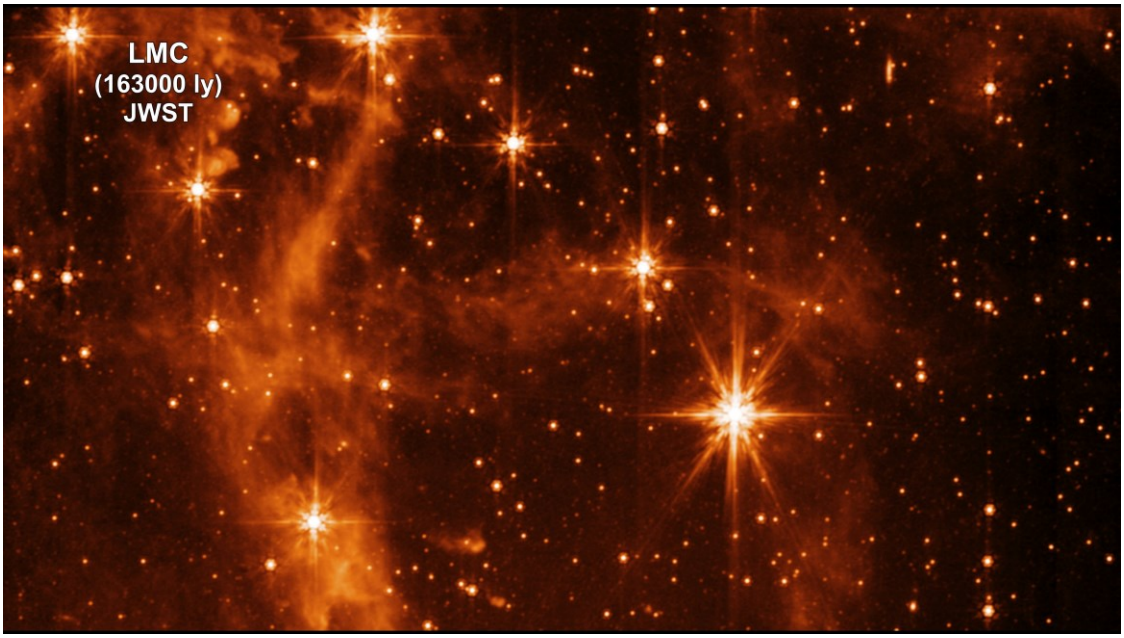
2022 JWST 1st Release

Introduction

Hello and welcome to the How Far Away Is It look at the first images released by the James Webb Space Telescope. It's been a long wait, but I'm sure you'll find it was worth it. I'll start with an early test photo of stars in the Lage Magellanic Cloud. It gives us a hint as to how much more detail we can expect to see with Webb over other space telescopes. Where I can, I start segment with a Hubble image to show the contrast. We'll take a look at the first formal image release starting with a look at the 'cosmic cliffs' in the Carina Nebula followed by the beautiful Southern Ring Nebula. We'll then cover Webbs analysis of three beautiful galaxies: a bared spiral, a classic spiral and the Cartwheel Ring galaxy. Next, we'll cover Stephan's Quintet with a deep look at what Webb found around its central supermassive black hole. And last, we'll take a deep dive into Webb's first deep field image. I trust you'll find it all interesting and informative.

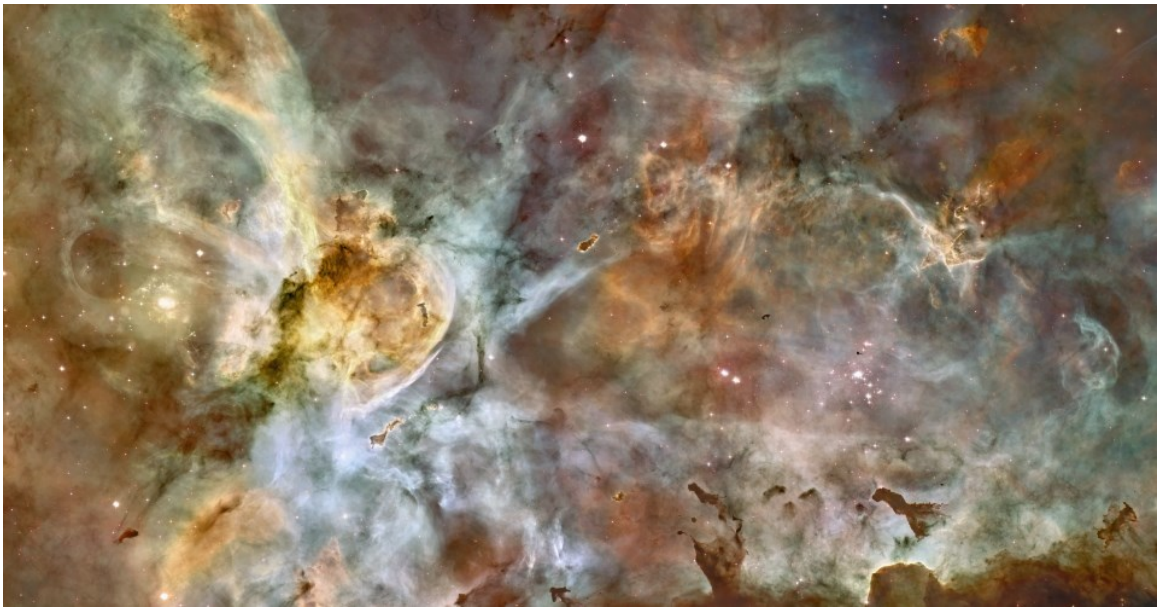
LMC – Spitzer vs Webb 163,000 ly

Here's a Spitzer infrared space telescope image of some stars in the Large Magellanic Cloud dwarf galaxy orbiting the Milky Way. Now we're morphing this into the image taken by Webb's Mid-Infrared Instrument. The retired Spitzer telescope was one of NASA's Great Observatories and the first to provide high-resolution images of the near- and mid-infrared universe. As you can see, Webb, with its significantly larger primary mirror and improved detectors, allows us to see the infrared sky with significantly improved clarity, enabling even more discoveries. For example, Webb's image shows the interstellar gas in unprecedented detail.



