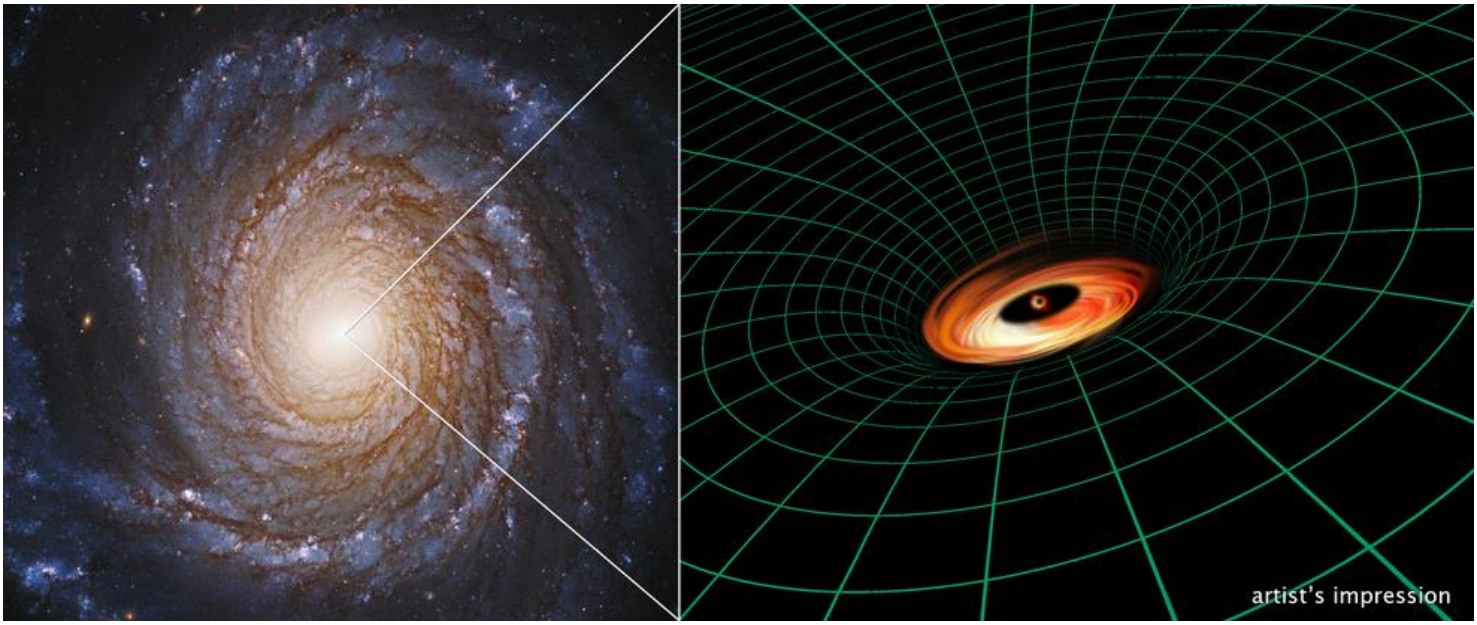
Space News Update

— July 16, 2019 —

Contents

1. Hubble Uncovers Black Hole Disk that Shouldn't Exist



A Hubble Space Telescope image of the spiral galaxy NGC 3147 appears next to an artist's illustration of the supermassive black hole residing at the galaxy's core. The Hubble image shows off the galaxy's sweeping spiral arms, full of young blue stars, pinkish nebulas, and dust in silhouette. However, at the brilliant core of NGC 3147 lurks a monster black hole, weighing about 250 million times the mass of our Sun. Hubble observations of the black hole demonstrate two of Einstein's theories of relativity. The reddish-yellow features swirling around the center are the glow of light from gas trapped by the hefty black hole's powerful gravity. The black hole is embedded deep within its gravitational field, shown by the green grid that illustrates warped space. The gravitational field is so strong that light is struggling to climb out, a principal described in Einstein's theory of general relativity. Material also is whipping so fast around the black hole that it brightens as it approaches Earth on one side of the disk and gets fainter as it moves away. This effect, called relativistic beaming, was predicted by Einstein's theory of special relativity. NGC 3147 is located 130 million light-years away in the northern circumpolar constellation Draco the Dragon. Credits: Hubble Image: NASA, ESA, S. Bianchi (Università degli Studi Roma Tre University), A. Laor (Technion-Israel Institute of Technology), and M. Chiaberge (ESA, STScI, and JHU); illustration: NASA, ESA, and A. Feild and L. Hustak (STScI)

As if black holes weren't mysterious enough, astronomers using NASA's Hubble Space Telescope have found an unexpected thin disk of material furiously whirling around a supermassive black hole at the heart of the magnificent spiral galaxy NGC 3147, located 130 million light-years away.

The conundrum is that the disk shouldn't be there, based on current astronomical theories. However, the unexpected presence of a disk so close to a black hole offers a unique opportunity to test Albert Einstein's theories of relativity. General relativity describes gravity as the curvature of space and special relativity describes the relationship between time and space.

"We've never seen the effects of both general and special relativity in visible light with this much clarity," said Marco Chiaberge of the European Space Agency, and the Space Telescope Science Institute and Johns Hopkins University, both in Baltimore, Maryland, a member of the team that conducted the Hubble study.

"This is an intriguing peek at a disk very close to a black hole, so close that the velocities and the intensity of the gravitational pull are affecting how the photons of light look," added the study's first author, Stefano Bianchi of Università degli Studi Roma Tre, in Rome, Italy. "We cannot understand the data unless we include the theories of relativity."

Black holes in certain types of galaxies like NGC 3147 are malnourished because there is not enough gravitationally captured material to feed them regularly. So, the thin haze of in-falling material puffs up like a

donut rather than flattening out in a pancake-shaped disk. Therefore, it is very puzzling why there is a thin disk encircling a starving black hole in NGC 3147 that mimics much more powerful disks found in extremely active galaxies with engorged, monster black holes.

"We thought this was the best candidate to confirm that below certain luminosities, the accretion disk doesn't exist anymore," explained Ari Laor of the Technion-Israel Institute of Technology located in Haifa, Israel. "What we saw was something completely unexpected. We found gas in motion producing features we can explain only as being produced by material rotating in a thin disk very close to the black hole."

