinguishing extensive array of wavelengths than it is on Earth. This is due to the presence of the Earth's atmosphere, which protects humans and other living things by absorbing certain wavelengths. From the data obtain, scientist would be able to distinguish certain characteristics of that cosmic body like say for example its temperature, disorder in the atmosphere, elemental and chemical composition, and pressure. All these are determined using the spectral records from the camera. The difference between the two spectrograph is that GHRS senses brighter objects in superb fine points but only in ultraviolet light while FOS distinguishes fine points in far-distanced cosmic bodies in a the spectral range of UV to red bands. The mechanism however on how the images are obtained was almost the same. The inbound light will pass through a trifling opening into the light strainers then into the deflection lattices, which will work as prism. The deflection lattices and the light strainers would help in the determination of wavelengths. The detectors inside the spectrograph records the power of each wavelength then transferred it on Earth.

The Corrective Optics Space Telescope Axial Replacement (COSTAR) is the one responsible in putting corrective mirrors in front of the openings of the FOS, FOC, and GHRS using its machine-driven arms. COSTAR was made to address the problem caused by the sphere-shaped deviation of the primary mirrors inside the camera and spectrographs. The mirrors equipped in the COSTAR would correct this abnormality by relocating the light redirected on the mirrors of FOC, FOS, and the GHRS. There are two corrective mirrors, the first mirror (M1) and the second mirror (M2). The first mirror diverts incoming light from Hubble’s secondary mirror. The light is then reflected to the second mirror (M2). Refocusing the light of the mirrors in the telescope increases energy entering in the three instruments. As such, the optical performance would then be increase.

The Wide/Planetary Camera II (WF/PC III) is responsible for magnifications of the images taken in two intensities. A team from Pasadena, California by Jet Propulsion Laboratory (JPL) established the Wide/Planetary Camera II (WF/PC III). JPL also made the first WF/PC. The second WF/ PC II was built to solve defects found inside Hubble’s mirrors. The new design included recreation of relay mirrors in the photosensitive train of the camera using visual modification. The mirrors were fine tuned to recompense unfitting figure on the principal mirrors of HST. There are three Fine guidance sensors indie the telescope. These sensors are equipped in the telescope to act as a science instrument and to relay data into the space capsule’s aiming system so that the telescope will be static aiming at the desired cosmic body. The sensors would also quantify the relative location of the stars and determine its brightness. These instruments are very useful in locating distances and

motions of the stars and other companion cosmic bodies.

Inside the Support System Module, there is the Optical Telescope Assembly (OTA). At the back of the OTA is the Equipment section composed of loops of coves and havens that hold the batteries and most of the electronics devices like computers and other communication devices. The hindmost side of the telescope contains the science devices.

The main purpose of the Solar Arrays is to provide sufficient energy to power up the space capsule. The Solar Arrays are located in the forward shell of the Support Systems Module. It is attached on the opposite sides of the telescope looking like wings. The arrays supported wings of solar panels of about 40 ft. in length and 8. 2 ft. in width. The arrays stand on a pole of 4 ft. The SAs are design so that it could rotate in any location facing the sun. The light energy absorbed by the solar panels will be transformed into electrical energy and will be used to power the telescope and its batteries. This whole system is part of what we called EPS or Electrical Power Subsystem. The batteries should be charge so that the whole telescope could still function even under shadows when rotating around the earth. There is this incident during the First Servicing Mission in which the Solar arrays were damage due to direct rotation in and out the Sun. The commotion caused thermal gradients. As a result, some fine observations were loss. As such, thermal shields were installed to reduce these effects.

There are two main computers in the Hubble’s DMS (Data Management Subsystems) namely the DF-224 flight computer and the SIC&DH (Science Instrument Control and Data Handling). Each computer performs different functions. Let us say for example, the SI C&DH reins the instructions

received by the science devices, set-ups science data, and transports this data to the communication system to be conveyed on the Earth. On the ship calculations and data management between the ground system and the telescope is performed by the DF-224. A coprocessor to intensify the ability of DF-224 flight computer was fixed by the astronauts during the First Servicing Mission. It is called 386-coprocessor. The coprocessor was found out to increase on-orbit calculation proficiencies and escalates computer inactivity.

The Hubble Space Telescope (HST) was equipped with around 3. 1 meters Light Shield and a Forward Shell. The Equipment Section and the Aft Shroud were around 4. 2 meters in diameter. Its focal length can reach up to 56. 7 meters and goes around 6. 3 meters when folded. The principal mirror’s diameter is about 2. 4 diameters while the secondary mirror is somewhat smaller with only a diameter size of about 0. 3 meter. The magnitude could extent up to 5 visual magnitudes to 29 visual magnitudes and has the pointing accuracy of about 0. 0007-arc sec for every 24 hours. The whole mission is expected to last up to 15 years.