The Carina Nebula NGC 3324 – 7,600 light years

Here we are zooming into an image of the giant Carina Nebula 7,600 ly away taken by the Hubble Space Telescope. It is a very large bright nebula that surrounds several star clusters. The nebula itself measures some 260 light years across, - that's about 7 times the size of the Orion Nebula!



Here's Hubble's view of NGC 3324 called the 'Cosmic Cliffs' located at the northwest corner of the Carina Nebula. The image is divided horizontally by an unbroken line between a cloudscape forming the nebula along the bottom portion and a comparatively clear upper portion. [The nebula has been carved out by intense ultraviolet radiation and stellar winds from several hot, young stars located above the area shown in this image.]

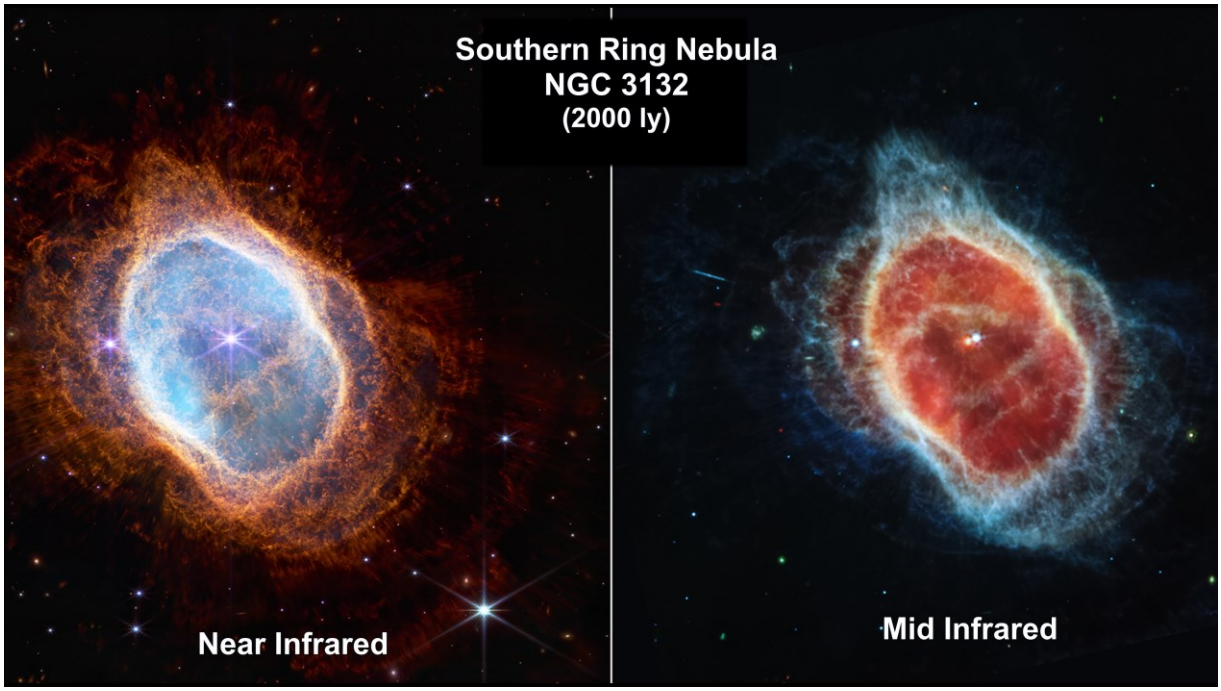
As we transition to the Webb near-infrared image, we begin to see hundreds of previously hidden stars of many sizes. The smallest of these are small, distant, and faint points of light. The largest appear closer, brighter, and more fully resolved with 8-point diffraction spikes. And even some background galaxies can be seen. The "steam" that appears to rise from the cloudscape is actually hot, ionized gas and hot dust streaming away from the nebula due to intense, ultraviolet radiation. The orangish cloudy formation in the bottom half varies in density and ranges from translucent to opaque. Dramatic pillars rise above the glowing wall of gas and cavities are being created on the bottom and left by the intense radiation and stellar winds from new stars.

Here we scan across a boarder view of the cloud with the near-infrared combined with the mid-infrared view.

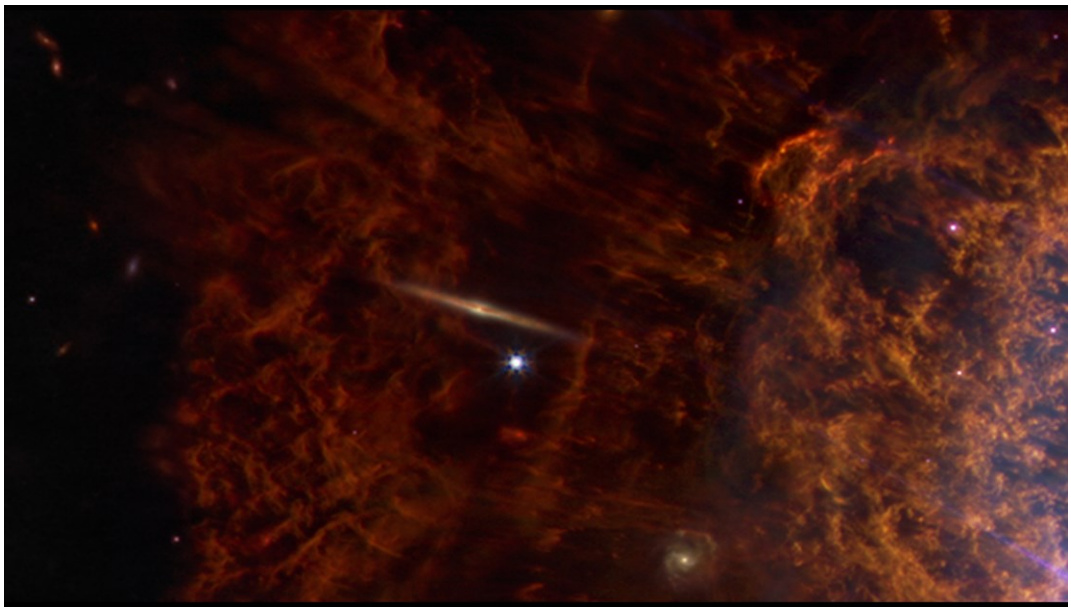
Southern Ring Nebula, NGC 3132 – 2000 ly

