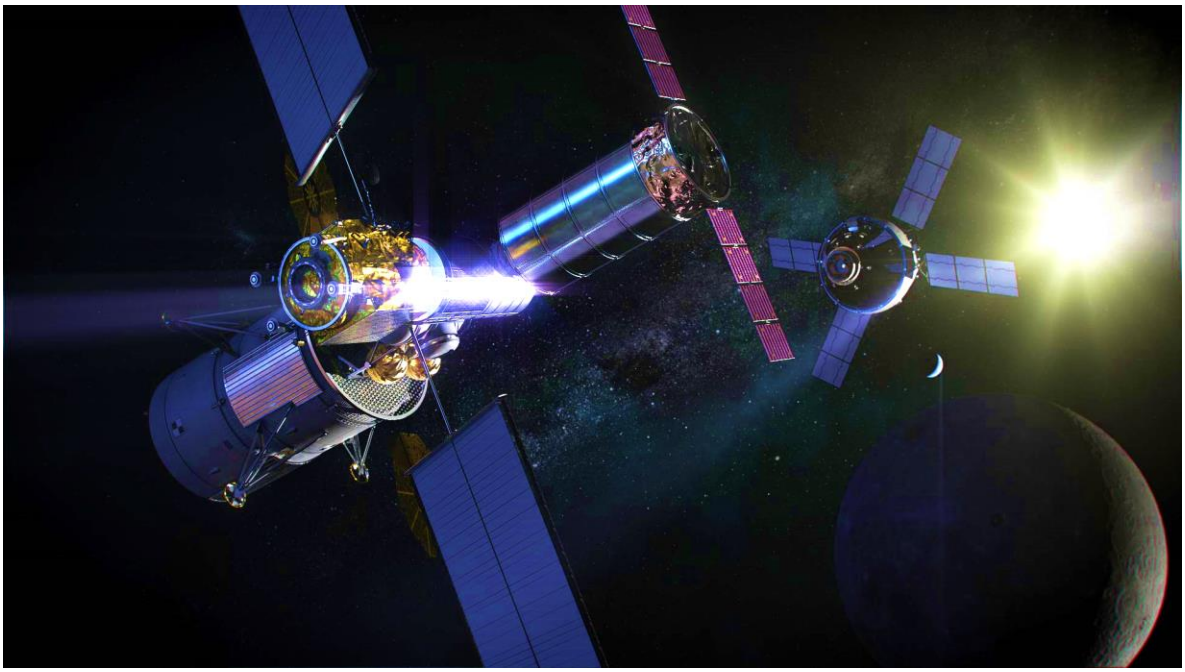
Space News Update

— July 30, 2019 —

Contents

1. NASA Taps Northrop Grumman in Sole-Source Agreement to Build Gateway Habitat



Artist's illustration of the Gateway in orbit around the moon, with the Power and Propulsion Element, a habitation module, and a visiting cargo resupply craft and Orion crew capsule. Credit: NASA

Racing against the clock to meet the Trump administration's 2024 deadline to land astronauts on the moon, NASA plans to select Northrop Grumman to build a pressurized habitation module derived from the company's Cygnus cargo craft for living quarters for crews transiting to and from the lunar surface.

The Northrop Grumman habitation module could be ready for launch in December 2023, and other companies under consideration for the work could not demonstrate they would be ready to launch a habitat into deep space in time for a 2024 lunar landing mission under NASA's Artemis program.

NASA is also bypassing a traditional procurement process for the Minimal Habitation Module. Rather than requesting bids from industry, and then evaluating the responses, NASA plans to fast-track a contract with Northrop Grumman Innovation Systems, an operating unit of Northrop Grumman formerly known as Orbital ATK.

The pressurized habitation compartment will be docked with the Gateway's Power and Propulsion Element in a stable near-rectilinear halo orbit around the moon. NASA announced in May that Maxar Technologies won a contract worth up to $375 million to build the Power and Propulsion Element, which will provide electricity and maneuvering capability for the Gateway station using high-power plasma thrusters, but does not include any pressurized section.

The Gateway is a mini-space station NASA plans to build in an orbit that swings as close as 2,000 miles from the moon about once per week. The Gateway will act as a stopover and safe haven for astronauts heading for the moon's surface.

NASA is designing the mini-station to accommodate myriad scientific experiments and engineering demonstrations required for more ambitious ventures deeper into the solar system, and eventually Mars.

NASA originally planned to build out the Gateway with a larger habitation module, a refueling and logistics depot, science labs, and a Canadian-built robotic arm before attempting a human landing on the moon around 2028.

Vice President Mike Pence changed that plan with a speech in March at NASA's Marshall Space Flight Center in Alabama. Pence declared NASA should land astronauts on the moon before the end of 2024 "by any means

necessary," prompting Gateway managers to shuffle their plans and focus on constructing a more operating base in lunar orbit within the next five years.

NASA still plans to add more elements to the Gateway, including contributions from international partners, after accomplishing the human landing on the moon.