Scientific Discoveries

In 1990, a new age of space exploration has begun. NASA deployed the Hubble Space Telescope or HST that time and after more than six years of operation, the space telescope’s rate of extraordinary discoveries has re-energized astronomy. This event did not happen not after the invention of the Hubble Space Telescope in which the people were just looking at the universe as a mere creation. The people’s vision about the universe been revolutionized over a short period of time. The Hubble Space Telescope was

created and designed to do basic jobs, which is capable of. These are to provide images with fine details, its ability to produce ultraviolet spectra and images, and its job to detect such faint objects in the outer space (nasa. gov).

The Telescope is very popular as it allows scientist to see what lies out in the space. It provides a clearest view of the cosmos that allows the scientists to gather information such as composition, motion, and temperature of celestial objects through analyzing radiation that is being emitted or even absorbed by the objects in the outer space. More than these advantages, uses and basic capabilities of the Hubble Telescope, it also made scientists discover stellar evolutions, new planets, and cosmology and galaxies.

The Hubble Telescope was able to prove that it is well suited for the study of different objects in the solar system. As such, the Telescope was able to provide our scientist the most clear view ever of the planet Mars (nationalgeographic. com). In addition, the image captured by the HST provided detailed information about the planet Mars, in which it shows the abundance of the planet’s wispy clouds. This has indicated that the Mars is a cooler planet because of the white clouds that covers most of its atmosphere. This discovery was not as clear when it was a research was conducted in the 1970s.

The Hubble Telescope was a great creation in discovering stellar evolution. The telescope captured hundreds of different photo angles that answered many questions that were long-standing before the operation of the Hubble Telescope such as a star’s birth and death. Detailed images were captured such as the hydrogen gas and dust that serve as an incubator stage for new

stars. Also, a photo evaporation process was captured. This is when the ultraviolet light coming from a nearby hot star slowly erodes the pillar. Basically, as the eroding of the pillar happens, globules of dense gas buried in the clouds are being uncovered. Stars also die after long period after it was born. This is another discovery that the Hubble Telescope was able to provide. The discovery shows that when the start is on its near destruction or death, it eventually grows and expands for more than fifty times its previous size, which becomes a red giant hot star.

The Telescope discovered that once the start is about to die, its outer layers are being ejected out in the space that will expose small hot core of the star. Additionally this revelation shows that even though a star will live for more than ten billion years, it only takes few thousand years to do the actual process of ejection. However, not all stars end up the same way. Some of them go to a violent ending. The Hubble Telescope discovered that a massive star named Eta Carinae had a giant outburst that was visible on earth about fifteen decades ago, which was one of the brightest stars covering the southern skies. This was one the astonishing discoveries made by the scientists with the help of the Hubble Telescope.

Moreover, the Hubble Telescope helped with the discoveries about galaxies and cosmology. Galaxies are the biggest star assemblages in the universe. This also entails the study of universe’s evolution on a larger scale. The Hubble Telescope discovered that universe does not stay in its own size. Thus, it showed that is continuously expands. The discovery revealed that galaxies from all directions are recedes back from earth. More investigations have increased since the first uses of the Hubble Telescope such as more

galaxies were being discovered. Previous astronomers thought that active galaxies are being powered by black holes. This thinking has changed after they viewed NGC 4261; a galaxy that was discovered located one hundred million light years away. The Telescope gave the astronomers a clear view of giant circulating disk made of matters, which formed around a suspected black hole of the galaxy.

The study of the nearby galaxy could provide a better understanding about how quasars and active galaxies produce energy. There was a discovery about three decades ago, in which showed that quasars are one of the most mysterious objects within the universe. This is because of their compact size as well as extraordinary energy output. With the help of the Hubble Space Telescope, astronomers discovered that a massive black hole, which gobbling up gas, dust, and stars, are the ones that powers up a quasar.

The Hubble Space Telescope was established as a leading astronomical observatory, which continuously makes extraordinary discoveries and observations in the astronomy world. It will continue to provide us the accurate information about the age and size of our universe. It also provides decisive evidence regarding the existence of the massive black holes that are in the centers of galaxies.

Works Cited

Asd. gsfc. nasa. gov. " Hubble Space Telescope Systems." N. p., Web. 3 Mar. 2014. .

Asd. gsfc. nasa. gov. " Main Hubble Page." Astrophysics Research Projects. NASA, n. d. Web. 4 Mar. 2014. .

Hyperphysics. phy-astr. gsu. edu. " Hubble Space Telescope Instruments."

hyperphysics. phy-astr. gsu. edu. gsu. edu, n. d. Web. 4 Mar. 2014. .

National Geographic. " Hubble Space Telescope Photos, Hubble Pictures, Images." National Geographic. National Geographic, n. d. Web. 4 Mar. 2014. .

Spacetelescope. org. " Hubble's instruments." ESA/Hubble. NASA, n. d. Web. 4 Mar. 2014. .

Starchild. gsfc. nasa. gov. " StarChild: The Hubble Space Telescope." N. p., Web. 3 Mar. 2014. .

Stillman, Dan. " What Is the Hubble Space Telescope?" NASA. nasa. gov, 28 Apr. 2009. Web. 4 Mar. 2014. .