Here we are zooming into the Southern Ring Planetary Nebula 2,000 light years away. A Planetary nebula is the remains of a star like our Sun after it has run out of hydrogen fuel for fusion. This side-by-side comparison shows Webb's observations in near-infrared light on the left, and mid-infrared light on the right.

The Southern Ring has a binary star system at its center. One is a white dwarf. The brighter star in both images has not yet run out of fuel. It closely orbits the dimmer white dwarf, impacting the distribution of the ejected material. Over thousands of years on its path to becoming a white dwarf, the dim star periodically ejected mass that now forms the visible shells of material. In cyclic fashion, it contracted, heated up and pulsated spewing stellar material in all directions –creating this beautiful landscape. [Today, the white dwarf is heating up the gas in the inner regions – which appear blue at left and red at right. Both stars are lighting up the outer regions, shown in orange and blue, respectively.]



This is not only a crisp image of a planetary nebula – it also shows us objects in the vast distances of space behind it. The transparent red sections of the planetary nebula – and all the areas outside it – are filled with distant galaxies. Distant spirals, of many shapes and colors, also dot the scene. Those that are farthest away – or very dusty – are small and red. Note the bright angled line at the upper left. It's a faraway galaxy seen edge-on.



NGC 7496 - 24 mly

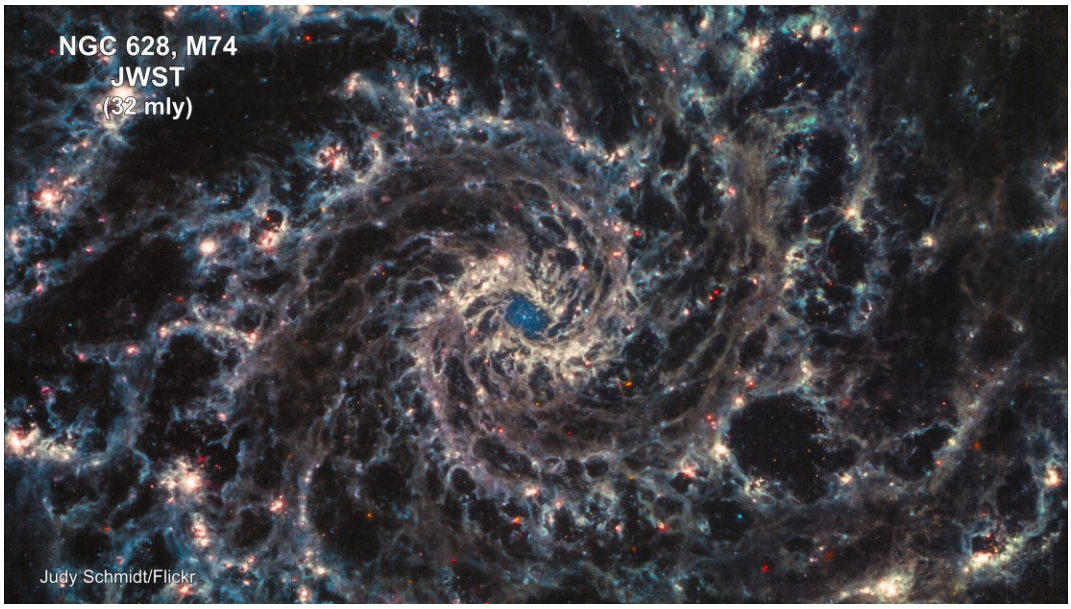
This image from Hubble released in May 2022 shows the barred spiral galaxy NGC 7496, which lies over 24 million light-years away. The spiral arms extend from a distinct bar that crosses the center of the galaxy. These bars are thought to be regions of rich star formation as gas is channeled inward towards their centers. It was expected that Webb was going to clearly see star clusters in the hearts of these dense molecular clouds that Hubble cannot see.

As we transition to the Webb view, we can see that it still picks up the glowing gas, but also shows much more detail. In Hubble's images, the galactic nucleus is just a bright, featureless glow. Webb cuts through and shows much greater detail about what's happening in the space around the supermassive black hole around which the galaxy revolves.