The astronomers initially selected this galaxy to validate accepted models about lower-luminosity active galaxies—those with black holes that are on a meager diet of material. Models predict that an accretion disk forms when ample amounts of gas are trapped by a black hole's strong gravitational pull. This in-falling matter emits lots of light, producing a brilliant beacon called a quasar, in the case of the most well-fed black holes. Once less material is pulled into the disk, it begins to break down, becomes fainter, and changes structure.

"The type of disk we see is a scaled-down quasar that we did not expect to exist," Bianchi said. "It's the same type of disk we see in objects that are 1,000 or even 100,000 times more luminous. The predictions of current models for gas dynamics in very faint active galaxies clearly failed."

The disk is so deeply embedded in the black hole's intense gravitational field that the light from the gas disk is modified, according to Einstein's theories of relativity, giving astronomers a unique look at the dynamic processes close to a black hole.

Hubble clocked material whirling around the black hole as moving at more than 10% of the speed of light. At those extreme velocities, the gas appears to brighten as it travels toward Earth on one side, and dims as it speeds away from our planet on the other side (an effect called relativistic beaming). Hubble's observations also show that the gas is so entrenched in the gravitational well the light is struggling to climb out, and therefore appears stretched to redder wavelengths. The black hole's mass is around 250 million Suns.

The researchers used Hubble's Space Telescope Imaging Spectrograph (STIS) to observe matter swirling deep inside the disk. A spectrograph is a diagnostic tool that divides light from an object into its many individual wavelengths to determine its speed, temperature, and other characteristics at a very high precision. The astronomers needed STIS's sharp resolution to isolate the faint light from the black-hole region and block out contaminating starlight.

"Without Hubble, we wouldn't have been able to see this because the black-hole region has a low luminosity," Chiaberge said. "The luminosities of the stars in the galaxy outshine anything in the nucleus. So if you observe it from the ground, you're dominated by the brightness of the stars, which drowns the feeble emission from the nucleus."

The team hopes to use Hubble to hunt for other very compact disks around low-wattage black holes in similar active galaxies.

The team's paper will appear online today in the Monthly Notices of the Royal Astronomical Society.

Source: NASA

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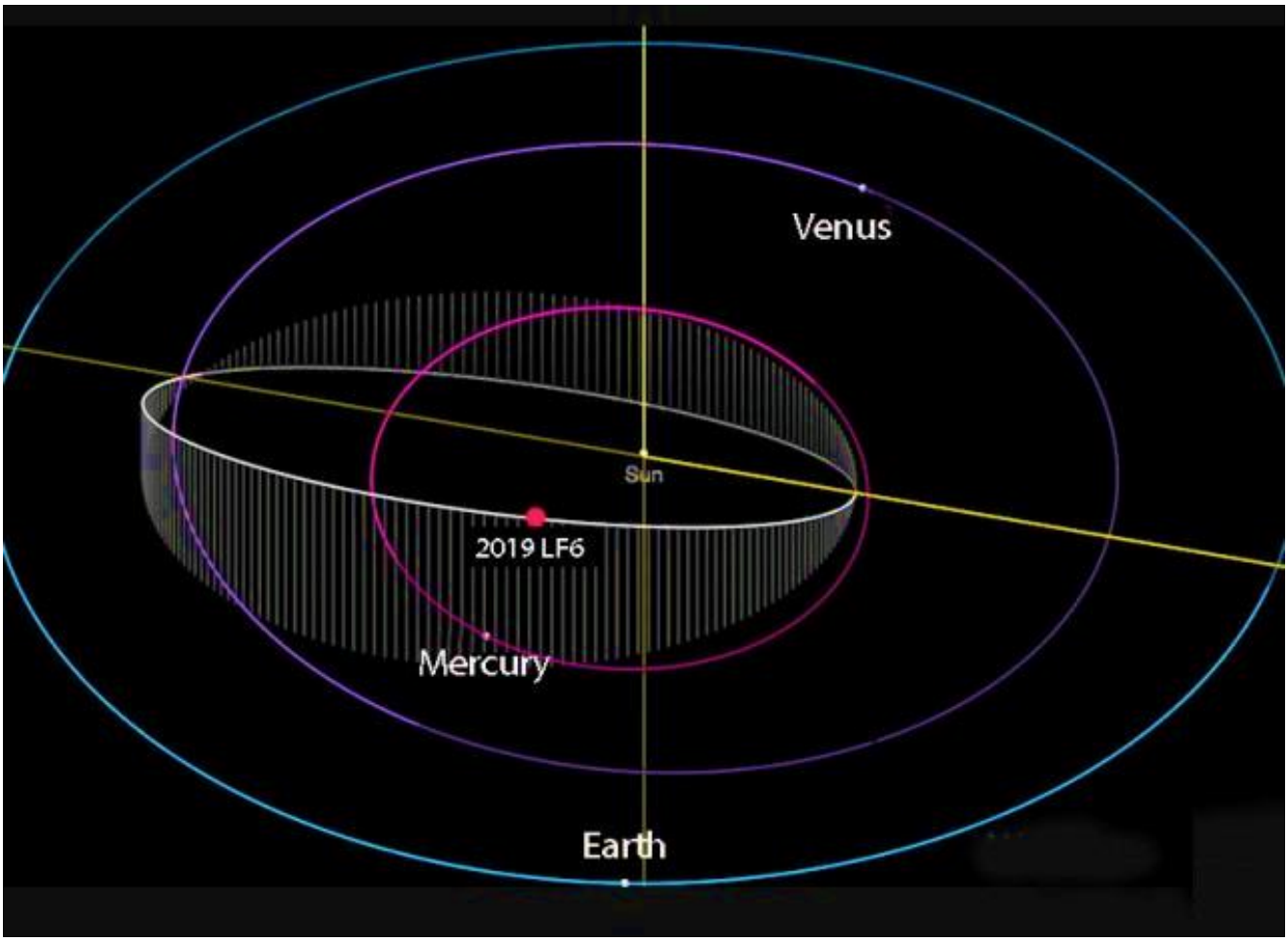
2. Caltech's Zwicky Transient Facility Spots Asteroid with Shortest Year



The asteroid orbits completely within Earth's orbit, circling the sun every 151 days, a record. The asteroid follows the white loop. Mercury's orbit is pink, Venus purple and the Earth blue. NASA / JPL-Caltech

The newfound kilometer-size object orbits the sun every 151 days

Astronomers have spotted an unusual asteroid with the shortest "year" known for any asteroid. The rocky body, dubbed 2019 LF6, is about a kilometer in size and circles the sun roughly every 151 days. In its orbit, the asteroid swings out beyond Venus and, at times, comes closer in than Mercury, which circles the sun every 88 days. 2019 LF6 is one of only 20 known "Atira" asteroids, whose orbits fall entirely within Earth's.

