How the James Webb Space Telescope changed astronomy in its first year

As Christmas approached last year, astronomers and space fans around the globe gathered to watch the much-anticipated launch of the James Webb Space Telescope. Though a wondrous piece of engineering, the telescope was not without its controversies – from being way over budget and behind schedule to being named after a former NASA administrator who has been accused of homophobia.

Despite the debates over the telescope's naming and history, one thing has become abundantly clear this year – the scientific ability of JWST is remarkable. Beginning its science operations in July 2022, it has already allowed astronomers to get new views and uncover mysteries about a huge range of space topics.

The most pressing aim of JWST is one of the most ambitious projects in the recent history of astronomy: to look back at some of the first galaxies, which formed when the universe was brand new.

As light takes time to travel from its source to us here on Earth, by looking at extremely distant galaxies, astronomers can, in effect, look back in time to see the earliest galaxies forming more than 13 billion years ago.

Though there was some debate among astronomers over the accuracy of some of the first detections of early galaxies – JWST's instrument hadn't been fully calibrated, so there was some wiggle room over exactly how old the most distant

galaxies were – recent findings have supported the idea that JWST has spotted galaxies from the first 350 million years after the Big Bang.

That makes these the earliest galaxies ever observed, and they had some surprises in store, such as being far brighter than expected. That means there's more for us to learn about how galaxies form in the early universe.

These early galaxies are identified using surveys and deep field images, which use Webb to look at large patches of the sky which might look empty at first glance. These areas don't have bright objects like solar system planets and are located away from the center of our galaxy, allowing astronomers to look out into the depths of space to spot these extremely far-off objects.

JWST was able to detect carbon dioxide in the atmosphere of an exoplanet for the first time and recently discovered a host of other compounds in the atmosphere of planet WASP-39b as well, including water vapor and sulfur dioxide. That not only means that scientists can see the composition of the planet's atmosphere, but they can also see how the atmosphere is interacting with light from the planet's host star, as sulfur dioxide is created by chemical reactions with light.

Learning about exoplanet atmospheres is crucial if we ever want to find Earth-like planets and search for life. Previous generation tools can identify exoplanets and determine basic information like their mass or diameter and how far they orbit from their star. But to understand what it would be like to be on one of these planets, we need to know about their atmospheres. With data from JWST, astronomers will be able to look for habitable planets far beyond our solar system.

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It’s not only distant planets that have been getting JWST’s attention. Closer to home, JWST has been used to study planets in our solar system, including Neptune and Jupiter, and will soon be used to study Uranus as well. By looking in the infrared range, JWST was able to pick out features like Jupiter’s auroras and a clear view of its Great Red Spot. And the telescope’s high accuracy meant it could view small objects even against the brightness of the planets, such as showing Jupiter’s rarely-seen rings. It also took the clearest image of Neptune’s rings in more than 30 years.

Another major investigation JWST performed this year was of Mars. Mars is the best-studied planet outside Earth, having played host to numerous rovers, orbiters, and landers over the years. That means astronomers have a fairly good understanding of its atmospheric composition and are beginning to learn about its weather system. Mars is also particularly difficult for a sensitive space-based telescope like JWST to study because it is so bright and so close. But those factors made it the perfect testing ground to see what the new telescope was capable of.

JWST used both its cameras and its spectrographs to study Mars, showing the composition of its atmosphere, which matched up almost perfectly with the expected model from current data, showing how accurate JWST’s instruments are for this kind of investigation.

Another aim of JWST is to learn about the lifecycle of stars, which astronomers currently understand in broad strokes. They know clouds of dust and gas form knots that gather more material to them and collapse to form protostars, for example, but exactly how that happens needs more research. They are also learning about the regions where stars form and why stars

tend to form in groups.

JWST is particularly useful for studying this topic as its infrared instruments allow it to look through clouds of dust to see inside regions where stars are forming. Recent images are showing the development of protostars and the clouds they throw off and are looking into regions of intense star formation, such as the famous Pillars of Creation in the Eagle Nebula. By imaging these structures in different wavelengths, JWST instruments can see different features of dust and star formation.

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Speaking of the Pillars of Creation, one of JWST’s biggest legacies in the mind of the public is the stunning images of space it has captured. From the international excitement at the reveal of the telescope’s first images in July to new views of iconic sights like the Pillars, Webb images have been everywhere this year.

As well as the gorgeous Carina Nebula and first deep field, other images worth taking a minute to wonder over include the star-sculpted shapes of the Tarantula Nebula, the dusty “tree rings” of binary star Wolf-Rayet 140, and the otherworldly glow of Jupiter in the infrared.

And the images keep coming: just last week, a new image was released showing the brightly glowing heart of galaxy NGC 7469.

Here’s to a year of incredible discoveries, and many more to come.

https://www.theverge.com/2023/1/2/23536193/james-webb-space-telescope-jwst-nasa