M74, NGC 628 – 32 mly

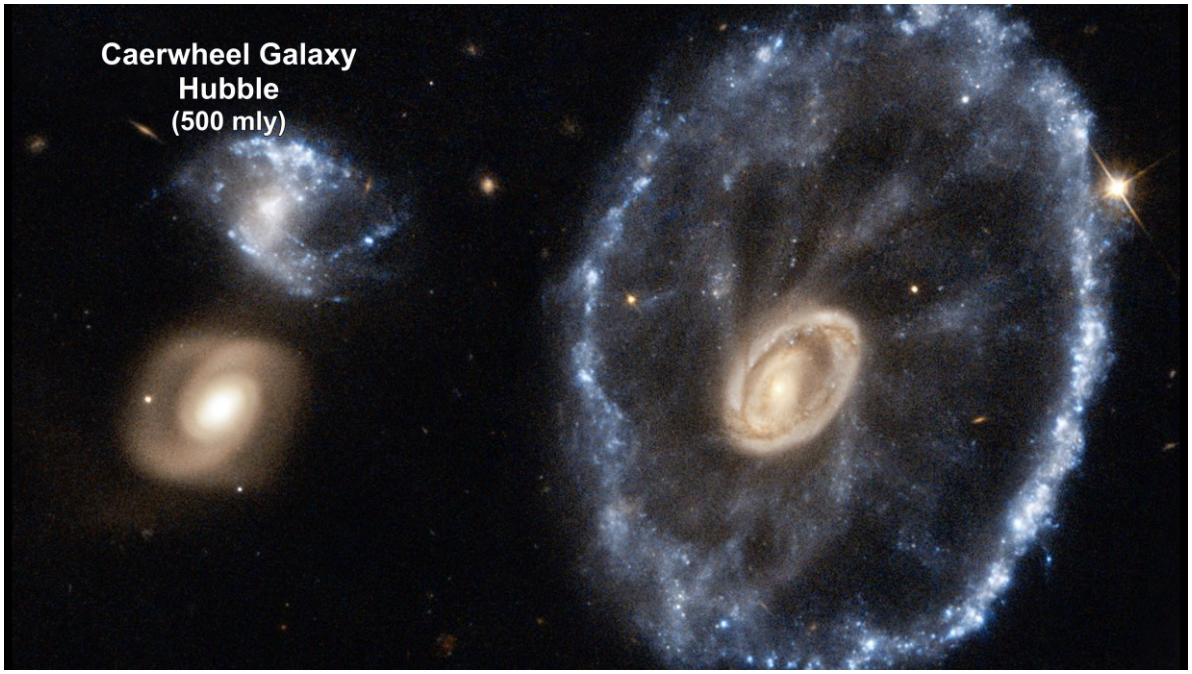
Here we are zooming into a Hubble image of M74, (also known as the Phantom Galaxy). It's a stunning example of a "grand-design" spiral galaxy that is viewed by Earth observers nearly face-on. It's perfectly symmetrical spiral arms emanate from the central nucleus and are dotted with clusters of young blue stars and glowing pink H II regions of ionized hydrogen. Tracing along the spiral arms are winding dust lanes that also begin very near the galaxy's nucleus and follow along the length of the spiral arms.

Here we see the Webb view. The galaxy's spiral arms are rich with star-forming gas seeded with young and emerging stars. The galaxy is part of an ongoing astrophysics survey designed to produce a better chart the connections between young stars and the clouds of cold molecular gas within which they evolved. Webb's early images like this one show that the newly deployed space telescope is going to help immensely in this endeavor.



Cartwheel Galaxy – 500 mly

Here's a Hubble view of the Cartwheel Galaxy a ring galaxy around 500 million light-years away. It's striking ring-like feature is a direct result of a smaller galaxy — possibly one of the two objects to the left of the ring — that passed through the core of this galaxy. Presumably the Cartwheel Galaxy was a normal spiral galaxy like our Milky Way before the collision.



Here's Webb's combined image from both the near-infrared and mid-infrared cameras. The galaxy has two rings: a bright inner ring and a surrounding, colorful outer ring. These two rings have been expanding outwards from the center of the collision for around 440 million years. The bright core contains a tremendous amount of hot dust with the brightest containing gigantic young star clusters. The outer ring is dominated by star formation and supernovas. As this ring expands, it ploughs into surrounding gas and triggers additional star formation. The galaxy is 150,000 light-years across. Our entire Milky Way galaxy would fit inside.

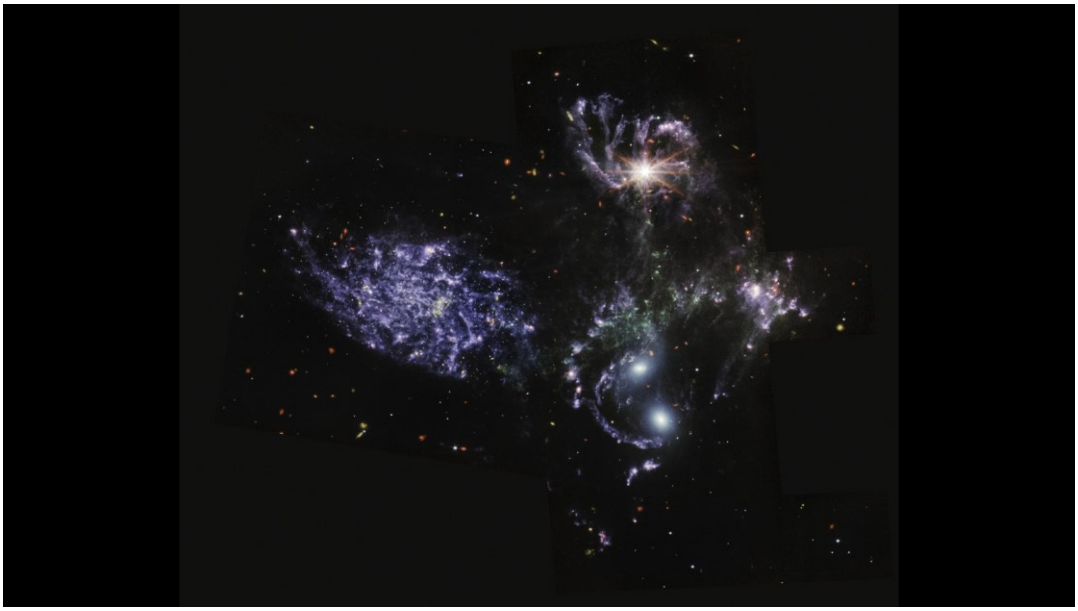
Here's a look at the galaxy from just the mid-infrared camera. The pre-collision spiral structure is beginning to re-emerge, as seen in the faint arms or spokes between the outer ring and the inner ring.

