

James Webb Space Telescope: The First Light Machine

°H. Philip Stahl¹⁾

NASA Marshall Space Flight Center¹⁾

E-mail: h.philip.stahl@nasa.gov

NASA James Webb Space Telescope (JWST) will search for the first luminous objects of the Universe to help answer fundamental questions about how the Universe came to look like it does today. At 6.5 meters in diameter, JWST will be the world's largest space telescope. Its architecture, e.g. aperture, wavelength range and operating temperature, is driven by JWST's science objectives.

1. Introduction

Scheduled to start its 5 year mission after 2018, JWST will study the origin and evolution of galaxies, stars and planetary systems. Its science mission is to: Identify the first bright objects that formed in the early Universe, and follow the ionization history. Determine how galaxies form. Determine how galaxies and dark matter, including gas, stars, metals, overall morphology and active nuclei evolved to the present day. Observe the birth and early development of stars and the formation of planets. And, study the physical and chemical properties of solar systems for the building blocks of Life.

2. Principle

To accomplish the JWST science objectives requires a larger aperture infrared cryogenic space telescope. A large aperture is required because the objects are very faint. The infrared spectral range is required because the objects are so far away that their ultraviolet and visible wavelength spectral lines are red-shifted into the infrared. Because the telescope is infrared, it needs to be cryogenic. And, because of the telescope is infrared, it must operate above the Earth's atmosphere, i.e. in space.

JWST is probably the single most complicated mission that humanity has attempted. It is certainly the most difficult optical fabrication and testing challenge of our generation. The JWST 6.5 m diameter primary mirror is nearly a parabola with a conic constant of -0.9967 and radius of curvature at 30K of 15.880 m. The primary mirror is divided into 18 segments with 3 different prescriptions; each with its own off-axis distance and aspheric departure. The radius of curvature for all 18 segments must match to +/- 0.150 mm at 30K. JWST is diffraction limited at 2 micrometers which translates into a transmitted wavefront specification of 156 nm rms. Of that amount, 50 nm rms is allocated to the primary mirror. Each segment is allocated 22 nm rms surface error. At the start of the JWST program, the capability to make such a mirror did not exist.

In 1996, NASA began a systematic and comprehensive mirror technology development effort which resulted in JWST. This program resulted in a qualified mirror fabrication process being approved in 2006. Today, all JWST primary mirror segments meet their requirements and are on schedule for a 2018 launch. The next step is system level assembly, integration and test. Ambient tests will be conducted at Goddard Space Flight Center and cryogenic system level testing will be performed in Chamber A at the Johnson Space Center.