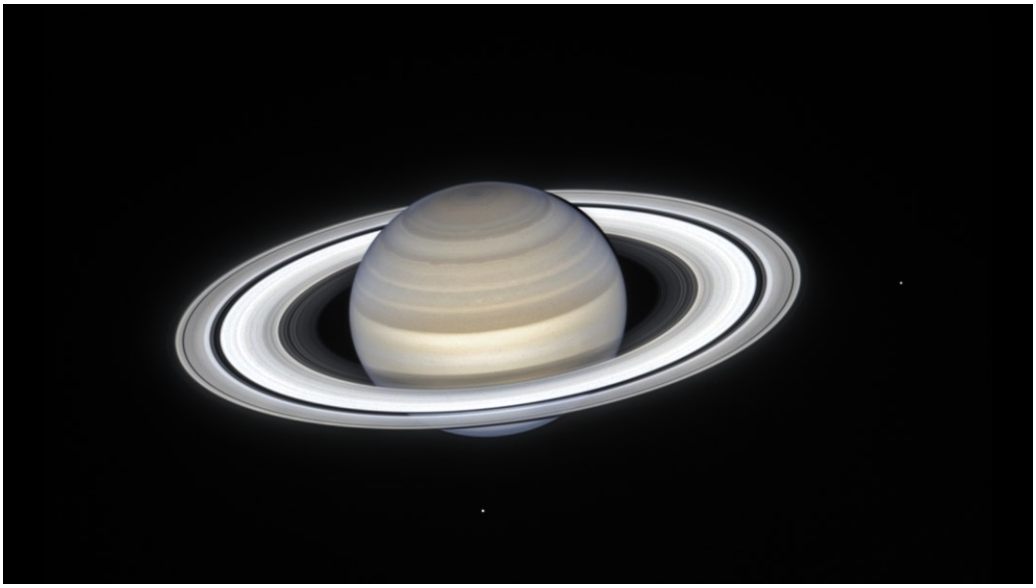
2020 Review

Introduction

Hello and welcome to the 2020 How far Away Is It review. It's been a terrible year for the globe, but Hubble and all the world's telescopes continued to examine the sky and found a number of fascinating things. Close to home, we'll see news on Saturn's rings, storms on Jupiter, and a comet with two tails. A little further out we'll see updates on the exoplanet Fomalhaut b, Betelgeuse dimming, a moving Bat Shadow, an interesting globular star cluster, and a fly-through the Orion Nebula. We'll cover Wolf-Rayet stars, a fading planetary nebula, and a look at the age of stars in the Milky Way Central Bulge. Still further out, we'll see some spectacular nebula around the Large Magellanic Cloud. We'll see a few distant galaxies, a fading Supernova and an early galaxy as seen through gravitational lensing. We'll end with a look at the new James Webb Space Telescope due for launch this year and a few of the astronomical areas it will investigate – dust and the first stars. We'll start with Saturn.

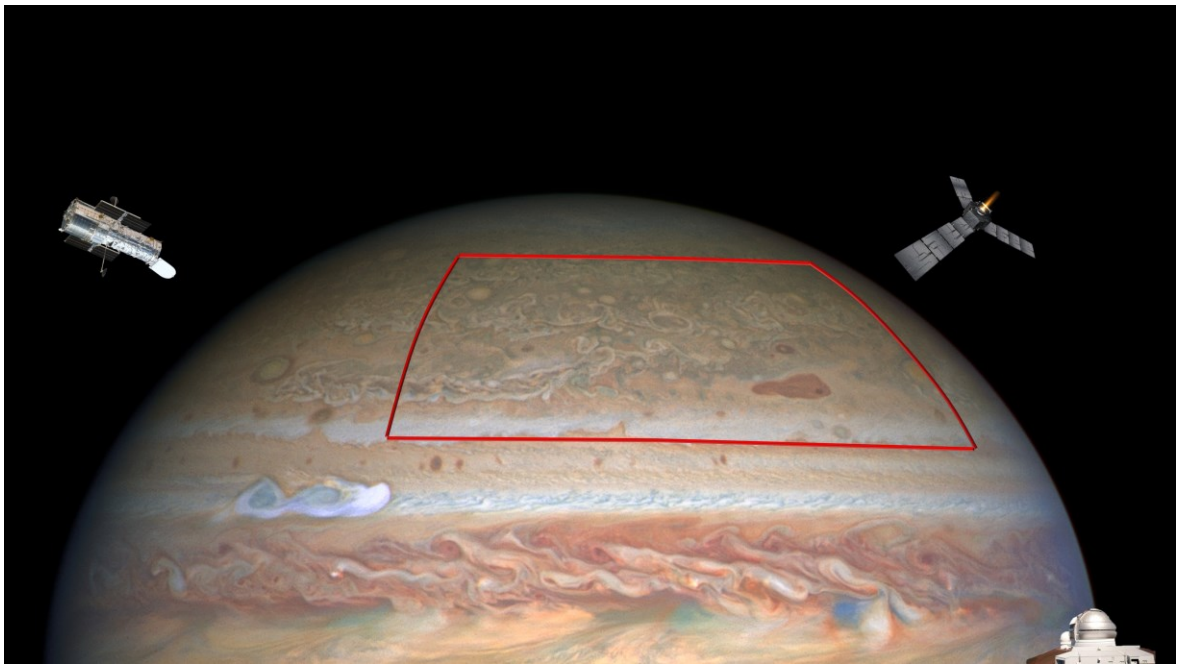
Summer Saturn **Music** Tchaikovsky: Chanson Triste

The Hubble Space Telescope took this picture of Saturn on July 4, 2020 when the planet was 1,350 million km from Earth (that's 839 million miles). At that time, it was summer in the planet's northern hemisphere. [The ringed planet's atmosphere is mostly hydrogen and helium with traces of ammonia, methane, water vapor, along with some hydrocarbons that give it a yellowish-brown color.] The rings are mostly made of pieces of ice, with sizes ranging from tiny grains to giant boulders. Just how and when the rings formed remains one of our solar system's biggest mysteries. Conventional wisdom is that they are as old as the planet, around 4 billion years. (We cover this in the "How Old Is It" video book.) But a competing theory is that they may have formed more recently during the past few hundred million years. The Cassini spacecraft measurements of tiny grains raining from the rings into Saturn's atmosphere suggest the rings can only last for 300 million more years. This is one of the arguments for a young age of the ring system.

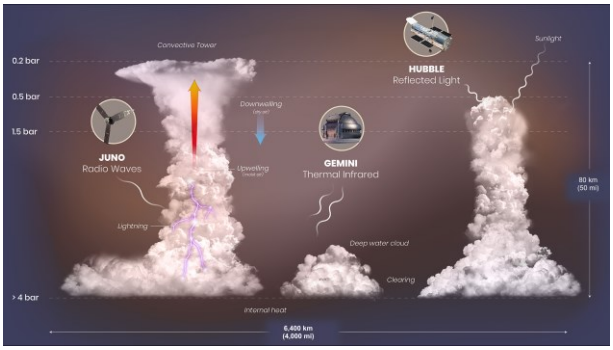


Jupiter Storms

The Hubble Space Telescope and the ground-based Gemini Observatory in Hawaii have teamed up with the Juno spacecraft to probe Jupiter's storms - more than 800 million km away (that's 500 million miles). Every 53 days, Juno moves low over the storm systems detecting high-frequency radio waves which can then be used to map lightning even on the day side of the planet or from deep clouds where flashes are not otherwise visible. Coinciding with each pass, Hubble's visible light images and Gemini's thermal infrared images tell us how thick the clouds are and how deep we are seeing into them.



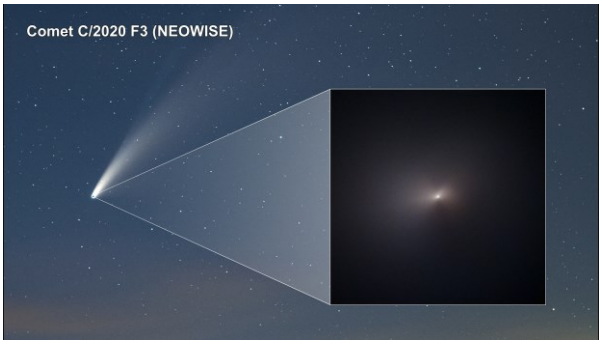
This is an illustration of lightning, convective towers (aka thunderheads), deep water clouds, and clearings in Jupiter's atmosphere. Thick, towering clouds form where moist air rises (upwelling and active convection). Clearings form where drier air sinks (downwelling). The region illustrated covers a horizontal span one-third greater than that of the continental United States.