Stephan's Quintet – 290 mly

Here we are zooming into a Hubble image of the Stephan's Quintet. As the name implies, it is a group of five galaxies. The name, however, is a bit of a misnomer. Studies have shown that group member NGC 7320 is actually a foreground galaxy. At 40 million light years, it is about seven times closer to Earth than the rest of the group.

Here's the Webb image. This mosaic, a composite of near and mid-infrared data, is Webb's largest image to date, covering an area of the sky 1/5 of the Moon's diameter (as seen from Earth). At the center of NGC 7319, there is a supermassive black hole around which the galaxy is rotating.

[Here's what they look like in the mid-infrared. Webb pierces through dust, providing new insight into how galaxy interactions like these may have driven galaxy evolution in the early universe.



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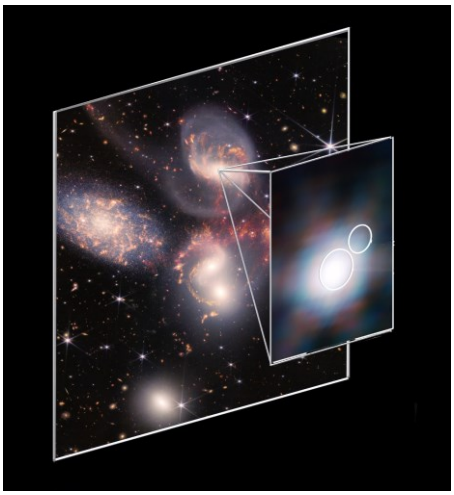
This one is 'active' meaning significant quantities of material are falling into it. These are referred to as [Seyfert galaxies or] galaxies with an Active Galactic Nucleus (AGN for short).



As falling matter approaches the black holes' event horizon, it becomes very hot and a small percentage of it is pushed away from the black hole in the form of winds and jets just before it would have passed across the event horizon – never to be seen again.

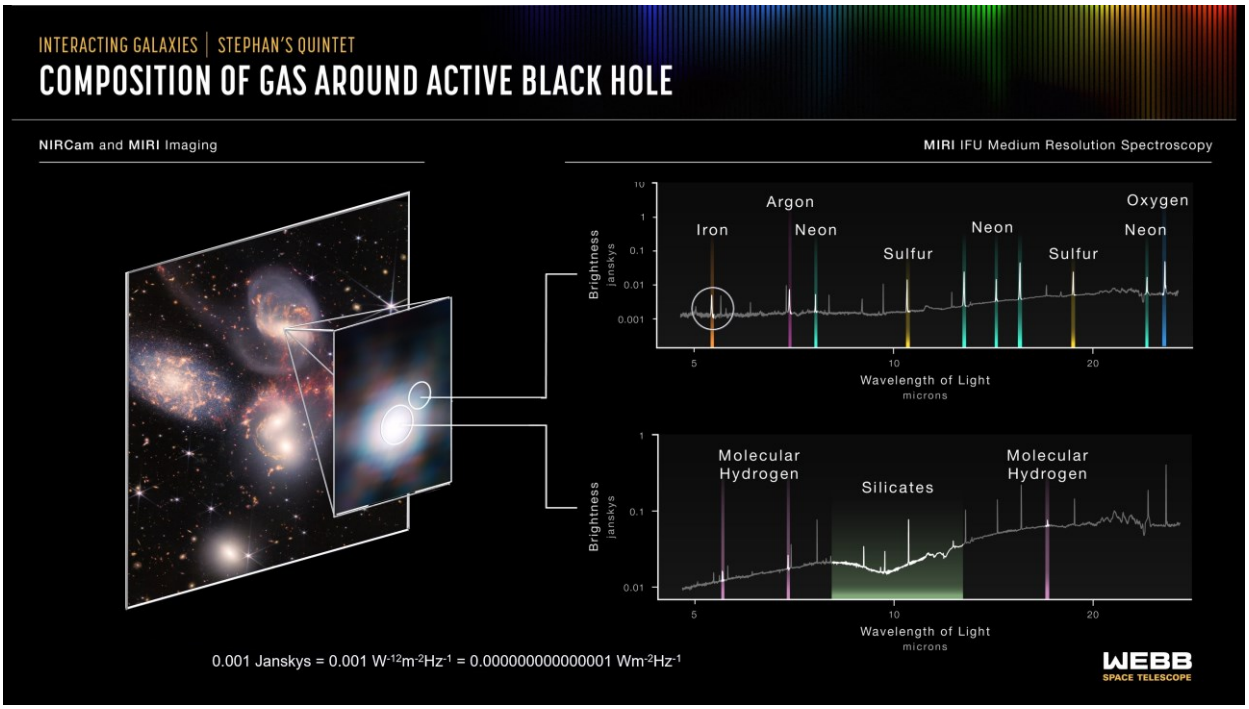
Webb has on board a medium-resolution spectrometer (MRS) as part of the Mid-Infrared Instrument to analyze the light spectrum of objects like these to determine the chemical makeup of the material falling into the black hole. With this, scientists can measure spatial structures, determine

the velocity of those structures, and get a full range of spectral data. This instrument was able to determine the composition of the gas near the supermassive black hole.

Here we are mapping the wavelength that identifies an element against the flux density that tells us the amount of that element present. The spectrum reveals that the supermassive black hole has a reservoir of colder, denser gas with large quantities of molecular hydrogen and silicate dust that absorb the light from the central regions of the galaxy.

