# James Webb Space Telescope : A Peep into the Deep

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The telescope has a long historical timeline. Reports of making distant things look closer using lenses were available in the late sixteenth century. At the beginning of the seventeenth century (1608) Hans Lippershey, a German-Dutch spectacle maker, applied for a patent for the instrument ahead of two other Dutch scientists and is considered the inventor of the telescope. In the next year (1609), the famous astronomer, physicist, engineer and mathematician Galileo Galilei improved the telescope built by Hans Lippershey calling it the 'perspicillum' and used it for many astronomical discoveries. The name telescope originated from the combination of two words 'tele' (far) and 'skopien' (to look or to see). The name telescope was officially announced by the Greek poet Giovanni Demisiani in 1611 at a banquet hosted by Prince Federico Cesi in honour of Galileo Galilei at the Italian Science Academy. After the discovery of the basic telescope in the seventeenth century, improvements in telescope have continued till the present century. The most recent and powerful telescope is the James Webb Space Telescope (JWST) which was launched on Christmas Day in 2021.

Those who have been following science progression regularly must have noticed inexplicable discoveries about space continuously appearing in newspapers and magazines since the launch of JWST. The JWST has been a great advancement compared to the well-known Hubble Space Telescope which was launched in 1990. The Hubble Space Telescope, which in a sense is a cousin of JWST, rotates around the Earth at an altitude of about 525 km, while JWST rotates around the sun about one million kilometres from Earth. To avoid direct sun, the earth is always positioned between the telescope and the sun.

The JWST is about six times the size of the Hubble Telescope, much more powerful and captures wonderful images. The JWST is as tall as a three-story building, being the largest, most powerful space telescope ever built. It is folded in origami style to fit inside a rocket for launching and unfolds only when it is in space. It views the universe by light like an ordinary telescope. While the light used in the Hubble telescope is in the ultraviolet and visible range, JWST views the universe through light in the infrared region. Infrared radiates from any heated body but is invisible to human eyes. The wavelength of this light is longer than that of the ordinary red light that we see, and we can feel it only as heat. Red light can travel long distances through fog, dust, clouds etc. and hence, 'stop' signals are in red to be seen from a long distance. This is also the reason why JWST uses infrared cameras to see through dust and clouds in our universe.

Since JWST rotates around the sun, it has a sunshield, about the size of a tennis court, to protect the camera from the intense heat of the sun, the way we block sun rays by using a hat or sunglasses. The temperature difference between the side of the telescope facing the sun and that in the shade is more than $3000^0$C.

In physics, distance and time are interrelated. In astronomy, distance is often measured in terms of the light year, which measures the distance travelled by light in a year. We know that light travels at a speed of about 300000000 metres per second. If the average distance between the earth and the sun is 150 million kilometres, it takes about 500 seconds or about eight minutes for the light to reach the earth; so, the light that we see at any point is older by eight minutes. A powerful telescope placed on earth can see any object up to a distance of 2 billion light years away. The Hubble space telescope can see objects up to a distance of 13.4 billion light years and JWST can see objects that are about 13.6 billion light years away.

Scientists claim that the universe began with a Big Bang which took place 13.8 billion years ago. The goal of the JWST is to peep deeper into space and explore the events around the Big Bang moment. Scientists believe that a huge amount of energy was concentrated in a tiny point, which they call a 'singularity'. This extremely dense point exploded with unimaginable force and temperature. With expansion, the temperature cooled down and hydrogen atoms were formed. These basic atoms then started combining and gradually created more complex atomic structures resulting in a wide range of elements. These elements were the basis for the formation of stars and subsequently, these stars started to form galaxies. Scientists estimate that the formation of a galaxy takes over a billion years and there are around 1 billion galaxies, some being relatively new while others are much older.

If the universe was formed 13.8 billion years ago, and JWST can see as far as 13.6 billion years ago, it means that JWST can see the universe when it was only 200 million years old i.e. when the universe was very young. With this cosmic understanding, JWST started its deep space exploration in June 2022.

The first image captured was on 12 July 2022. The incredible range of images and astronomical data obtained have transformed our understanding of star formation and depth, galaxies, planets, black holes, exoplanets and more. Infrared also allows us to see further into the past than ever before. This is because the ultraviolet and visible light released at the beginning of the Big Bang has stretched to longer wavelengths (towards red) over time due to the expansion of the universe. This process is called 'redshift'. Today that light reaches us as infrared light. The redshift helps us to answer questions like what happened at the beginning of the Big Bang and how the universe came to be. The Uranus was seen as a clean, featureless, dull object in visible light while the image captured by JWST highlights 11 of Uranus' 13 rings and all the activities around the planet.

We are still a long way from answering several critical existential questions. However, just in about two years, JWST has led to several interesting discoveries and we look forward to seeing more intriguing mysteries of the deep universe being explained by this powerful instrument shortly. ■

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