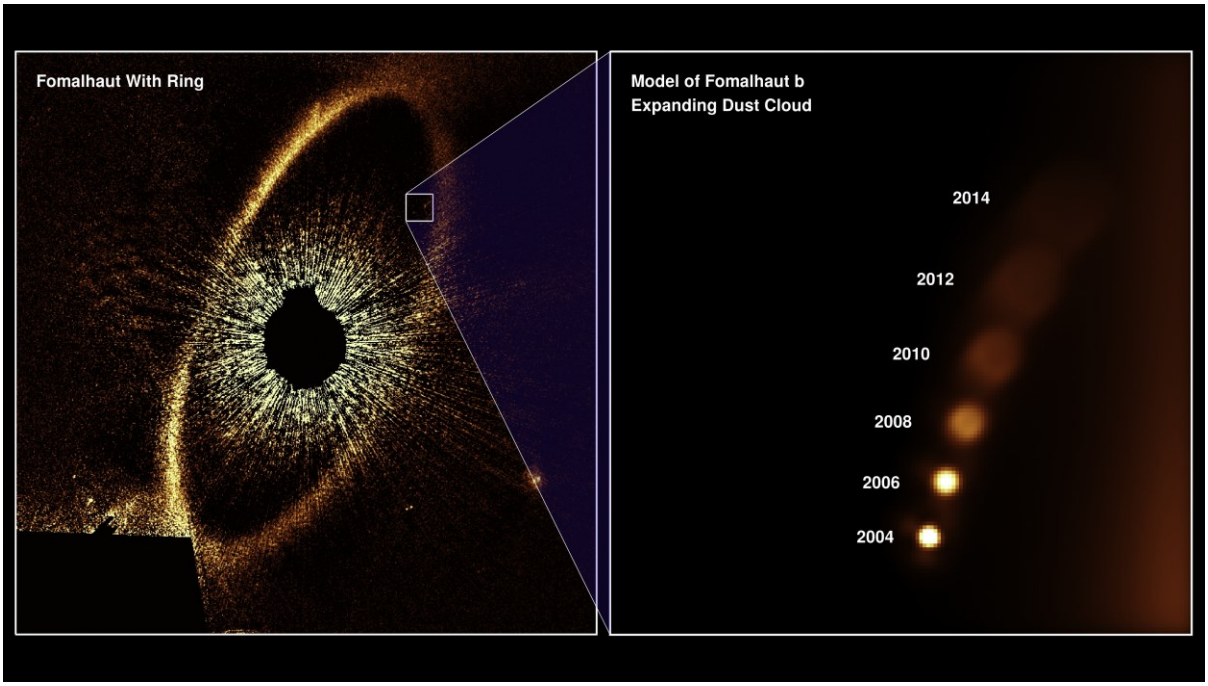
Comet C/2020 F3 (NEOWISE)

This ground based C/2020 F3 NEOWISE comet photo was taken on July 16, 2020 just 13 days after the comet's closest approach to the sun at a distance of 43 million kilometers or 27 million miles. NEOWISE stands for the Near-Earth Object Wide-field Infrared Survey Explorer mission that discovered the comet. It is the brightest comet visible from the Northern Hemisphere since 1997's Hale-Bopp. It's headed to the outer solar system, currently traveling at 232,000 km/hr (that's 144,000 miles per hour). It will not return to the Sun for another 7,000 years. Note the separate blue tail veering off the top. Normal tails are pushed by sunlight. The blue tail contains ions – electrified particles that are pushed by the charged particles in the solar wind.

The inset image, was taken by the Hubble Space Telescope on August 8. Other comets often break apart due to thermal and gravitational stresses at such close encounters with the Sun, but NEOWISE's solid nucleus stayed intact. Hubble's image zeroes in on the comet's nucleus, which is too small to be seen. It's estimated to measure no more than 4.8 kilometers or 3 miles across. Instead, the image shows a portion of the comet's coma which measures about 18,000 kilometers or 11,000 miles across.

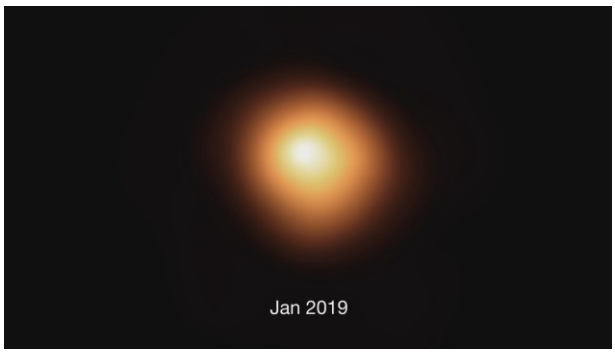


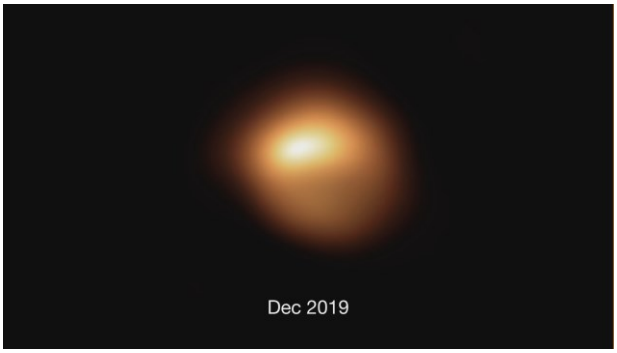
Fomalhaut b – 25 ly
In our segment on nearby stars, we covered the protoplanet Fomalhaut b around the star Fomalhaut. It turns out that that planet has disappeared. Astronomers are looking for a plausible explanation. One interpretation is that, rather than being a full-sized planetary object, which was first photographed in 2004, it could instead be a vast, expanding cloud of dust produced in a collision between two large bodies orbiting the star. If confirmed, this will become a blueprint for how planets destroy each other. Others analyzed all available archival Hubble data on Fomalhaut b and concluded that the planet-sized object never existed in the first place. This diagram simulates an expanding and fading cloud instead of a planet. We should know more when the new James Webb space telescope is available for deeper infrared examination of the Fomalhaut disk. This is scheduled for some time in 2021.



Betelgeuse – 725 ly
Here's Betelgeuse in early 2019. Normally, the star expands and contracts, brightening and dimming, on a 420-day cycle. However, in October 2019, the star dimmed dramatically. Hubble captured signs of dense, heated material moving through the star's atmosphere in September, October, and November 2019. Then, in December, several ground-based telescopes observed the star decreasing in brightness in its southern hemisphere. By mid-February 2020, the star had lost more than two-thirds of its luminosity. The ultraviolet observations by Hubble suggest that the unexpected dimming was probably caused by an immense amount of superhot material ejected into space. The material cooled and formed a dust cloud that blocked the starlight coming from about a quarter of Betelgeuse's surface as seen from our line of sight. By April 2020, the star returned to normal

brightness. The giant star is destined to end its life in a supernova blast. Some astronomers think the sudden dimming may be a pre-supernova event.



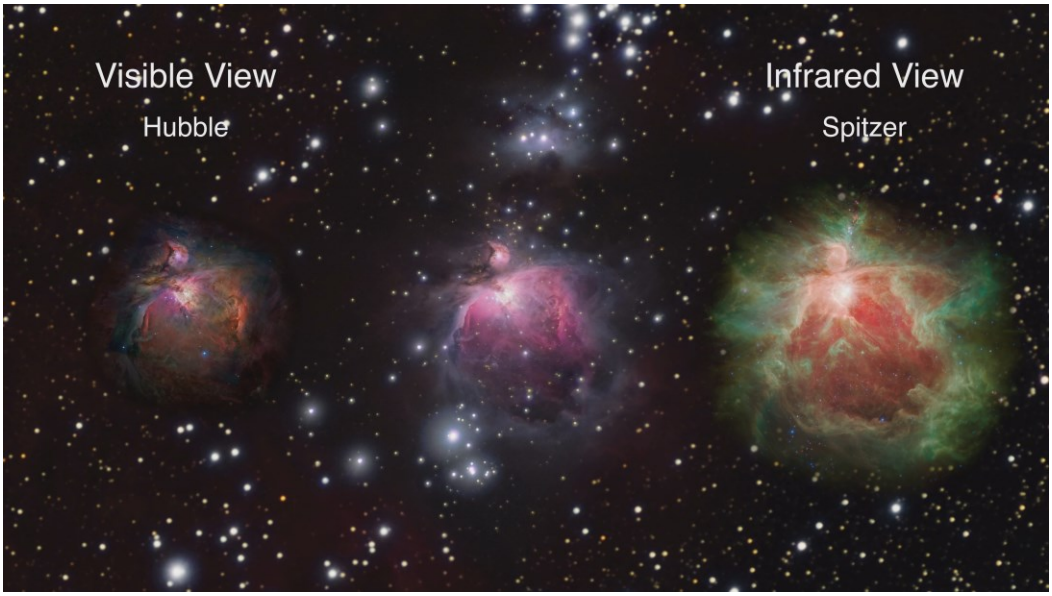


Serpens Nebula Bat Shadow – 1,300 ly **Music** Schubert: Symphony No. 3, Allegretto

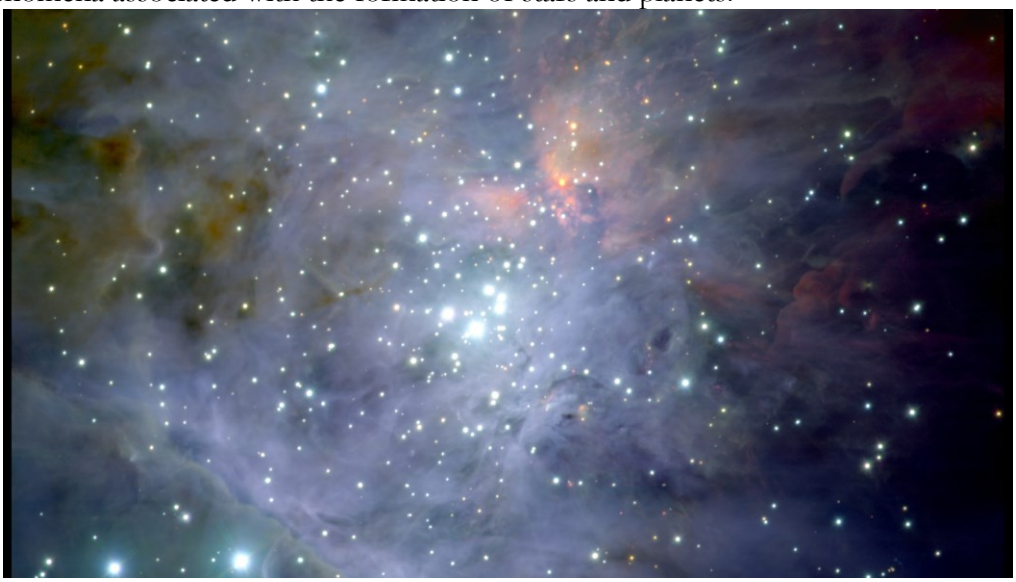
In our 2018 review, we covered the shadow cast by a debris ring around the star HBC 672 in the Serpens Nebula 13 hundred light years away. Its nickname was the "Bat Shadow". A recent relook at the object, showed that the shadow had unexpectedly moved slightly. Astronomers think that the disk of circling gas, dust, and rock might be roughly saddle-shaped, with an imbedded planet with an orbit inclined to the disk's plane. They estimate that this planet would be about the same distance from its star as Earth is from the Sun. This planet would be the cause of the doubly warped shape of the orbiting disk and the resulting movement in its shadow.