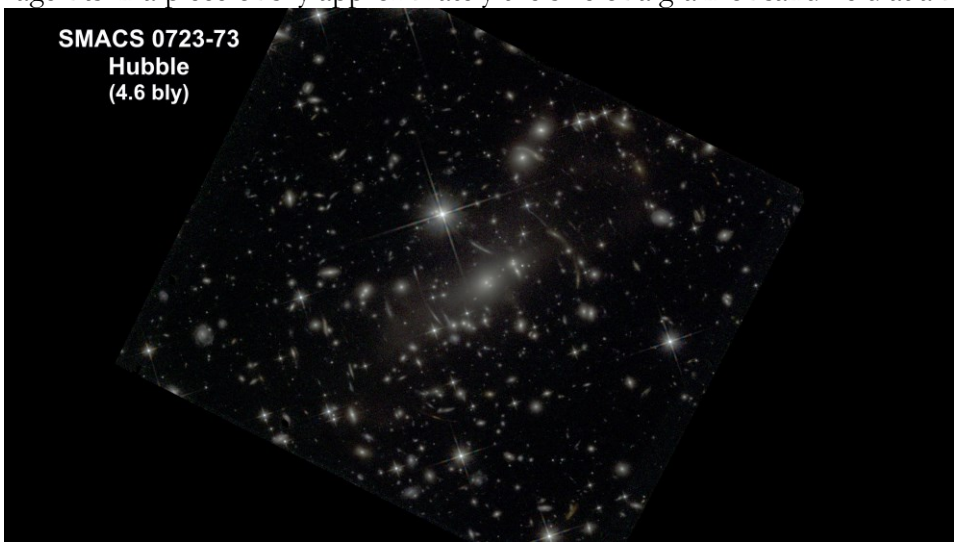
The spectrum, from the black hole's outflow, shows a region filled with hot, ionized gases, including iron, argon, neon, sulphur and oxygen as denoted by the peaks at given wavelengths. The presence of multiple emission lines from the same element with different degrees of ionization is valuable for understanding the properties and origins of the outflow.

Note the units for 'brightness'. A jansky is a very small unit – 10^{-12} watts and Webb is detecting down to 0.001 janskys. Picture a dim 1-watt lightbulb. Webb can detect a wattage that is 0.000000000000001 watts. It's quite remarkable.



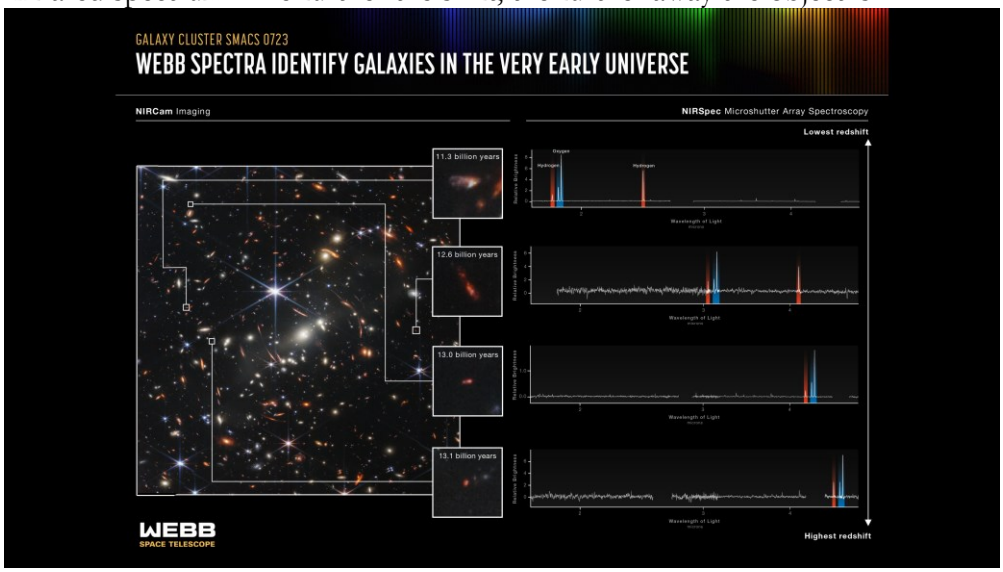
Deep Field with SMACS 0723-73 at 4.6 bly to 13.1 bly

In 2017, Hubble took this image of distant galaxies. Thousands of galaxies appear all across the view. The image fits in a piece of sky approximately the size of a grain of sand held at arm's length.



In 2022, Webb examined the same piece of sky, releasing its first Deep Field image. The detail and clarity improvements are striking. A very bright star is just above and left of center. It has eight bright blue, long diffraction spikes. Between 4 o'clock and 6 o'clock in its spikes are several very bright galaxies. A group of three are in the middle, and two are closer to 4 o'clock. These galaxies are part of the galaxy cluster SMACS 0723. The light we see left the cluster 4.6 billion years ago. This cluster is warping the appearances of galaxies seen behind them in a process known as gravitational lensing.