"You don't find kilometer-size asteroids very often these days," says Quanzhi Ye, a postdoctoral scholar at Caltech who discovered 2019 LF6 and works with Tom Prince, the Ira S. Bowen Professor of Physics at Caltech and a senior research scientist at JPL, and George Helou, the executive director of IPAC, an astronomy center at Caltech.

"Thirty years ago, people started organizing methodical asteroid searches, finding larger objects first, but now that most of them have been found, the bigger ones are rare birds," he says. "LF6 is very unusual both in orbit and in size—its unique orbit explains why such a large asteroid eluded several decades of careful searches."

2019 LF6 was discovered via the Zwicky Transient Facility, or ZTF, a state-of-the-art camera at the Palomar Observatory that scans the skies every night for transient objects, such as exploding and flashing stars and

moving asteroids. Because ZTF scans the sky so rapidly, it is well-suited for finding Atira asteroids, which have short observing windows.

"We only have about 20 to 30 minutes before sunrise or after sunset to find these asteroids," says Ye.

To find the Atira asteroids, the ZTF team has been carrying out a dedicated observing campaign, named Twilight after the time of day best suited for discovering the objects. Twilight was developed by Ye and Wing-Huen Ip of the National Central University in Taiwan. So far, the program has discovered one other Atira asteroid, named 2019 AQ3. Before 2019 LF6 came along, 2019 AQ3 had the shortest known year of any asteroid, orbiting the sun roughly every 165 days.

"Both of the large Atira asteroids that were found by ZTF orbit well outside the plane of the solar system," says Prince. "This suggests that sometime in the past they were flung out of the plane of the solar system because they came too close to Venus or Mercury," says Prince.

In addition to the two Atira objects, ZTF has so far found around 100 near-Earth asteroids and about 2,000 asteroids orbiting in the Main Belt between Mars and Jupiter.

Ye says he hopes the Twilight program will lead to more Atira discoveries, and he looks forward to the possible selection by NASA of the Near-Earth Object Camera (NEOCam) mission, a proposed spacecraft designed to look for asteroids closer to the sun than previous surveys. NEOCam would pick up the infrared, or heat, signatures of asteroids. (Ye works at IPAC, which would process and archive data for the NEOCam mission, but is not part of that team.)

"Because Atira asteroids are closer to the sun and warmer than other asteroids, they are brighter in the infrared," says Helou. "NEOCam has the double advantage of its location in space and its infrared capability to find these asteroids more easily than telescopes working at visible wavelengths from the ground."

Atira asteroids, like the newly discovered asteroid 2019 LF6, are a unique class of near-Earth objects (called interior-Earth objects) with orbits that are entirely contained within Earth's orbit. This artist's concept depicts a near-Earth asteroid hurtling through space. NASA/JPL-Caltech

Source: California Institute of Technology

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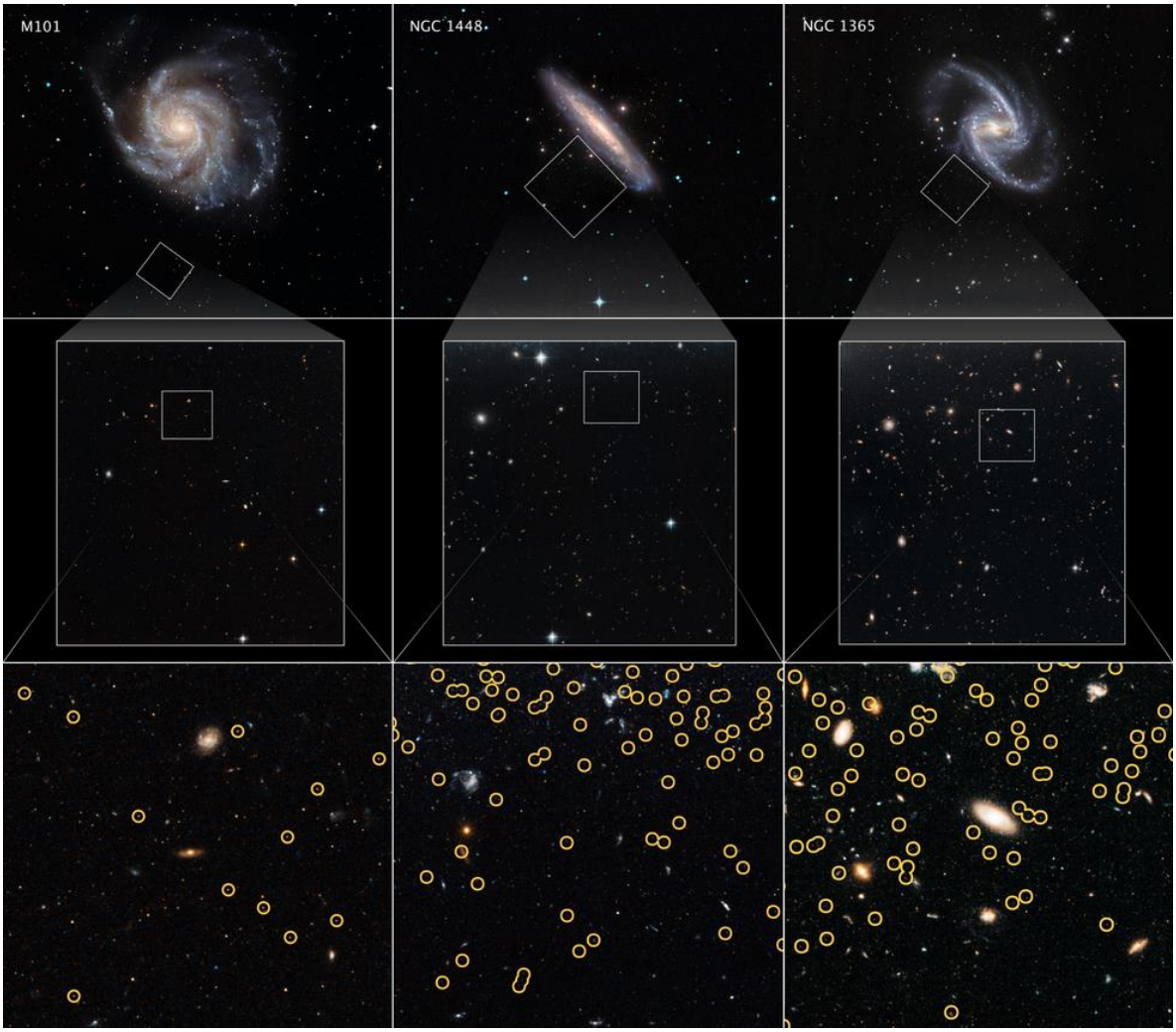
3. New Hubble Constant Measurement Adds to Mystery of Universe's Expansion Rate