Orion Flythrough – 1,344 ly

This visualization explores the Orion Nebula using both visible and infrared light. The sequence begins with a wide-field view of the sky showing the plane of our Milky Way Galaxy, then zooms down to the scale of the Orion Nebula. The visible light observation (from the Hubble Space Telescope) and the infrared light observation (from the Spitzer Space Telescope) are compared first in two-dimensional images, and then in three-dimensional models. As the camera flies into the star-forming region, the sequence cross-fades back and forth between the visible and infrared views.

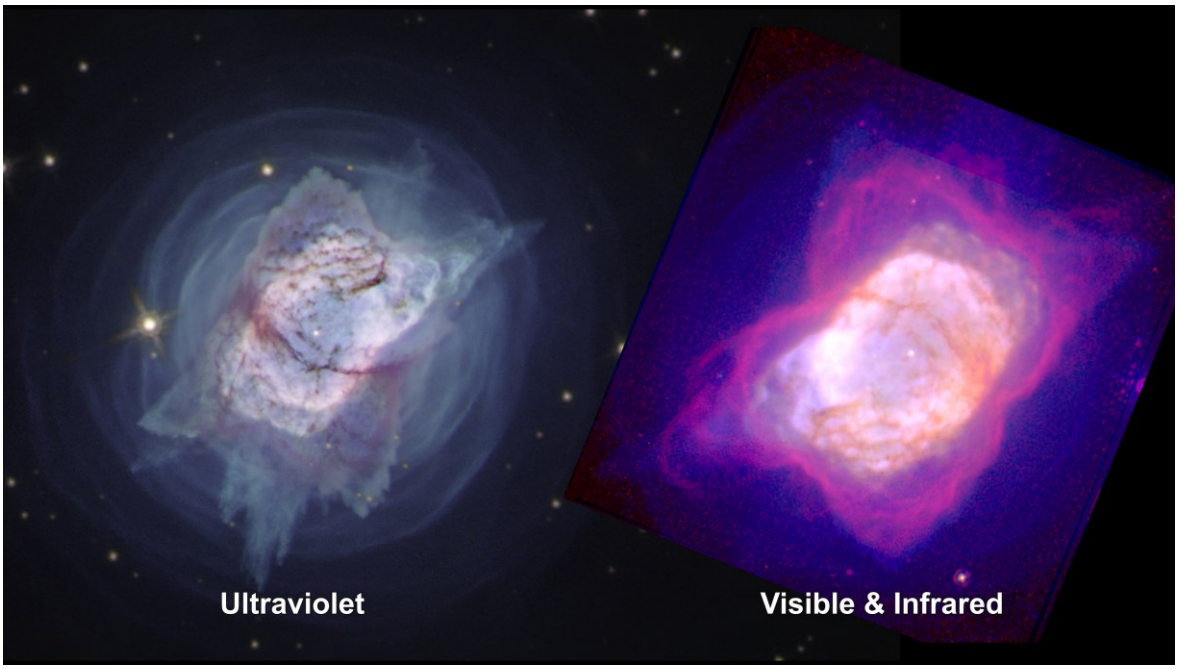


This color-composite mosaic of the central part of the Orion Nebula is based on 81 images from the European Southern Observatory Very Large Telescope in Chile. The famous Trapezium stars appear near the center, amid the Trapezium Cluster, the very crowded home of more than a thousand young stars. Researchers will train the James Webb Space Telescope on this region to study phenomena associated with the formation of stars and planets.



Planetary Nebula NGC 7027 – 3,000 ly

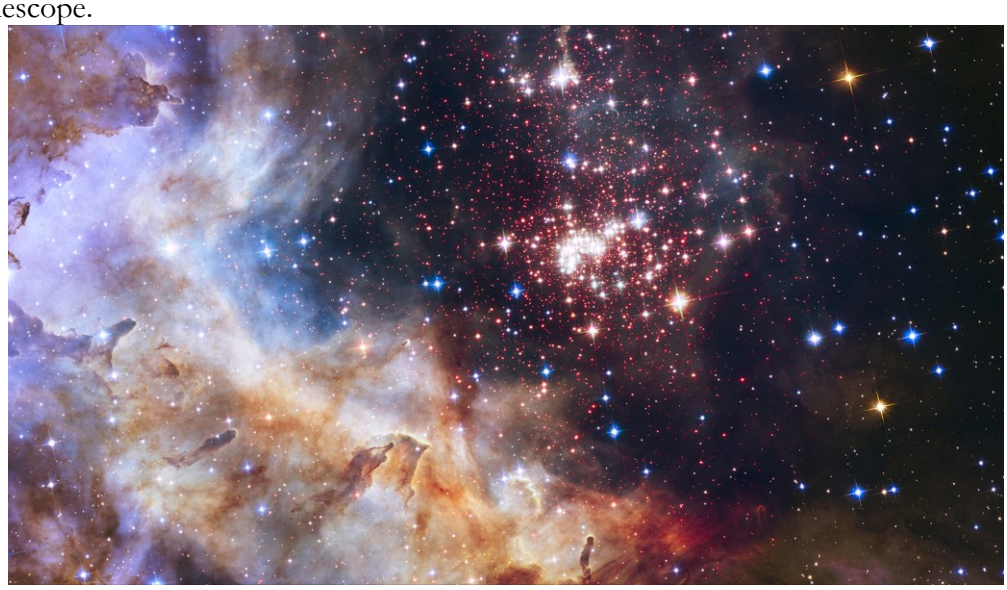
Here we are zooming into the Planetary nebula NGC 7027. The nebula is about 1 light-year across. In 2020, NGC 7027's central star was viewed by Hubble in near-ultraviolet light. Hubble first looked at this planetary nebula in 1998 using visible and infrared light. By comparing the old and new Hubble observations, researchers have additional opportunities to study the object as it changes over time. These observations will help reveal how much dust obscures the star and how hot the star really is.



Star Cluster Westerlund 2 – 14,000 ly

Here we are zooming into the globular star cluster Westerlund 2 in the Gum 29 H II star forming region 14,000 ly away. It's only two million years old, and contains some of the most massive, hottest, youngest stars in the Milky Way. The Hubble Space Telescope was used to conduct a three-year study of this cluster from 2016 to 2019. This study sought to investigate the properties of stars during their early evolutionary phases and to trace the evolution of their circumstellar disk environments. They found that the most massive and brightest stars in the cluster are found in the core. Westerlund 2 contains at least 37 extremely massive stars, some with up to 100 solar masses. These stars do not have planet forming circumstellar disks around them, and the study found that the stars near these giants also exist without circumstellar disks. Further form the center, they found that most of the stars do indeed have these dust cloud disks. One explanation for this situation is that the blistering ultraviolet radiation and strong stellar winds from the central stars erode the discs around neighboring stars, dispersing the giant dust clouds that one day may have formed planets.

This cluster will be an excellent target for follow-up observations with the upcoming James Webb Space Telescope.

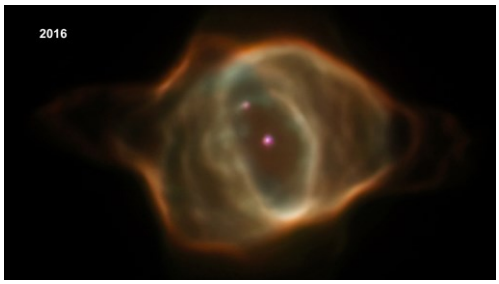


Wolf–Rayet star WR 124 – 15,000 ly

Here we see the spectacular cosmic pairing of the Wolf–Rayet star WR 124 — and the nebula M1-67 which surrounds it. Both objects, captured here by Hubble lie 15,000 light-years away. The star shines brightly at the very center of this explosive image and around the hot clumps of gas that are ejected into space at over 150,000 km per hour. That's 93,000 mi/hr. The nebula M1-67 is estimated to be no more than 10,000 years old, which is quite young in astronomical terms. A version of this image was released in 1998, but has now been re-reduced with the latest software. Wolf–Rayet stars are a rare set of very hot stars with spectra that indicate a very high surface content of heavy elements, little or no hydrogen, and strong stellar winds. Their surface temperatures range from 30,000 to around 210,000 K. That's hotter than almost all other stars. These stars are older, massive stars that have completely lost their outer hydrogen and are fusing helium or heavier elements in the core.