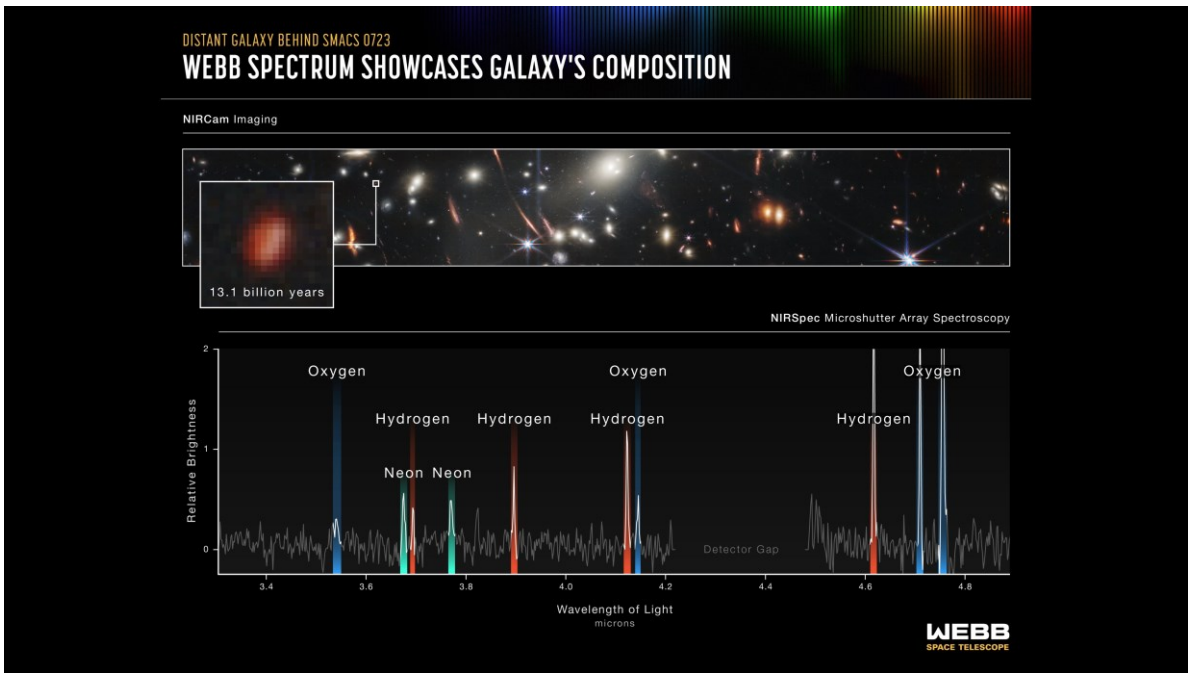
Here we see Webb's analysis of a few of these galaxies. The oldest galaxy in the picture dates back to 13.1 billion years ago, making it just about 700 million years younger than the universe itself. A few other early galaxies have ages ranging from 13 billion years to 11.3 billion years. These age estimates come from carful measurement of the redshift for hydrogen and oxygen detected by Webbs instruments. During all the time the light was traveling, the Universe was expanding. Light is attached to the space it passes through, so it's wavelength is stretched as the space expands - shifting it into the infrared spectrum. The further the shift, the further away the object is.



Here we see two similar looking lensed galaxies between the bright star's 6 o'clock and 8 o'clock spikes. Their bright central regions are similar, despite their stretched appearances. The question was are they two images of the same galaxy or different galaxies? Webb's spectrograph shows how ionized oxygen and atomic hydrogen emission lines are distributed along each arc. The graphs match, indicating that the arcs are mirror images of the same gravitationally lensed galaxy.

Here we're back with the original Deep Field image. Note how it shows a variety of colors and highlights where the dust is – a major ingredient for star formation, and ultimately life itself. Blue galaxies contain stars, but very little dust. The red objects in this field are enshrouded in thick layers of dust. Green galaxies are populated with hydrocarbons and other chemical compounds.

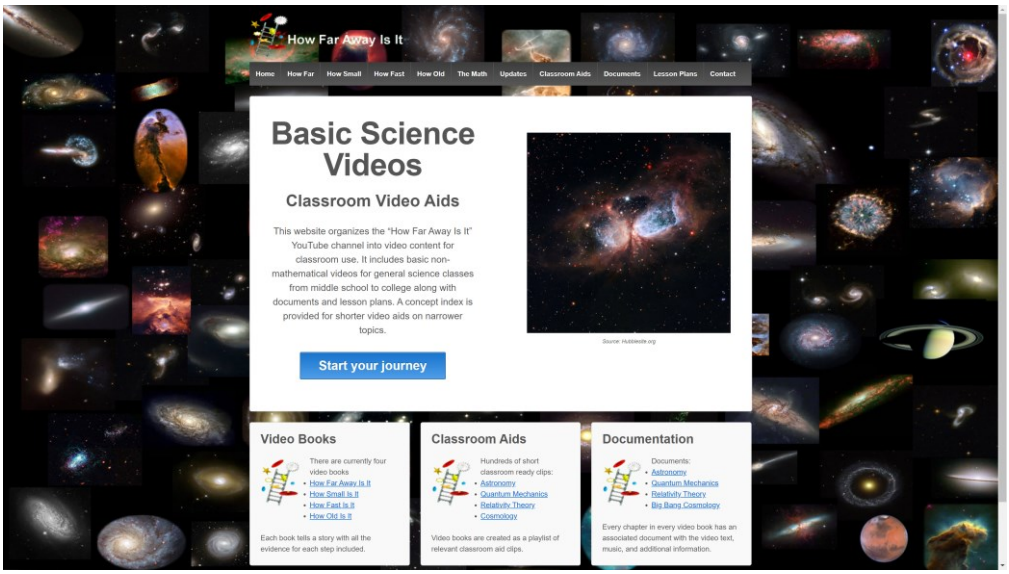
Focusing on the oldest galaxy, 13.1 bly away, Webb was able to determined its chemical composition, its temperature, and the density of its ionized gas.



This first James Webb Space Telescope release was an amazing start after such a long wait. I congratulate the entire Webb team and look forward to the coming discoveries.

Credits and Research

Here are the links to Hubble and Webb sites, whitepapers and other locations where I found the information contained in this James Webb first release review. These are also the places where you can begin to do your own research.