These galaxies are selected from a Hubble Space Telescope program to measure the expansion rate of the universe, called the Hubble constant. The value is calculated by comparing the galaxies' distances to the apparent rate of recession away from Earth (due to the relativistic effects of expanding space). By comparing the apparent brightnesses of the galaxies' red giant stars with nearby red giants, whose distances were measured with other methods, astronomers are able to determine how far away each of the host galaxies are. This is possible because red giants are reliable milepost markers because they all reach the same peak brightness in their late evolution. And, this can be used as a "standard candle" to calculate distance. Hubble's exquisite sharpness and sensitivity allowed for red giants to be found in the stellar halos of the host galaxies. The red giants were searched for in the halos of the galaxies. The center row shows Hubble's full field of view. The bottom row zooms even tighter into the Hubble fields. The red giants are identified by yellow circles. Credits: NASA, ESA, W. Freedman (University of Chicago), ESO, and the Digitized Sky Survey

Astronomers have made a new measurement of how fast the universe is expanding, using an entirely different kind of star than previous endeavors. The revised measurement, which comes from NASA's Hubble Space Telescope, falls in the center of a hotly debated question in astrophysics that may lead to a new interpretation of the universe's fundamental properties. Scientists have known for almost a century that the universe is expanding, meaning the distance between galaxies across the universe is becoming ever more vast every second. But exactly how fast space is stretching, a value known as the Hubble constant, has remained stubbornly elusive.

Now, University of Chicago professor Wendy Freedman and colleagues have a new measurement for the rate of expansion in the modern universe, suggesting the space between galaxies is stretching faster than scientists would

expect. Freedman's is one of several recent studies that point to a nagging discrepancy between modern expansion measurements and predictions based on the universe as it was more than 13 billion years ago, as measured by the European Space Agency's Planck satellite.

As more research points to a discrepancy between predictions and observations, scientists are considering whether they may need to come up with a new model for the underlying physics of the universe in order to explain it. "The Hubble constant is the cosmological parameter that sets the absolute scale, size and age of the universe; it is one of the most direct ways we have of quantifying how the universe evolves," said Freedman. "The discrepancy that we saw before has not gone away, but this new evidence suggests that the jury is still out on whether there is an immediate and compelling reason to believe that there is something fundamentally flawed in our current model of the universe."

In a new paper accepted for publication in The Astrophysical Journal, Freedman and her team announced a new measurement of the Hubble constant using a kind of star known as a red giant. Their new observations, made using Hubble, indicate that the expansion rate for the nearby universe is just under 70 kilometers per second per megaparsec (km/sec/Mpc). One parsec is equivalent to 3.26 light-years distance.

This measurement is slightly smaller than the value of 74 km/sec/Mpc recently reported by the Hubble SH0ES (Supernovae H0 for the Equation of State) team using Cepheid variables, which are stars that pulse at regular intervals that correspond to their peak brightness. This team, led by Adam Riess of the Johns Hopkins University and Space Telescope Science Institute, Baltimore, Maryland, recently reported refining their observations to the highest precision to date for their Cepheid distance measurement technique.

How to Measure Expansion

A central challenge in measuring the universe's expansion rate is that it is very difficult to accurately calculate distances to distant objects. In 2001, Freedman led a team that used distant stars to make a landmark measurement of the Hubble constant. The Hubble Space Telescope Key Project team measured the value using Cepheid variables as distance markers. Their program concluded that the value of the Hubble constant for our universe was 72 km/sec/Mpc.

But more recently, scientists took a very different approach: building a model based on the rippling structure of light left over from the big bang, which is called the Cosmic Microwave Background. The Planck measurements allow scientists to predict how the early universe would likely have evolved into the expansion rate astronomers can measure today. Scientists calculated a value of 67.4 km/sec/Mpc, in significant disagreement with the rate of 74.0 km/sec/Mpc measured with Cepheid stars.

Astronomers have looked for anything that might be causing the mismatch. "Naturally, questions arise as to whether the discrepancy is coming from some aspect that astronomers don't yet understand about the stars we're measuring, or whether our cosmological model of the universe is still incomplete," Freedman said. "Or maybe both need to be improved upon."

Freedman's team sought to check their results by establishing a new and entirely independent path to the Hubble constant using an entirely different kind of star. Certain stars end their lives as a very luminous kind of star called a red giant, a stage of evolution that our own Sun will experience billions of years from now. At a certain point, the star undergoes a catastrophic event called a helium flash, in which the temperature rises to about 100 million degrees and the structure of the star is rearranged, which ultimately dramatically decreases its luminosity. Astronomers can measure the apparent brightness of the red giant stars at this stage in different galaxies, and they can use this as a way to tell their distance.

The Hubble constant is calculated by comparing distance values to the apparent recessional velocity of the target galaxies — that is, how fast galaxies seem to be moving away. The team's calculations give a Hubble constant of 69.8 km/sec/Mpc — straddling the values derived by the Planck and Riess teams.