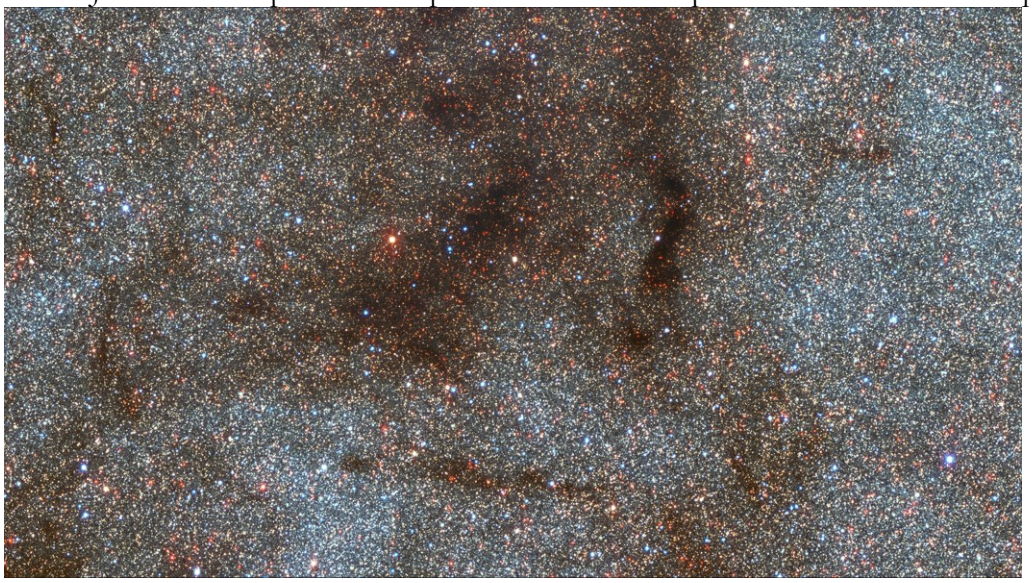
Stingray Nebula, Hen-1357 – 18,000 ly

Here we are zooming into Hen-1357 known as the Stingray Nebula. Even though the Universe is constantly changing, most processes are too slow to be observed within a human lifespan. However, this nebula is now providing scientists a unique opportunity to observe a system's evolution in real time. Stingray is the youngest known planetary nebula having formed around its collapsing central supergiant star He3-1357 starting in 1987. By 1995, the central star was a white dwarf. Images captured by Hubble in 2016, when compared to Hubble images taken in 1996, show a nebula that has drastically dimmed in brightness and changed shape. Bright blue shells of gas near the center of the nebula have all but disappeared, and the wavy edges that earned this nebula its aquatic-themed name are virtually gone. The young nebula no longer shines as brightly against the black background of the distant Universe. The oxygen gas emission, in particular, has dropped in brightness by a factor of nearly 1000.



Milky Way Central Bulge Stars – 26,000 ly **Music** Buffardin: Flute Concerto in G Minor

This image captures a 220 by 110 light-years portion of our galaxy's bulge. It contains over 180,000 stars. A survey team is analyzing these stars to see how old they are. The question at hand is did the stars within the bulge form early in our galaxy's history, 10 to 12 billion years ago, or did they build up over time through multiple episodes of star formation? Some studies have found evidence for at least two star-forming bursts, leading to stellar populations as old as 10 billion years or as young as 3 billion years. Now, a comprehensive new survey of millions of stars found that most stars within 1,000 light-years of the Milky Way's center formed 10 billion years ago. But the study is not conclusive. The James Webb Space Telescope will be used to help find the answers to this question.



LHA 120-N150 – 160,000 ly

Here we are zooming into LHA 120-N 150, a star forming region near the outskirts of the famous Tarantula Nebula in the Large Magellanic Cloud. This cloud of gas and dust, as well as the many young and massive stars surrounding it, is an excellent laboratory for studying the origins of massive stars. Theoretical models for the formation of massive stars suggest that they form within clusters of stars; but observations indicate that up to ten percent of them form in isolation. With the help of Hubble, astronomers are trying to find out whether the isolated stars visible in the nebula truly formed alone or just moved away from their original stellar grouping. However, such a study is not an easy task; young stars, before they are fully formed — especially massive ones — look very similar to dense clumps of dust. This star forming region contains several dozens of these objects. They are a mix of unclassified sources — some probably young stellar objects and others probably dust clumps. Only detailed analysis and observations will reveal their true nature and that will help to finally solve the unanswered question of the origin of massive stars.

NGC 1805 in LMC 163,000 ly

Many colorful stars are packed close together in this image of the globular cluster NGC 1805, taken by Hubble. This tight grouping of thousands of stars is located near the edge of the Large Magellanic Cloud. In the dense center of one of this cluster, stars are 100 to 1000 times closer together than the nearest stars are to our Sun. This makes planetary system formation around them highly unlikely. The striking difference in star colors is illustrated beautifully in this image, which combines two different types of starlight: blue stars, shining brightest in near-ultraviolet light; and red stars, illuminated in red and near-infrared. Usually, globular clusters contain stars which are born

at the same time; however, NGC 1805 is unusual as it appears to host two different populations of stars with ages of the older red stars being millions of years older than the blue young stars.

NGC 2014 and NGC 2020 in LMC 163,000 ly

Here's an interesting pair of nebulae in the Large Magellanic Cloud nicknamed the "Cosmic Reef". They show how young, energetic, massive stars illuminate and sculpt their vicinity with powerful winds and searing ultraviolet radiation. The blue nebula at lower left (NGC 2020) has been created by a solitary mammoth star 200,000 times brighter than our Sun. The blue gas was ejected by the star through a series of eruptive events during which it lost part of its outer envelope of material. The giant red nebula (NGC 2014) on the upper right has, at its center, a grouping of bright stars, each 10 to 20 times more massive than our Sun. The stars' ultraviolet radiation heats the surrounding dense gas, and unleash fierce winds of charged particles that blast away lower-density gas, forming the bubble-like structures seen on the right. The stars' powerful stellar winds are pushing gas and dust to the denser left side of the nebula, where it is piling up, creating a series of dark ridges bathed in starlight.

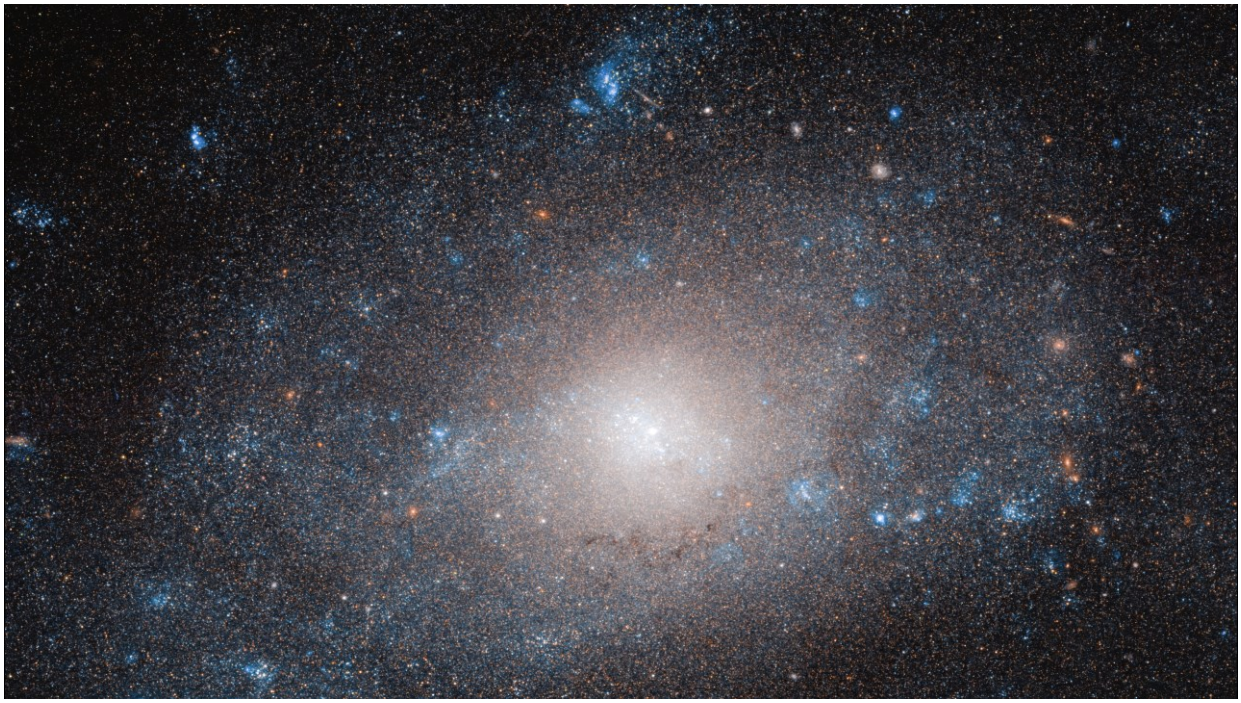
[The blue areas reveal the glow of oxygen, heated to nearly 11,400 degrees by the blast of ultraviolet light. The cooler, red gas indicates the presence of hydrogen and nitrogen.]

NGC 2188 – 25 mly

The blue and orange stars of the faint galaxy NGC 2188 sparkle in this image taken by. Although the galaxy appears at first glance to consist solely of a narrow band of stars, it is classified by astronomers as a barred-spiral galaxy. It appears this way from our viewpoint on Earth as the center and spiral arms of the galaxy are tilted away from us, making only the very narrow outer edge of the galaxy's disc visible to us. The true shape of the galaxy was identified by studying the distribution of the stars in the inner central bulge and outer disc and by observing the stars' colors.

NGC 5585 – 28 mly

The many stars, and dust and gas clouds that make up NGC 5585, shown here in this Hubble image, contribute only a small fraction of the total mass of the galaxy. As in many galaxies, this discrepancy can be explained by the presence of dark matter. The stellar disc of the galaxy extends over 35 000 light-years across. When compared with galaxies of a similar shape and size, NGC 5585 stands out by having a notably higher proportion of dark matter.