NASA has worked with Bigelow Aerospace, Boeing, Lockheed Martin, Northrop Grumman Innovation Systems, Sierra Nevada Corp. and NanoRacks to develop ground prototypes and concepts for deep space habitats since 2016. The Next Space Technologies for Exploration Partnerships-2 (NextSTEP-2), Appendix A, agreements included habitation module prototypes at NASA centers in Alabama, Florida and Texas, and at Bigelow Aerospace's facility in North Las Vegas, Nevada.

NASA concluded the other companies' habitat proposals would be not ready in time for a launch before the end of 2023.

The cost of the Minimal Habitation Module was redacted from the sole-source justification document, and a NASA spokesperson said final value of the contract will hinge on negotiations between Northrop Grumman and NASA.

"NASA and Northrop Grumman will be negotiating a contract value in the coming months," said Rachel Kraft, a NASA spokesperson. "Selecting them now allows Northrop Grumman to procure some long-lead items before we finalize a contract value."

The space agency outlined officials' rationale for selecting Northrop Grumman in lieu of a full and open competition in a contracting document.

"In order to meet the Gateway program's schedule and support the vice president's 2024 human lunar landing mandate, NASA determined it was necessary to continue to work with NGIS (Northrop Grumman Innovation Systems) for these highly specialized services," NASA wrote in a justification document. "NGIS was the only NextSTEP-2 contractor with a module design and the production and tooling resources capable of meeting the 2024 deadline."

Northrop Grumman has launched 12 Cygnus missions to resupply the International Space Station, and another is set for launch in October. The Cygnus spacecraft itself has a perfect record, but one mission was lost on a launch failure.

"After an assessment of current design work already underway, the agency decided in May to procure one or more modules for the Gateway from the American companies which already developed concepts for deep space habitats as part of the agency's NextSTEP-2 initiative," Kraft said in a statement. "NASA now has determined that Northrop Grumman Innovation Systems is best suited to meet the agency's timeline for building and launching the first habitation module for the Gateway because it plans to leverage its extensive production capabilities and design maturity from its Cygnus cargo spacecraft to meet NASA's goals and timeline for a 2024 moon landing."

NASA said arranging a full and open competition would take 12-to-18 months, time the space agency can ill afford if it aims to land astronauts on the moon in five years.

In order to support a December 2023 launch, the Minimal Habitation Module must arrive at the Kennedy Space Center in Florida to begin launch preparations in mid-2023, NASA said.

According to the sole-source justification document, NASA has spent $87 million to date on the NextSTEP habitation module studies.

In selecting Northrop Grumman to develop the Minimal Habitation Module, NASA officials wrote that "no other NextSTEP-2 provider has … existing capabilities which, when considered collectively, provide the only viable approach to successfully achieving the 2024 lunar mandate."

NASA cited Northrop Grumman's existing Cygnus production line, in which Cygnus service modules are manufactured at Northrop Grumman's headquarters in Dulles, Virginia, and pressurized cargo modules come from Thales Alenia Space in Turin, Italy.

Northrop Grumman has also advanced design and development for adaptations to the existing Cygnus spacecraft that will be used at the Gateway, such as body-mounted radiators and radial docking ports to accommodate visiting crew and cargo vehicles, and future permanent additions to the Gateway complex.

"NGIS is the only NextSTEP-2 contractor uniquely able to complete design, development and production of the MHM (Minimal Habitation Module) within the time necessary to launch in late 2023 and get the module on station in lunar orbit early 2024 using existing launch vehicles," NASA wrote in the sole-source justification document.

"NGIS has an existing, active pressurized module manufacturing capability via their ongoing Cygnus module construction subcontractor that has provided experience and lessons learned from development of 13 Cygnus vehicles to date, refining management and technical interactions and interchanges," NASA wrote.

Northrop Grumman has an exclusive contracting agreement with Thales for pressurized cargo modules. The Cygnus cargo compartment is based on the Multi-Purpose Logistics Modules built by Thales to launch inside the payload bay of the space shuttle packed with several tons of supplies and experiments for the International Space Station.

Thales Alenia Space also manufactured several permanent modules on the International Space Station.

"This existing contractual relationship (between Northrop Grumman and Thales Alenia Space) and its associated production pedigree are critical to timely development progress and problem resolution, which are substantive mitigations to schedule risk," NASA wrote.

According to NASA's sole-source justification document, the Gateway's Minimal Habitation Module use a pressurized module with the same 10-foot (3.07-meter) diameter as the Cygnus cargo compartment, allowing the spacecraft to fit inside the payload fairing envelope of existing commercial rockets.

Cygnus resupply missions to the space station have launched on Northrop Grumman's own Antares booster, and aboard United Launch Alliance's Atlas 5 rocket.

"Additionally, the smaller diameter of the NGIS module enables other externally mounted capabilities, including batteries, communication antennae, and payloads to be incorporated upon launch and available for the initial mission," NASA wrote. "These capabilities uniquely establish a minimum risk development posture for supplying the initial docking and habitable transfer capability necessary to support lunar operations in 2024."