Source: NASA Return to Contents

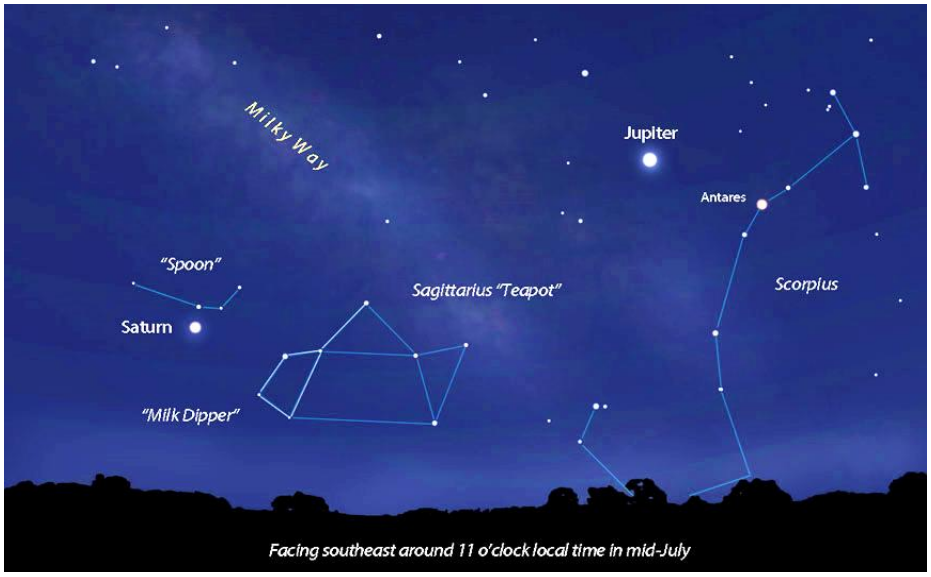
The Night Sky

Tuesday, July 16

• Full Moon (exact at 5:38 p.m. EDT). A partial lunar eclipse is visible from most of the world's continents *except* North America. (For us in North America, the full Moon shines on just as normal as can be, about 10° east of Saturn.)

Wednesday, July 17

• High in the northwest after dark, the Big Dipper has started its long, slow scoop toward the right. Lower in the north-northeast, meanwhile, the upright W of Cassiopeia has slowly begun to tilt and climb.



All this week Jupiter hangs upper left of Antares, and Saturn hangs upper left of the Sagittarius Teapot.

Thursday, July 18

• Week by week, bright Arcturus is losing some of its height in the west after dark.

Look for Spica to the lower left of Arcturus by about three fists at arm's length. Lower right of Arcturus by the same amount is Denebola, the tail-tip of Leo. These three stars form an almost perfect equilateral triangle.

Friday, July 19

• The tail of Scorpius is low due south after dark, as shown above. *How* low depends on how far north or south you live: the farther south, the higher.

Look for the two stars especially close together in the tail. These are Lambda and fainter Upsilon Scorpii, known as the Cat's Eyes. They're canted at an angle; the cat is tilting his head and winking.

The Cat's Eyes point to the right by nearly a fist-width toward Mu Scorpii, a much tighter pair (shown as a single dot on the map) known as the Little Cat's Eyes. They're oriented almost exactly the same way as Lambda and Upsilon. Are your eyes sharp enough to resolve the Mu pair without using binoculars? Not many people can!

Saturday, July 20

• Scorpius is sometimes called "the Orion of Summer" for its brightness, its blue-white giant stars, and its prominent red supergiant (Antares in the case of Scorpius, Betelgeuse for Orion). But Scorpius passes a lot lower across the south than Orion does, for those of us at mid-northern latitudes. That means it has only one really good evening month: July.

Catch Scorpius due south just after dark now, before it starts to tilt lower toward the southwest. It's full of deep-sky objects to hunt with a sky atlas and binoculars or a telescope, before the waning gibbous Moon rises later tonight to light the sky.

• Once the Moon does rise in the east-southeast, contemplate the moment 50 years ago today when a man took the first step onto another world. The sunset terminator tonight is approaching Tranquility Base, and everything there must be casting long shadows.

Source: Sky and Telescope

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ISS Sighting Opportunities (from Denver)

Date	Visible	Max Height	Appears	Disappears
Tue Jul 16, 9:13 PM	5 min	21°	11° above S	10° above E
Tue Jul 16, 10:49 PM	6 min	39°	12° above W	12° above NE
Wed Jul 17, 3:42 AM	6 min	29°	10° above NW	11° above E
Wed Jul 17, 5:19 AM	3 min	32°	11° above WNW	32° above SW
Wed Jul 17, 9:59 PM	6 min	68°	10° above WSW	11° above NE
Wed Jul 17, 11:38 PM	4 min	15°	10° above NW	10° above NNE
Thu Jul 18, 2:53 AM	5 min	20°	11° above NNW	11° above ENE
Thu Jul 18, 4:29 AM	6 min	62°	10° above WNW	10° above SE
Thu Jul 18, 9:10 PM	6 min	64°	10° above SW	11° above ENE
Thu Jul 18, 10:48 PM	5 min	20°	10° above WNW	10° above NNE
Fri Jul 19, 2:04 AM	4 min	15°	11° above NNW	11° above NE
Fri Jul 19, 3:40 AM	6 min	70°	10° above NW	10° above ESE
Fri Jul 19, 5:18 AM	2 min	11°	10° above WSW	10° above SSW

Sighting information for other cities can be found at NASA's Satellite Sighting Information

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NASA-TV Highlights (all times Eastern Time Zone)

July 16, Tuesday

- 1 p.m. – Apollo 11 50th Anniversary - Crew Interviews (June 9, 1989) with Neil Armstrong, Buzz Aldrin and Michael Collins (All Channels)
- 2 p.m., 9 p.m. – Replay – Apollo 11 50th Anniversary: Launch Reflection at Pad 39A with Astronauts Buzz Aldrin, Michael Collins and Kennedy Center Director Bob Cabana (All Channels)
- 5 p.m. – Replay - National Air and Space Museum Presents: Neil Armstrong Apollo 11 Spacesuit Unveiling (Public Channel)
- 6 p.m. – Apollo 11 50th Anniversary – Premiere – In the Shadow of the Moon (All Channels)