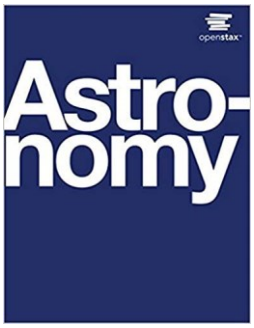


howfarawayisit.com

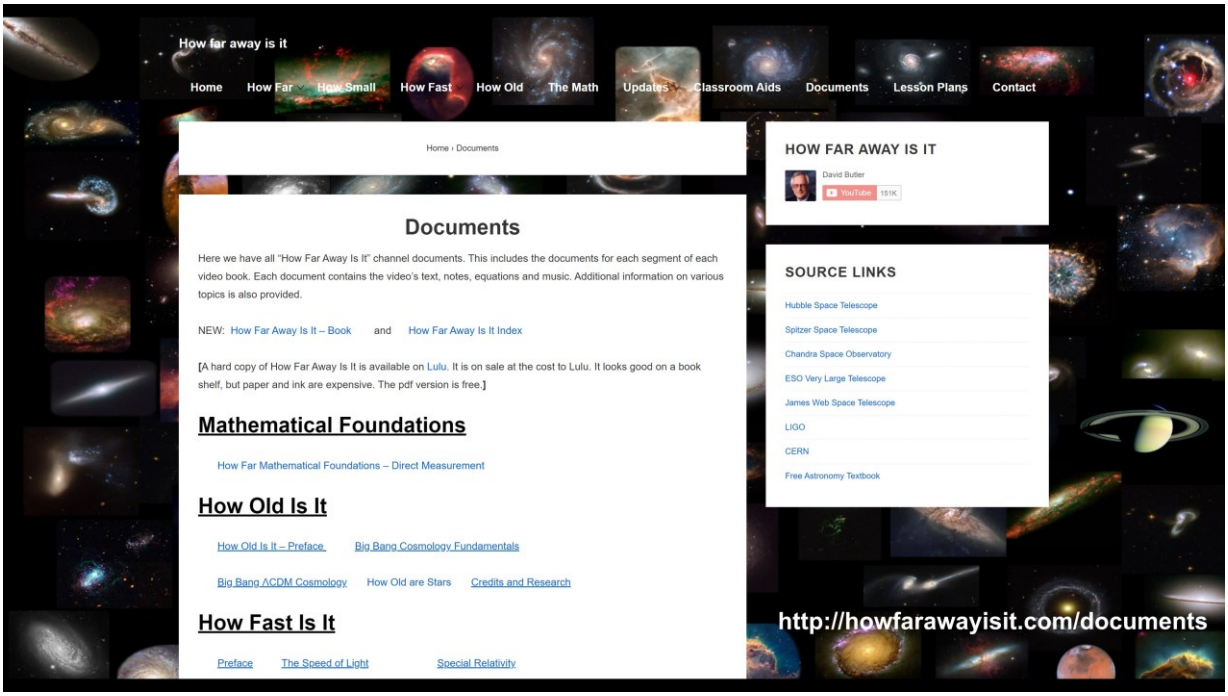
Also, thanks to Jonathan Onstead, there is a 'How Far Away Is It' wiki available for anyone who wants to engage in conversations about this or any channel video.

https://howfarawayisit.fandom.com/wiki/Encyclopedia_Howfarawayica

Here's a free online textbook called 'Astronomy" that anyone interested in astronomy can use.



https://openstax.org/details/astronomy



And don't forget. Every video has a document on the howfarawayisit.com website containing all the text. Download and translate as needed.

http://howfarawayisit.com/documents/

Thanks for watching.

Credits

JWST – Alignment picture
https://www.nasa.gov/press-release/nasa-s-webb-reaches-alignment-milestone-optics-working-successfully

LMG – Spitzer vs Webb 163,000 ly
https://www.flickr.com/photos/nasawebbtelescope/52061788279/in/album-72177720296737701/
https://blogs.nasa.gov/webb/2022/
https://blogs.nasa.gov/webb/2022/05/09/miris-sharper-view-hints-at-new-possibilities-for-science/

The Carina Nebula NGC 3324 – 7,600 light years

https://webbtelescope.org/contents/news-releases/2022/news-2022-031#section-id-2

Southern Ring Nebula, NGC 3132 – 2000 ly
https://webbtelescope.org/contents/media/images/2022/033/01G709QXZPFH83NZFAFP66WVCZ

M74
https://www.sciencealert.com/new-webb-images-of-spiral-galaxies-are-so-beautiful-we-could-cry

Cartwheel Galaxy – 500 mly
https://esawebb.org/news/weic2211/?lang

Deep Field with SMACS 0723-73 at 4.6 bly to 13.1 bly
https://www.republicworld.com/science/space/nasa-compares-hubble-images-with-those-of-webb-telescope-check-the-staggering-difference-articleshow.html

Water World to Dying Star, NASA unveils James Webb Telescope's deepest look at the cosmos

https://www.esa.int/Science_Exploration/Space_Science/Webb/Webb_delivers_deepest_image_of_Universe_yet

Music

[Music: *Massenet, Jules: Meditation from 'Thais'; Hans Kalafusz (violin), Stuttgart Radio Symphony Orchestra / Sir Neville Marriner, 1987 EMI Electrola GmbH - from the album "The most relaxing classical album in the world…ever!"****]***

[Music *Bizet, Georges: Entracte to Act III from "Carman"; Orchestre National de France / Seiji Ozawa, 1984; from the album "The most relaxing classical album in the world…ever!"****]***

[Music @05:14** Bach, Johann Sebastian: Air 'on the G string'; Academy of St. Martin in the Fields – Sir Neville Marriner, 1974; from the album "The most relaxing classical album in the world…ever!"**]

[Music: @15:20** Rachmaninov, Sergei: Rhapsody on a Theme of Paganini – Variation 18; Cecile Ousset (Piano), City of Birmingham Symphony Orchestra / Sir Simon Rattle, 1984; from the album "The most relaxing classical album in the world…ever!"**]

Greek letters:
- α β γ δ ε ζ η θ ι κ λ μ ν ξ ο π ρ σ τ υ φ χ ψ ω
- Α Β Γ Δ Ε Ζ Η Θ Ι Κ Λ Μ Ν Ξ Ο Π Ρ Σ Τ Υ Φ Χ Ψ Ω

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