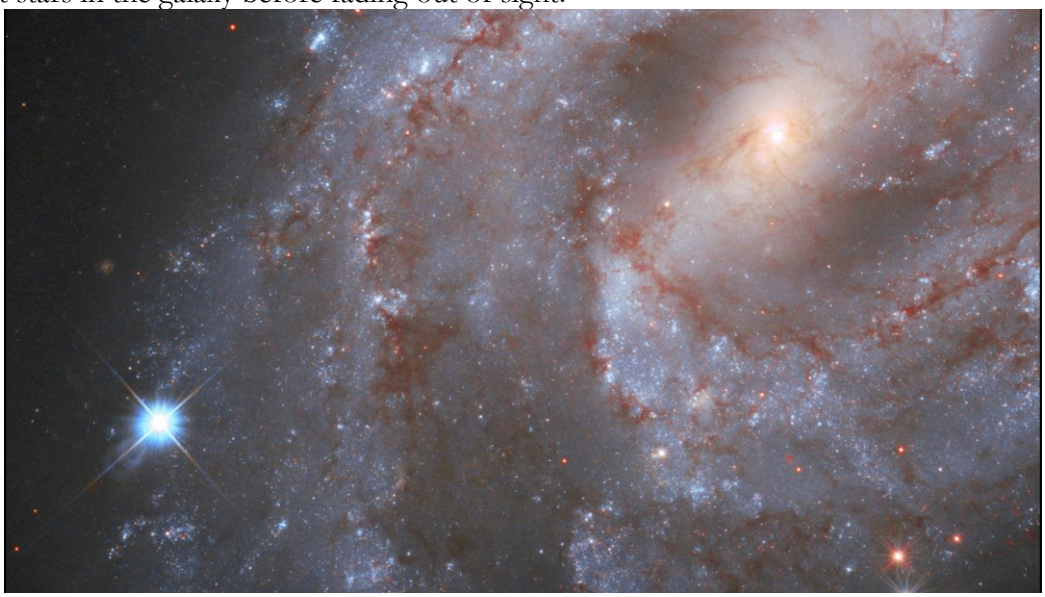
NGC 2835 – 33.8 mly **Music** Haydn; Symphony No. 94 - Surprise

The twisting patterns created by the multiple spiral arms of NGC 2835 create the illusion of an eye. This stunning barred spiral galaxy, with a width of just over half that of the Milky Way, is brilliantly featured in this Hubble image. Although it cannot be seen in this image, a supermassive black hole with a mass millions of times that of our Sun is known to exist in the center of the galaxy. This galaxy was imaged as part of a large galaxy survey that's studying the connections between cold gas and young stars in a variety of galaxies in the local Universe. Within NGC 2835, this cold, dense gas produces large numbers of young stars within large star formation regions. The bright blue areas,

show where near-ultraviolet light is being emitted more strongly, indicating recent or ongoing star formation.

SN 2018gv in NGC 2525– 70 mly

Here's SN 2018gv, a Type 1a Supernova in the spiral galaxy NGC 2525, 70 million light-years away. Hubble began observing it in February 2018, after the supernova was first detected by amateur astronomer Koichi Itagaki a few weeks earlier in mid-January. This was one of the supernovae used as part of the program to precisely measure the expansion rate of the universe that we covered in the How Far Away Is It segment on the Cosmos. In the time-lapse sequence, spanning nearly a year, the supernova first appears as a blazing star located on the galaxy's outer edge. It initially outshines the brightest stars in the galaxy before fading out of sight.

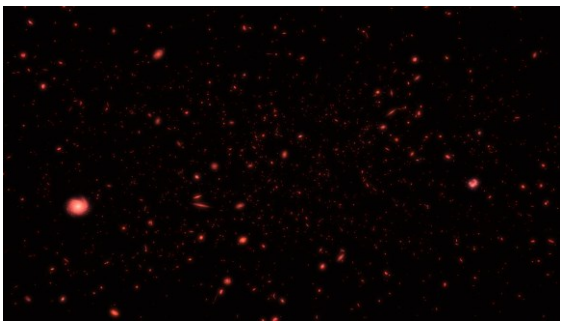


UGC 2885 - 232 mly

This Hubble Space Telescope photograph showcases the majestic spiral galaxy UGC 2885, located 232 million light-years away. The galaxy is 2.5 times wider than our Milky Way and contains 10 times as many stars. A number of foreground stars in our Milky Way can be seen in the image, identified by their diffraction spikes. The brightest one is on the line of sight to the galaxy's disk. The galaxy has been nicknamed "Rubin's galaxy," after astronomer Vera Rubin (1928 – 2016), who studied the galaxy's rotation rate in search of dark matter. The James Webb Space Telescope could be used to explore the center of this galaxy as well as the globular cluster population.

First Stars

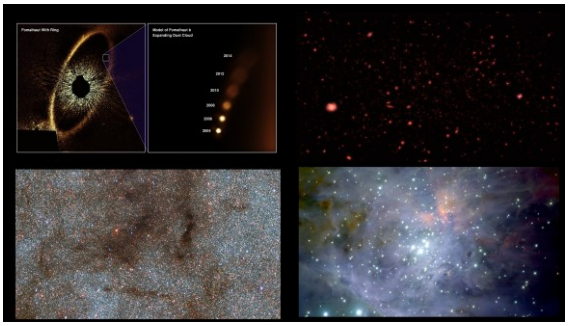
In the How Old Is It video book segment on the Lambda Cold Dark Matter Big Bang benchmark model, we covered the Dark Ages between the release of the Cosmic Background Radiation photons and the first light from stars formed from Hydrogen, Helium and Lithium, the only elements available in the Universe at that time. These are called Population III stars. The earliest expected time for these stars is 150 million years after the Big Bang.



Using gravitational lensing created by the galaxy cluster MACS J0416 and its surroundings, a team of astronomers, using the Hubble Space Telescope, were able to see galaxies 10 to 100 times fainter than any previously observed with ages as far back as 500 million years after the big bang. They found no evidence of these first-generation Population III stars. The Big Bang theory has it that there should be plenty of them. This creates a mystery that might be resolved by the new James Web Space Telescope.

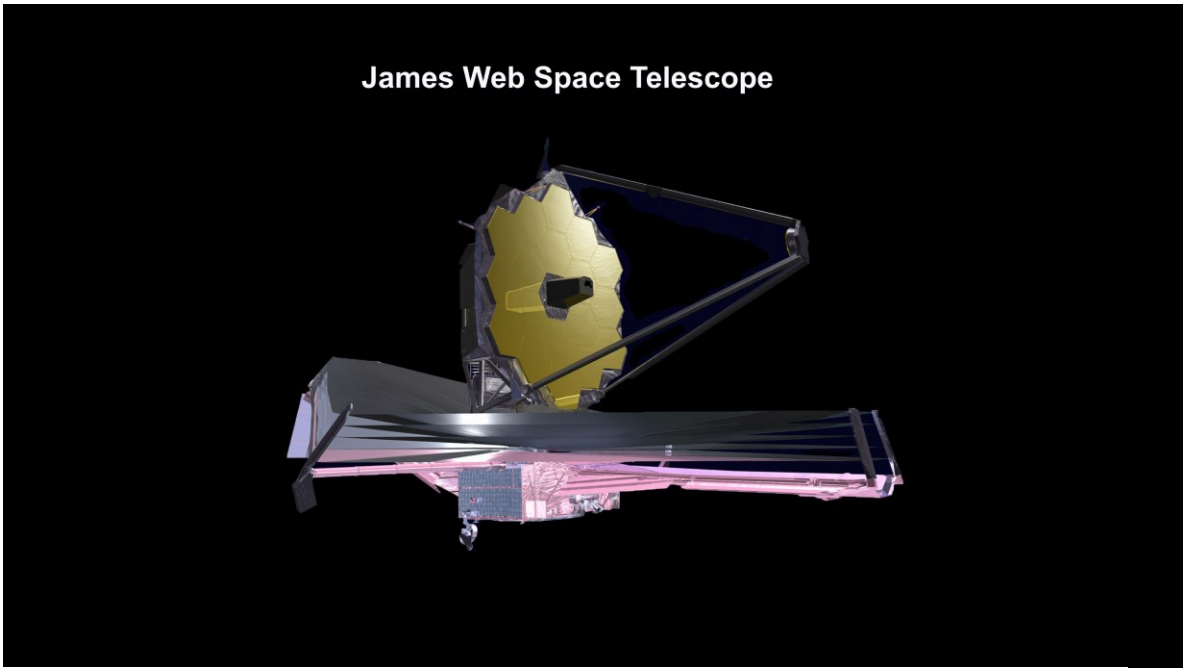
James Webb Space Telescope

In this 2020 Review we pointed to a few areas of astronomical research that need a better look with a telescope larger than Hubble. These include: exoplanet formation exploration like finding out what happened to Fomalhaut b; star and planet formation in places like the Trapezium Cluster in the Orion Nebula; the age of stars in the Milky Way's Central bulge; and the search for first-generation Population III stars just to name a few.

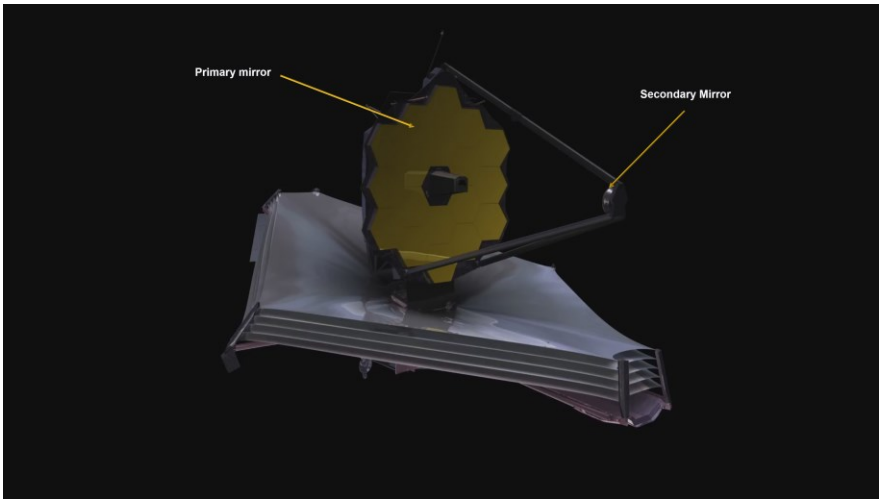


That telescope, is the James Web Space Telescope. It is almost three times the size of Hubble. It has been in development for over a decade and is schedule for launch in 2021. It's optimized for observations in the near infrared. We'll cover its key components and where it will orbit. We'll finish

with a deeper look at two areas of investigation that Web will probe: galactic dust, and the makeup of the early Universe.