July 17, Wednesday

- 9 a.m., 6 p.m. – Apollo 11 50th Anniversary - Mission Control: Human Spaceflight (All Channels)
- 10:15 a.m. – Live Interview for CNBC with NASA Astronaut Joe Acaba (All Channels)
- 1 p.m. – Apollo 11 50th Anniversary – Documentary: 1969-1989 (All Channels)
- 2 p.m., 10 p.m. – Apollo 11 50th Anniversary - Moon 101 Series - Episode 3: The Lunar Environment (Public Channel)
- 4 p.m. – Apollo 11 50th Anniversary - Documentary: Moonwalk One (All Channels)
- 7 p.m. – Apollo 11 50th Anniversary - Crew Interviews (June 9, 1989) with Neil Armstrong, Buzz Aldrin and Michael Collins (All Channels)
- 8 p.m. – Apollo 11 50th Anniversary – In the Shadow of the Moon (All Channels)

July 18, Thursday

- 7 a.m., 2 p.m., 10 p.m. – Apollo 11 50th Anniversary - Moon 101 Series - Episode 4: The Crust of the Moon (Public Channel)
- 8 a.m. – Apollo 11 50th Anniversary - Crew Interviews (June 9, 1989) with Neil Armstrong, Buzz
- 9 a.m. – Apollo 11 50th Anniversary – The Flight of Apollo 11 (All Channels)
- 10 a.m. – Apollo 11 50th Anniversary – Documentary: 1969-1989 (All Channels)
- 4 p.m. – Apollo 11 50th Anniversary - Documentary: For All Mankind (Public Channel)
- 4 p.m. - Video File of the International Space Station Expedition 60-61/Soyuz MS-13 Rollout to the Launch Pad and Launch Pad Interviews at the Baikonur Cosmodrome in Kazakhstan – Johnson Space Center via Baikonur, Kazakhstan (Media Channel)
- 5 p.m. – Apollo 11 50th Anniversary - Documentary: Moonwalk One (All Channels)
- 7 p.m. – Apollo 11 50th Anniversary – In the Shadow of the Moon (All Channels)

July 19, Friday

- 7 a.m. – Apollo 11 50th Anniversary - Moon 101 Series - Episode 4: The Crust of the Moon (Public Channel)
- 8 a.m. – Apollo 11 50th Anniversary - Mission Control: Human Spaceflight (All Channels)
- 10 a.m. – Apollo 11 50th Anniversary - Documentary: For All Mankind (All Channels)
- 11 a.m. – Russian State Commission Meeting and Final International Space Station Expedition 60-61 Pre-Launch Crew News Conference in Baikonur, Kazakhstan (Skvortsov, Parmitano, Morgan) – Johnson Space Center via Baikonur, Kazakhstan (All Channels)
- 1 p.m. – NASA's Giant Leaps: Past and Future – Celebrating Apollo 50th as We Go Forward to the Moon (All Channels)
- 3 p.m. – Apollo 11 50th Anniversary - STEM: Forward to the Moon (All Channels)
- 5.p.m. – Replay of the International Space Station Expedition 60 State Commission and Crew News Conference in Baikonur, Kazakhstan (Skvortsov, Parmitano, Morgan) - Johnson Space Center via Baikonur, Kazakhstan (All Channels)

