HOW THE JAMES WEBB SPACE TELESCOPE VIEWS THE COSMOS

The James Webb Space Telescope gives an unprecedented view of the ancient universe through the use of deep range infrared light imaging

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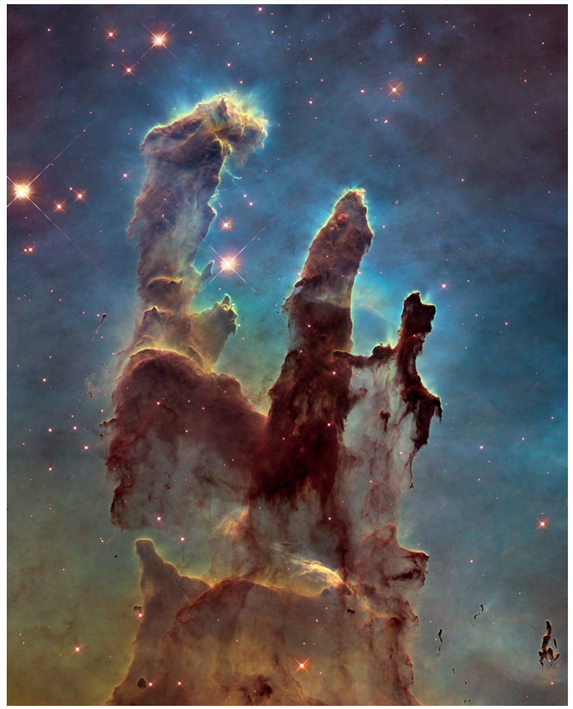
Directly after the Hubble Space Telescope launched in the 1980's, observational scientists started discussing a follow-up technology that would use long wavelength or infrared imaging. This telescope, named after James Webb, director of NASA from 1961 to 1968, was originally supposed to launch in 2007 on a 500 million dollar budget. After failing to make launch dates in 2007 and 2013, due to construction delays, many people following this satellite's journey thought it was never going to be ready to take to the stars. Finally in October of 2021, the James Webb Space Telescope (JWST), coming in at a final cost of nearly 9.7 billion dollars (as estimated by NASA), was launched.

The JWST started its journey nestled on the head of the ESA Ariane 5 rocket and proceeded to make a 1.5 million kilometer journey to the second Lagrange Point. A Lagrange Point is a stable orbit point that maintains a smaller orbiting body's position relative to two larger bodies. In this case, gravitational forces keep the Earth in between the telescope and the Sun, which helps maintain a cool telescope temperature and limits the amount of infrared light coming from the Sun which would effectively ruin the telescope's "night vision". This is an ideal place for the JWST to call home as its sensitive instruments need to be kept very cold, a chilly -255 degrees Celsius, and can become oversaturated by the Sun's light.

The ability to pick up wavelengths of light that are far into the infrared spectrum is important for observational astronomers, such as Dr. Erica Nelson, an Astrophysical and Planetary Sciences professor here at CU Boulder studying the early formation of galaxies, because of a phenomenon known as redshift. The universe is expanding, and when light travels across space a phenomenon known as the Doppler Effect stretches out the light to be at a longer wavelength. In order to see further into the past, the JWST must be able to pick up light deep into the infrared spectrum that has been shifted there after traveling through billions of lightyears in an expanding universe.

James Webb Space Telescope Mirror Seen in Full Bloom" by James Webb Space Telescope is marked with CC BY 2.0.



Visible Light

The Pillars of Creation

Infrared Light

Hubble Goes High Def to Revisit the Iconic 'Pillars of Creation'" by NASA Goddard Photo and Video is marked with CC BY 2.0.

Dr. Erica Nelson and her team are attempting to understand "how the universe evolved from its uniform state, shortly after the Big Bang, to the diversity of galaxies we see today." Through her prior research with the Hubble Telescope, Dr. Nelson categorized most galaxies that we can currently observe as forming like massive disks and also creating a majority of their stars as galactic disks. She said, "If we are going to understand how early galaxies evolve, we are going to have to understand how the stars that make them up formed." It is predicted that at earlier times in the universe, galaxies did not form in these massive disk-like structures, and at a certain point, there was a time when galaxies evolved from a mess into an organized structure that Dr. Nelson describes as a "dawn of disks.' Dr. Nelson is hoping to observe and understand this hypothesized shift to disk formations.

The formation of galaxies and stars is a chaotic process and during their construction, stars are surrounded by dust. Dust can become an issue for observational astronomers like Dr. Nelson, because it absorbs, heats up, and re-radiates up to 95% of the light that those emerging stars produce. Most of this light is emitted as longer wavelengths of infrared. A good example of this phenomenon is to look at the Pillars of Creation, a giant cloud filled with dust and gas, in visible and infrared light. In Dr. Nelson's words, "At earlier cosmic times galaxies are way dustier."

Another application of the JWST's ability to see through dust and small particles is to examine in more chemical and visual detail, past the icy clouds and waters of the ice giants Neptune and Uranus. This will give scientists a new window to view Earth's celestial neighbors. The JWST will be able to pick up these long wavelengths of infrared, and it will be the first time scientists, such as Dr. Nelson, are going to see early galaxies and other previously opaque celestial bodies clearly.