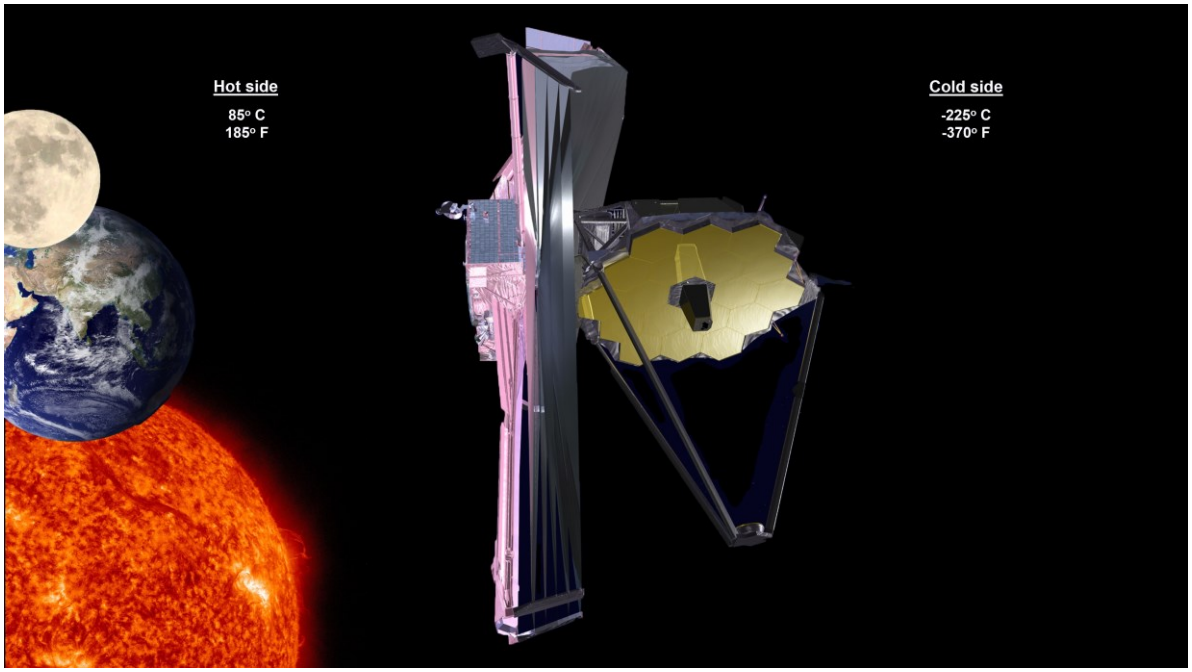


Here are Web's primary and secondary mirrors. The primary is the size of a tennis court. This animation shows the light path through the telescope. The light reflects off the primary and is focused onto the secondary, where it is beamed into the camera. Webb's mirrors are covered in a microscopically thin layer of gold, which optimizes them for reflecting infrared light.

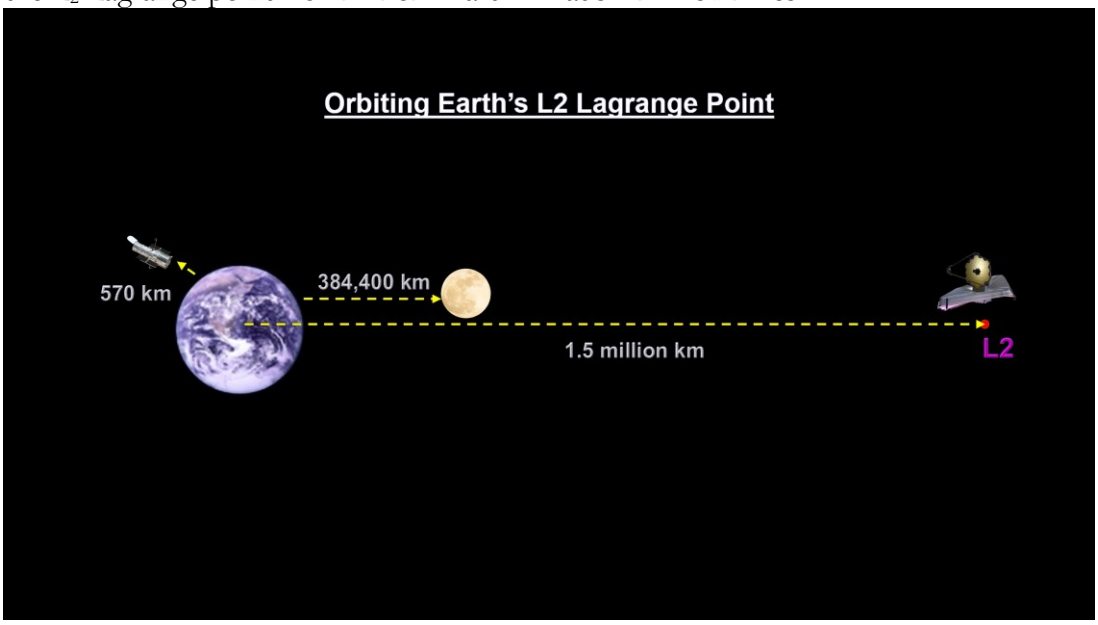


Other key components include the camera, the sunshield, the solar panels, communication antenna, computer, and spacecraft control. The sunshield is particularly important because of the telescope's extreme sensitivity to heat. Webb primarily observes infrared light, which can sometimes be felt as heat. Because the telescope will be observing the very faint infrared signals of very distant objects, it

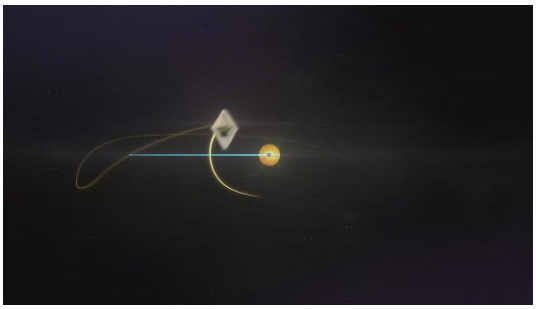
needs to be shielded from any bright, hot sources. This also includes the telescope's own electronics equipment. It operates at 233 degrees below zero Celsius. That's -388 degrees Fahrenheit. That's cold enough to freeze nitrogen. The shield can protect against temperatures on its hot side as high as 85 degrees Celsius. That's 185 degrees Fahrenheit a little under the boiling point for water. If either the Sun, Earth or the Moon are on the cold side, the telescope won't work.



So, to have the sunshield be effective protection against the light and heat of the Sun, Earth and Moon, these bodies all have to be located in the same direction. This is why the telescope must be out at the L_2 Lagrange point 1.5 km from Earth. That's 1 million miles.



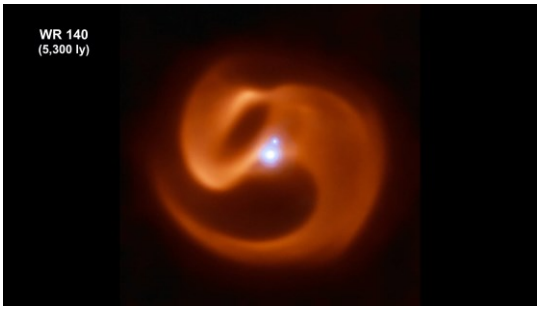
You'll recall from our coverage of Lagrange Points in our "How Far Away Is It" segment on the Solar System, that objects can, with a little assist, orbit L_2. This animation shows how this will work. To remain in orbit around L_2 Web will have to periodically burn small amounts of fuel. This puts a time limit on its usefulness at around 10 years.



WR 140 Dust – 5,300 ly

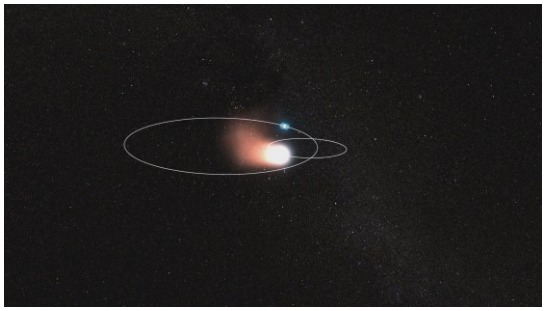
Dust is a key ingredient in interstellar space, because cosmic dust shelters forming stars, becomes part of planets, and can contain the organic compounds that lead to life as we know it. One of astronomies mysteries is where did galactic dust come from.

To find out, Web will be studying dust-producing Wolf-Rayet binary stars like this one WR 140 5,300 ly away. There is evidence that these stars, through interactions with a companion star, produce large amounts of dust in a distinctive pinwheel pattern as the two stars orbit each other and their stellar winds collide as shown in this image.