Watch NASA TV online by going to the NASA website. Return to Contents

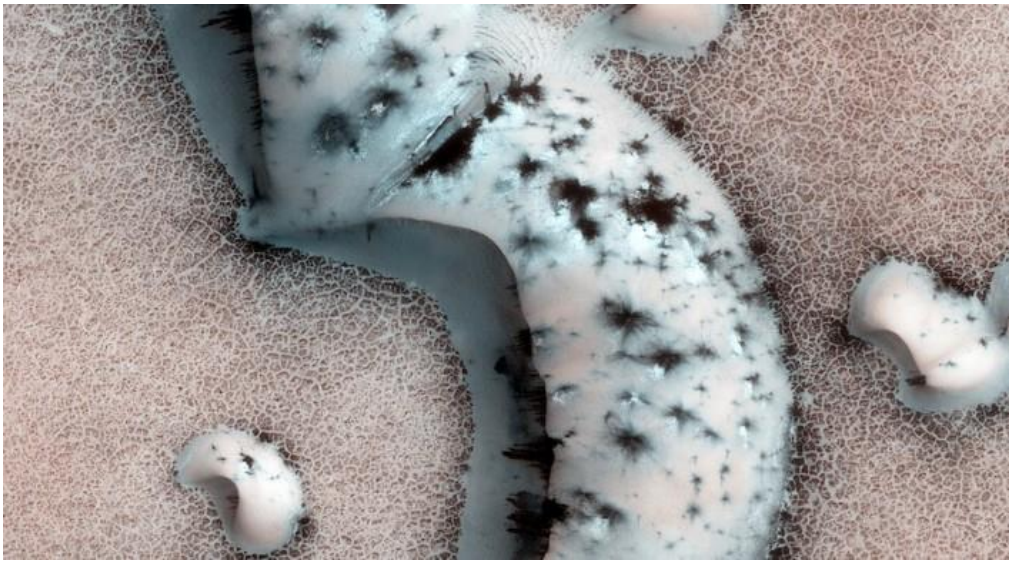
Space Calendar

- **Jul 16 - 50th Anniversary (1969), Apollo 11 Launch (1st Manned Moon Landing)**
- **Jul 16 - Partial Lunar Eclipse**
- **Jul 16 - Moon Occults Saturn**
- **Jul 16 - Moon Occults Dwarf Planet Pluto**
- Jul 16 - Asteroid 1103 Sequoia Closest Approach To Earth (0.815 AU)
- Jul 16 - Joint IOP and RAS Lecture: Connecting With People - Developing Unity and Understanding Under the Night Sky, London, United Kingdom
- Jul 16-17 - Earth Explorer-9 User Consultation Meeting, Cambridge, United Kingdom
- Jul 16-19 - 5th Conference on Perspectives in Nonlinear Dynamics (PNLD 2019), Sao Paulo, Brazil
- Jul 16-22 - 25th Anniversary (1994), Comet Shoemaker-Levy 9 Impacts on Jupiter
- Jul 17 - Aten Asteroid 2019 NF1 Near-Earth Flyby (0.049 AU)
- Jul 17 - Asteroid 9965 GNU Closest Approach To Earth (1.160 AU)
- Jul 17 - Asteroid 12464 Manhattan Closest Approach To Earth (1.415 AU)
- Jul 17 - Space Tech Summit, Silicon Valley, California
- Jul 17 - Lecture: Apollo 11 - The First Men on the Moon, London, United Kingdom
- Jul 17-19 - Workshop: Modeling Meerkats - Comparing Galaxy Formation Simulations to MeerKAT Surveys, Kruger Park, South Africa
- Jul 17-19 - Workshop on Computational Intelligence in Remote Sensing and Astrophysics, Heraklion, Crete
- Jul 18 - Apollo Asteroid 2014 MJ6 Near-Earth Flyby (0.091 AU)
- Jul 18 - Lecture: Back to the Moon - For Science and Exploration, Menlo Park, California
- Jul 18-19 - International Meeting on Paleoclimate: Change and Adaptation, Coimbra, Portugal
- Jul 18-20 - Workshop: Anomalies 2019, Telangana, India
- Jul 18-21 - Bluedot Event, Cheshire, United Kingdom
- Jul 19 - Apollo Asteroid 2019 NJ2 Near-Earth Flyby (0.034 AU)
- Jul 19 - Colloquium: US Astronomy in the 2020s - Decadal Survey & ngVLA, Sydney, Australia
- **Jul 20 - 50th Anniversary (1969), 1st Man On The Moon (Neil Armstrong - Apollo 11)**
- **Jul 20 - Soyuz MS-13 Soyuz-FG Launch (International Space Station 59S)**
- Jul 20 - Amor Asteroid 481984 Cernunnos Closest Approach To Earth (0.947 AU)
- Jul 20 - Asteroid 8553 Bradsmith Closest Approach To Earth (0.959 AU)
- Jul 20 - Sky Fest Event: Apollo 11 - Looking Back to Move Forward, Tucson, Arizona
- Jul 20 - Event: Apollo 11 50th Celebration, London, United Kingdom
- Jul 20 - Star Stories, Bentonville, Virginia
- **Jul 20 - 20th Anniversary (1999), Retrieval Of Liberty Bell 7 Capsule From Ocean Floor**
- Jul 20-21 - Gordon Research Seminar: Archaea - Ecology, Metabolism and Molecular Biology, Les Diableret, Switzerland
- **Jul 21 - Dragon CRS-18 (SpX 18)/ IDA 3/ RFTSat 1 Falcon 9 Launch (International Space Station)**

Source: JPL Space Calendar Return to Contents

Food for Thought

A Material Way to Make Mars Habitable



Polar ice caps on Mars are a combination of water ice and frozen CO2. Like its gaseous form, frozen CO2 allows sunlight to penetrate while trapping heat. In the summer, this solid-state greenhouse effect creates pockets of warming under the ice, seen here as black dots in the ice. Credit Harvard SEAS

People have long dreamed of re-shaping the Martian climate to make it livable for humans. Carl Sagan was the first outside of the realm of science fiction to propose terraforming. In a 1971 paper, Sagan suggested that vaporizing the northern polar ice caps would "yield ~10 s g cm-2 of atmosphere over the planet, higher global temperatures through the greenhouse effect, and a greatly increased likelihood of liquid water."

Sagan's work inspired other researchers and futurists to take seriously the idea of terraforming. The key question was: are there enough greenhouse gases and water on Mars to increase its atmospheric pressure to Earth-like levels?

In 2018, a pair of NASA-funded researchers from the University of Colorado, Boulder and Northern Arizona University found that processing all the sources available on Mars would only increase atmospheric pressure to about 7 percent that of Earth – far short of what is needed to make the planet habitable. Terraforming Mars, it seemed, was an unfulfillable dream.

Now, researchers from the Harvard University, NASA's Jet Propulsion Lab, and the University of Edinburgh, have a new idea. Rather than trying to change the whole planet, what if you took a more regional approach?

The researchers suggest that regions of the Martian surface could be made habitable with a material — silica aerogel — that mimics Earth's atmospheric greenhouse effect. Through modeling and experiments, the researchers show that a two to three-centimeter-thick shield of silica aerogel could transmit enough visible light for photosynthesis, block hazardous ultraviolet radiation, and raise temperatures underneath permanently above the melting point of water, all without the need for any internal heat source.

The paper is published in Nature Astronomy.

"This regional approach to making Mars habitable is much more achievable than global atmospheric modification," said Robin Wordsworth, Assistant Professor of Environmental Science and Engineering at the Harvard John A. Paulson School of Engineering and Applied Sciences (SEAS) and the Department of Earth and Planetary Science.

"Unlike the previous ideas to make Mars habitable, this is something that can be developed and tested systematically with materials and technology we already have."

"Mars is the most habitable planet in our Solar System besides Earth," said Laura Kerber, Research Scientist at NASA's Jet Propulsion Laboratory. "But it remains a hostile world for many kinds of life. A system for creating small islands of habitability would allow us to transform Mars in a controlled and scalable way."

The researchers were inspired by a phenomenon that already occurs on Mars. Unlike Earth's polar ice caps, which are made of frozen water, polar ice caps on Mars are a combination of water ice and frozen CO2. Like its gaseous form, frozen CO2 allows sunlight to penetrate while trapping heat. In the summer, this solid-state greenhouse effect creates pockets of warming under the ice.

"We started thinking about this solid-state greenhouse effect and how it could be invoked for creating habitable environments on Mars in the future," said Wordsworth. "We started thinking about what kind of materials could minimize thermal conductivity but still transmit as much light as possible."

The researchers landed on silica aerogel, one of the most insulating materials ever created. Silica aerogels are 97 percent porous, meaning light moves through the material but the interconnecting nanolayers of silicon dioxide infrared radiation and greatly slow the conduction of heat. These aerogels are used in several engineering applications today, including NASA's Mars Exploration Rovers.

"Silica aerogel is a promising material because its effect is passive," said Kerber. "It wouldn't require large amounts of energy or maintenance of moving parts to keep an area warm over long periods of time."

Using modeling and experiments that mimicked the Martian surface, the researchers demonstrated that a thin layer of this material increased average temperatures of mid-latitudes on Mars to Earth-like temperatures.