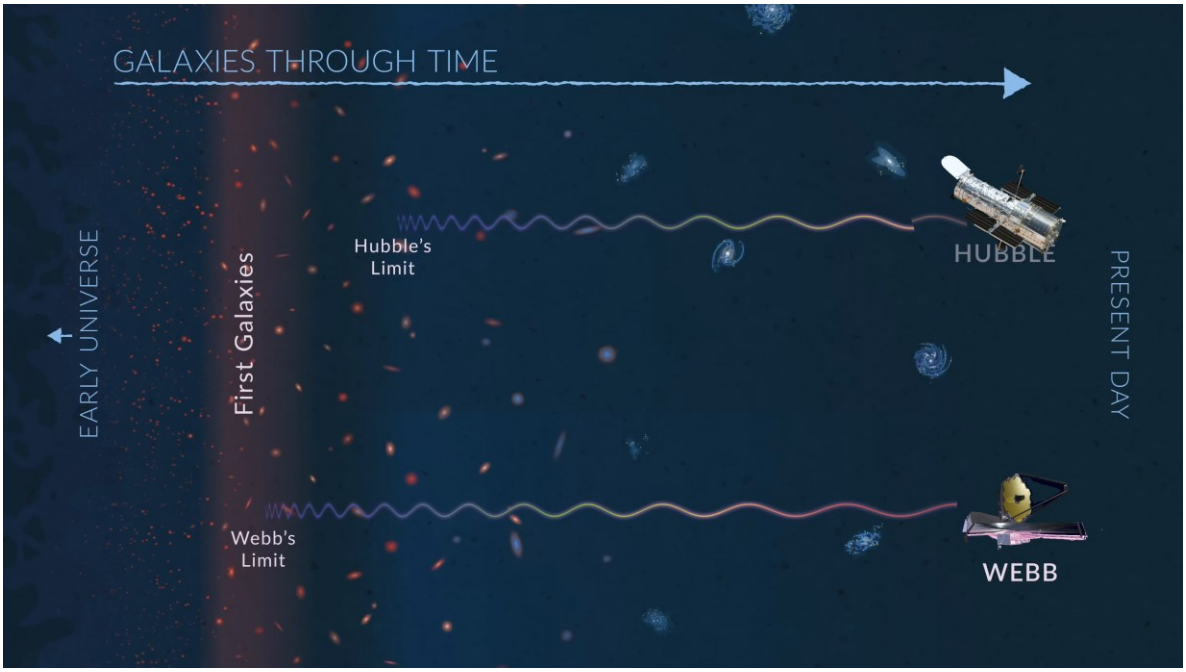
This animation shows the production of dust in the binary star system WR 140 as the orbit of the Wolf-Rayet star approaches the O-type star and their stellar winds collide. The stronger winds of the Wolf-Rayet star blow back behind the O star, and dust is created in its wake as the mixed stellar material cools. As the process repeats over and over, the dust will form a distinctive pinwheel shape.

It is possible that these binary-star systems account for a large percentage of a galaxy's dust. However, the intense luminosity and heat coming from the Wolf-Rayet stars has made it difficult to study the faint, more diffuse dust of these systems. This is where Webb comes in. The mid-infrared light that Webb can detect is exactly the wavelength of light we need to study the dust and its chemical composition.



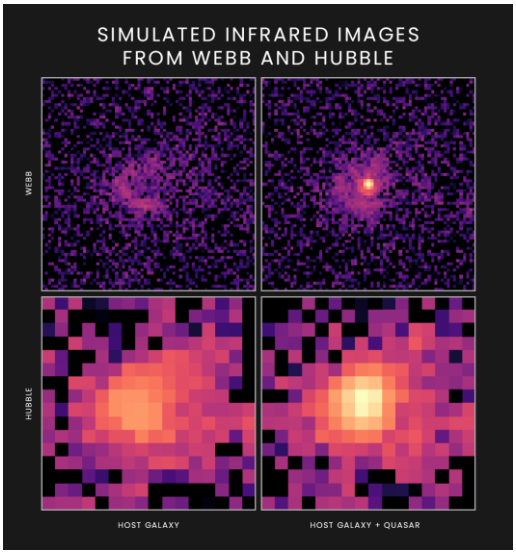
Early Universe

Our ability to see into the earliest galaxies is limited by how far the Hubble Space Telescope can reach because the light is so dim, and the wavelength of that light has been stretched into the infrared due to the expansion of the Universe. The James Web Space Telescope is larger for collecting more light, and built for the infrared part of the electromagnetic spectrum.

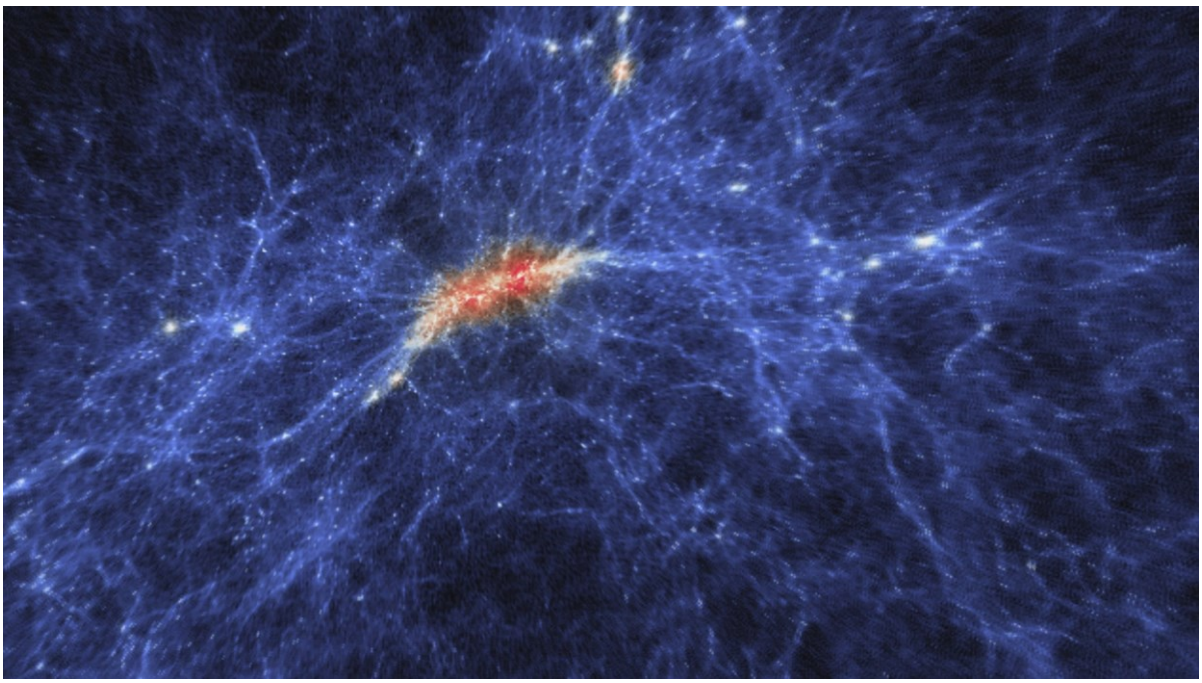


Early quasars provide a good example of what we can expect. Quasars are the brightest objects in the universe and among the most energetic. They outshine entire galaxies of billions of stars. A supermassive black hole lies at the heart of every quasar, but not every black hole is a quasar.

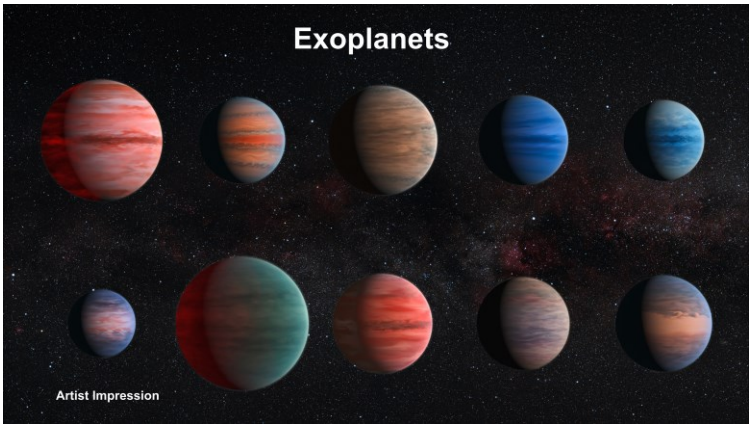
Only the black holes that are acquiring massive amounts of new matter can power a quasar. Although quasars are known to reside at the centers of galaxies, it's been difficult to tell what those galaxies are like and how they compare to galaxies without quasars. The challenge is that the quasar's glare makes it difficult or impossible to tease out the light of the surrounding host galaxy. It's like looking directly into a car headlight and trying to figure out what kind of automobile it is attached to. The James Webb Space Telescope will be able to reveal the host galaxies of some distant quasars despite their small sizes and obscuring dust.



To determine what Webb is expected to see, a team of astronomers used a state-of-the-art computer simulation called BlueTides. It's designed to study the formation and evolution of galaxies and quasars in the first billion years of the universe's history. Its large cosmic volume and high spatial resolution enables it to study those rare quasar hosts on a statistical basis. It's providing good agreement with current observations and allows astronomers to predict what Webb will see. This video zooms into a highly detailed simulation of the universe. It stars out spanning about 200 million light-years and ends spans only 200,000 light-years focused on two galaxies.

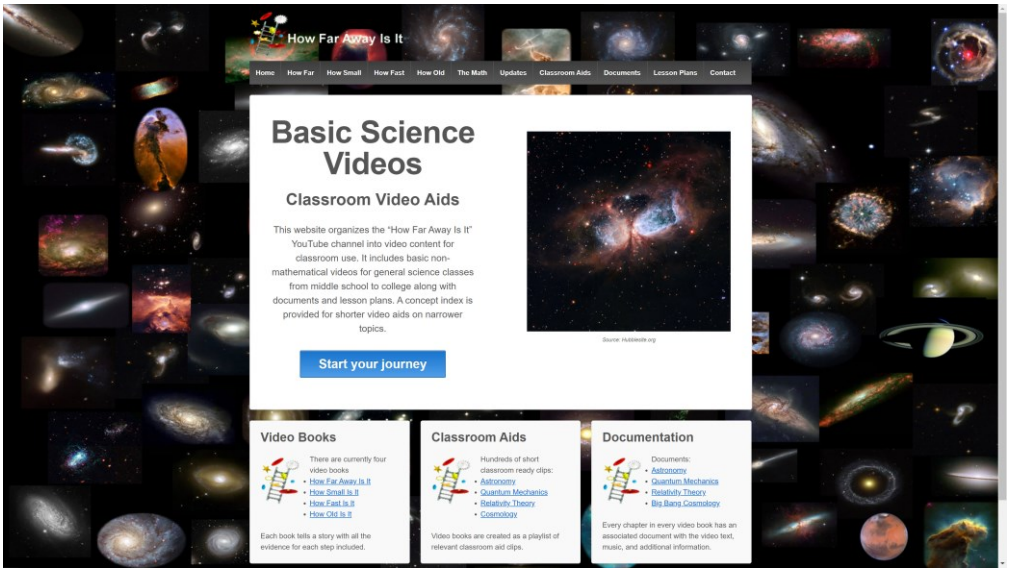


One final note: Web's ability to see into circumstellar disks where planets form should provide enough material for an entire video book chapter on exoplanets. Hopefully, we'll know by this time next year.



Credits

Here are the links to Hubble sites, whitepapers and other locations where I found the information contained in this 2020 review. These are also the places where you can begin to do your own research.

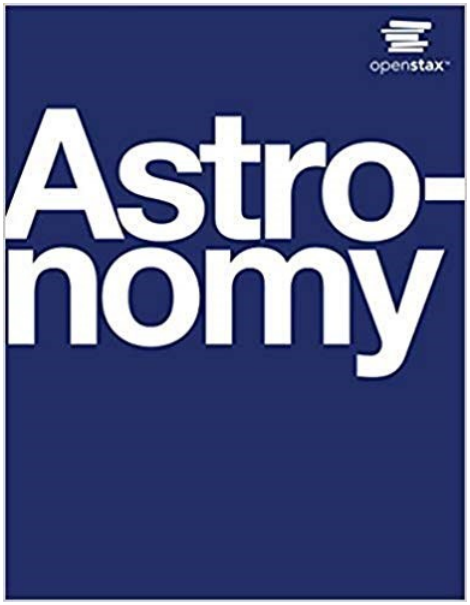


howfarawayisit.com

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.

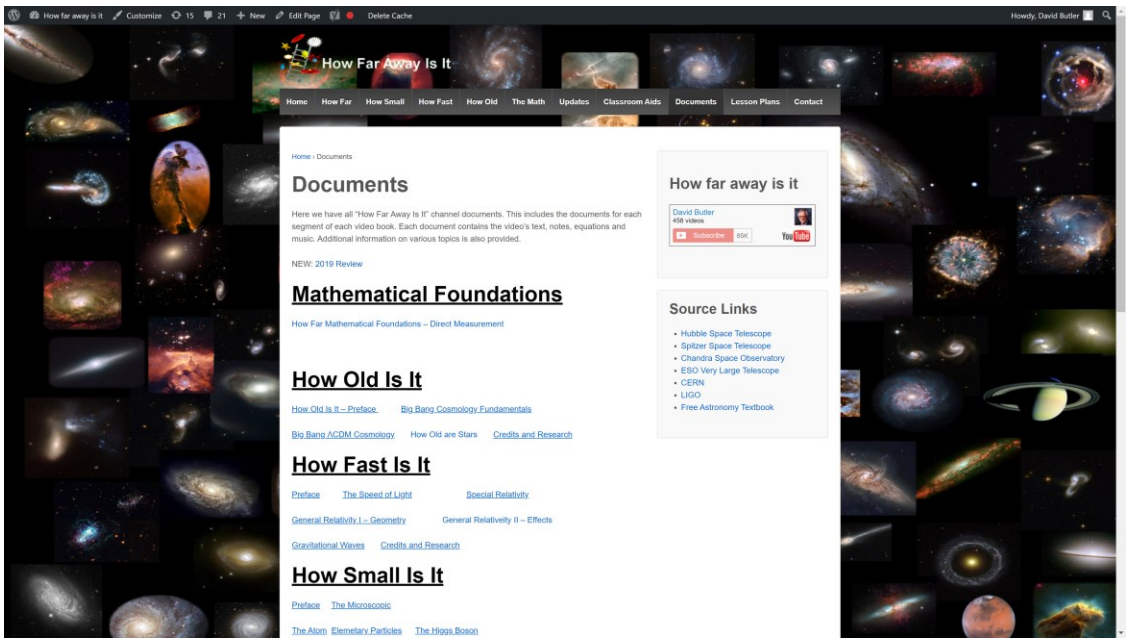
https://howfarawayisit.fandom.com/wiki/Encyclopedia_Howfarawayica

I want to call your attention to a new free online textbook called 'Astronomy" that anyone interested in astronomy can use. It is supported by OpenStax, a Rice University 501(C)(3) nonprofit charity. The book builds student understanding through the use of relevant analogies, clear and non-technical explanations, and rich illustrations. Take a look at Synchrotron radiation on page 972.



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. Thanks for watching.



http://howfarawayisit.com/documents/

Summer Saturn
https://hubblesite.org/contents/media/images/2020/43/4713-Image

Jupiter Storms
https://hubblesite.org/contents/news-releases/2020/news-2020-21#section-id-2

Comet C/2020 F3 (NEOWISE)
https://hubblesite.org/contents/news-releases/2020/news-2020-45
https://apod.nasa.gov/apod/ap200711.html

Fomalhaut b – 25 ly
https://hubblesite.org/contents/news-releases/2020/news-2020-09

Betelgeuse – 725 ly
https://www.eso.org/public/videos/eso2003c/
https://hubblesite.org/contents/news-releases/2020/news-2020-44

Serpens Nebula Bat Shadow – 1,300 ly
https://hubblesite.org/contents/news-releases/2020/news-2020-22

Orion Flythrough – 1,344 ly
https://webbtelescope.org/contents/media/videos/2020/24/1278-Video?news=true

Planetary Nebula NGC 7027 – 3,000 ly
https://hubblesite.org/contents/media/images/2020/31/4682-Image?news=true
https://hubblesite.org/contents/media/images/1998/11/623-Image.html

Star Cluster Westerlund 2 – 14,000 ly
https://www.spacetelescope.org/news/heic2009/?lang

Wolf–Rayet star WR 124 – 15,000 ly
https://en.wikipedia.org/wiki/Wolf%E2%80%93Rayet_star
https://esahubble.org/images/potw1533a/

Stingray Nebula, Hen-1357 – 18,000 ly
https://www.spacetelescope.org/news/heic2020/?lang
https://www.spacetelescope.org/images/opo9815a/

Milky Way Central Bulge Star Age – 26,000 ly
https://hubblesite.org/contents/news-releases/2020/news-2020-56

LHA 120-N150 – 160,000 ly
https://www.spacetelescope.org/news/heic2004/?lang

NGC 1805 in LMC 163,000 ly
https://www.spacetelescope.org/images/potw2036a/?lang

NGC 2014 and NGC 2020 in LMC 163,000 ly
https://hubblesite.org/contents/media/images/2020/16/4646-Image?news=true

NGC 2188 – 25 mly
https://www.spacetelescope.org/images/potw2035a/?lang

NGC 5585 – 28 mly
https://www.spacetelescope.org/images/potw2038a/

SN 2018gv in NGC 2525– 70 mly
https://hubblesite.org/contents/news-releases/2020/news-2020-52

UGC 2885 - 232 mly
https://hubblesite.org/contents/news-releases/2020/news-2020-01

First Stars
https://hubblesite.org/contents/news-releases/2020/news-2020-34
https://arxiv.org/pdf/1807.07580 pdf
https://www.spacetelescope.org/videos/hubblecast118a/

James Webb Space Telescope
https://www.youtube.com/watch?v=v6ihVeEoUdo
Launch
https://www.youtube.com/watch?v=6cUe4oMk69E&feature=emb_logo
Orbit

https://jwst.nasa.gov/content/about/orbit.html

https://www.youtube.com/watch?v=y9Z2GbFJWmo&feature=emb_logo

https://jwst.nasa.gov/content/about/orbit.html

https://webbtelescope.org/contents/news-releases/2020/news-2020-60
https://webbtelescope.org/contents/news-releases/2020/news-2020-57?news=true

https://www.nasa.gov/feature/goddard/2020/the-cosmic-dust-in-your-bones-nasa-s-webb-telescope-will-investigate-the-intertwined-origins

https://webbtelescope.org/contents/news-releases/2020/news-2020-51

Dust
https://webbtelescope.org/contents/media/videos/2020/51/1293-Video?news=true

Blue Tides3
https://www.youtube.com/watch?v=N0Tx-IsloSE&feature=emb_logo

Exoplanets
https://esahubble.org/images/heic1524a/

Music

@02:35 Tchaikovsky: Chanson Triste; from the album Meditation: Classical Relaxation, 2010

@10:13 Dvorák: Serenade for Strings In E, Op.22, B. 52 - 4. Larghetto; Berliner Philharmoniker and Herbert von Karajan; from the album Tchaikovsky / Dvorák: String Serenades, 1982

@17:15 Buffardin: Flute Concerto in G Minor, Andante; from the album Meditation: Classical Relaxation, 2010

@23:49 Haydn; Symphony No. 94 - Surprise, Andante; from the album Meditation: Classical Relaxation, 2010

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

⇒ → ± ⊙ ∞ ↛ ∃ ∄ ∈ ∉ ∬ ∫ ≅ ≥ ≤ ≈ ≠ ≡ √ ∛ ~ ∝ ℏ ÷