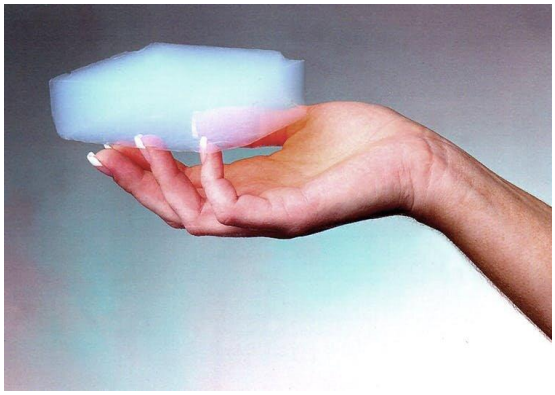
"Spread across a large enough area, you wouldn't need any other technology or physics, you would just need a layer of this stuff on the surface and underneath you would have permanent liquid water," said Wordsworth.

This material could be used to build habitation domes or even self-contained biospheres on Mars on Mars. "There's a whole host of fascinating engineering questions that emerge from this," said Wordsworth.

Next, the team aims to test the material in Mars-like climates on Earth, such as the dry valleys of Antarctica or Chile.

Wordsworth points out that any discussion about making Mars habitable for humans and Earth life also raises important philosophical and ethical questions about planetary protection.

"If you're going to enable life on the Martian surface, are you sure that there's not life there already? If there is, how do we navigate that," asked Wordsworth. "The moment we decide to commit to having humans on Mars, these questions are inevitable."



Aerogel. Credit: NASA/JPL-Caltech

Source: Harvard University

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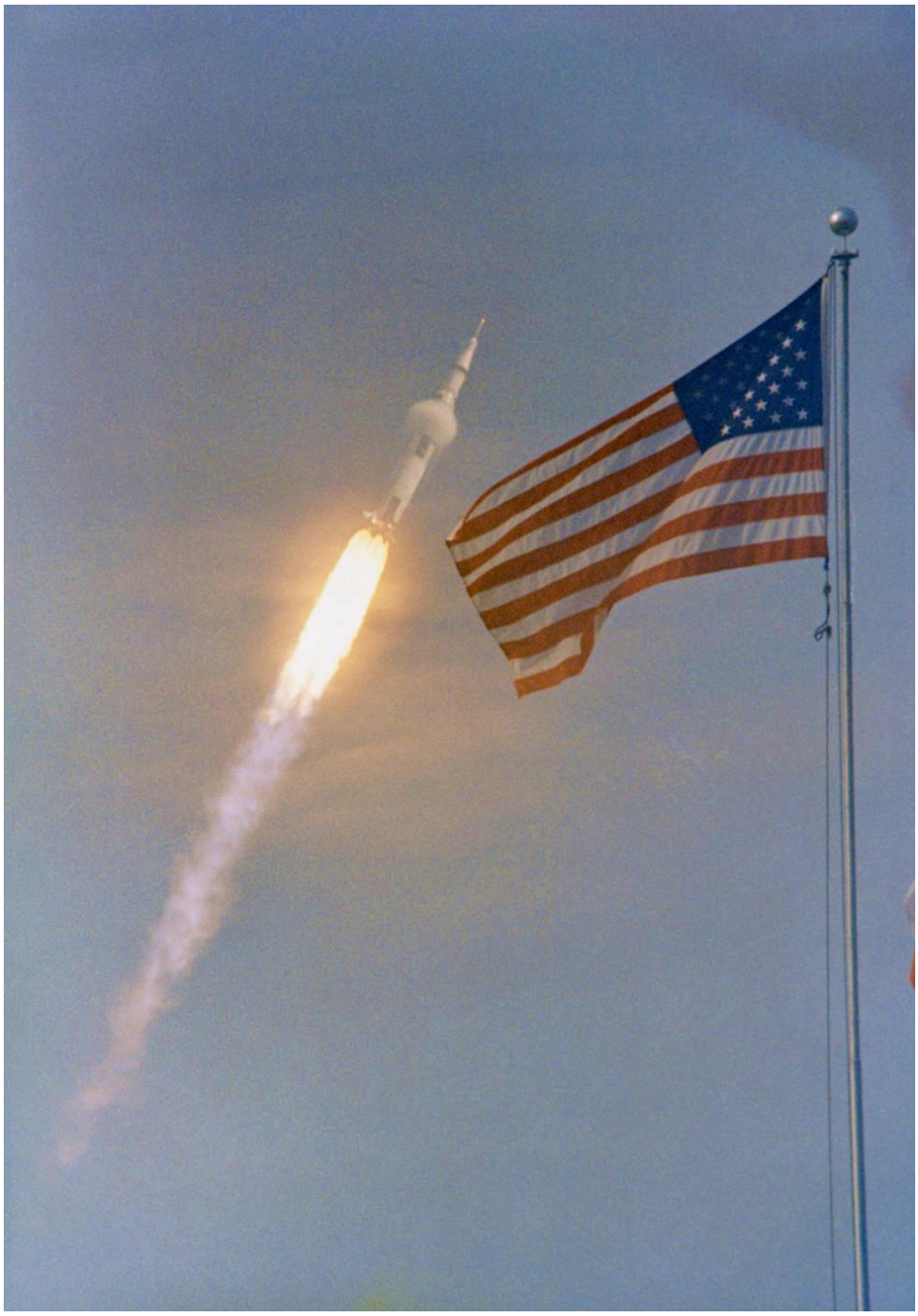
Space Image of the Week



50 Years Ago Today --- Apollo 11 Launches

Image credit: NASA

Explanation: This photograph shows the Saturn V launch vehicle (SA-506) for the Apollo 11 mission liftoff at 8:32 am CDT, July 16, 1969, from launch complex 39A at the Kennedy Space Center. Apollo 11 was the first manned lunar landing mission with a crew of three astronauts: Mission commander Neil A. Armstrong, Command Module pilot Michael Collins, and Lunar Module pilot Edwin "Buzz" E. Aldrin, Jr. A ring of condensation has formed around the Saturn V rocket as it compresses the air around it as it goes supersonic.

Source: NASA Return to Contents