In an interview with Spaceflight Now earlier this year, a senior Northrop Grumman official discussed the company's plans for a deep space habitat.

"Going out to cislunar space will be a little bit different," said Frank DeMauro, vice president and general manager of Northrop Grumman's space systems division. "So we've looked at the avionics upgrades required for the higher radiation environment, different communications systems, docking versus berthing systems.

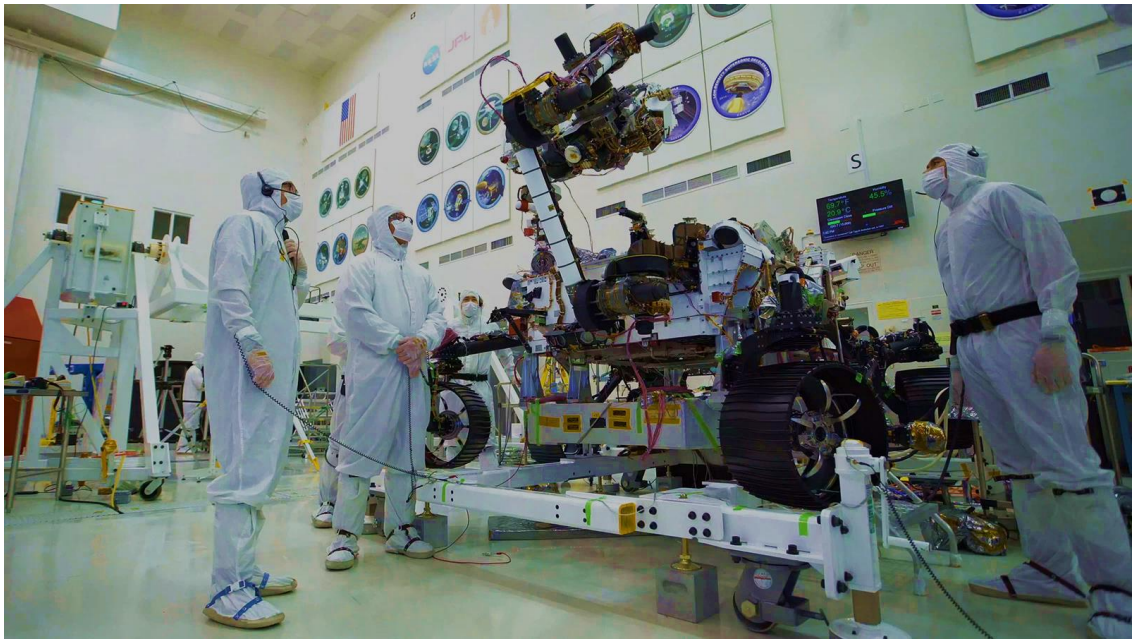
"We think we're in a good place to offer NASA a proven, yet upgraded technology suite on a Cygnus-class vehicle to provide all sorts of services out in cislunar space, whether it's habitats, logistics services, science and utilization services, as well as even power and propulsion systems out there. Cygnus is a stepping stone from that point of view," DeMauro said.

Meanwhile, NASA has kicked off procurement steps to select a commercial provider for a human-rated lunar lander that launch on a commercial rocket and dock with the Gateway, where astronauts arriving on an Orion spacecraft — lifted into space by NASA's Space Launch System heavy-duty rocket — will transfer to the descent craft for the trip to the moon's surface.

NASA hopes to select a company to oversee development of the human-rated moon lander by the end of the year.

Source: Spaceflight Now Return to Contents

2. NASA's Mars 2020 Rover Does Biceps Curls



In this image, taken July 19, 2019, in the clean room of the Spacecraft Assembly Facility at JPL, the rover's 7-foot-long (2.1-meter-long) arm maneuvers its 88-pound (40-kilogram) sensor-laden turret as it moves from a deployed to a stowed configuration. Credit: NASA/JPL-Caltech

The robotic arm on NASA's Mars 2020 rover does not have deltoids, triceps or biceps, but it can still curl heavy weights with the best. In this time-lapse video, taken July 19, 2019, in the clean room of the Spacecraft Assembly Facility at the Jet Propulsion Laboratory in Pasadena, California, the rover's 7-foot-long (2.1-meter-long) arm handily maneuvers 88 pounds' (40 kilograms') worth of sensor-laden turret as it moves from a deployed to a stowed configuration.

In the time-lapse video (at the link below), taken July 19, 2019, in the clean room of the Spacecraft Assembly Facility at JPL, the rover's 7-foot-long (2.1-meter-long) arm maneuvers its 88-pound (40-kilogram) sensor-laden turret as it moves from a deployed to a stowed configuration.

The rover's arm includes five electrical motors and five joints (known as the shoulder azimuth joint, shoulder elevation joint, elbow joint, wrist joint and turret joint). The rover's turret includes HD cameras, the Scanning Habitable Environments with Raman & Luminescence for Organics & Chemicals (SHERLOC) science instrument, the Planetary Instrument for X-ray Lithochemistry (PIXL), and a percussive drill and coring mechanism.

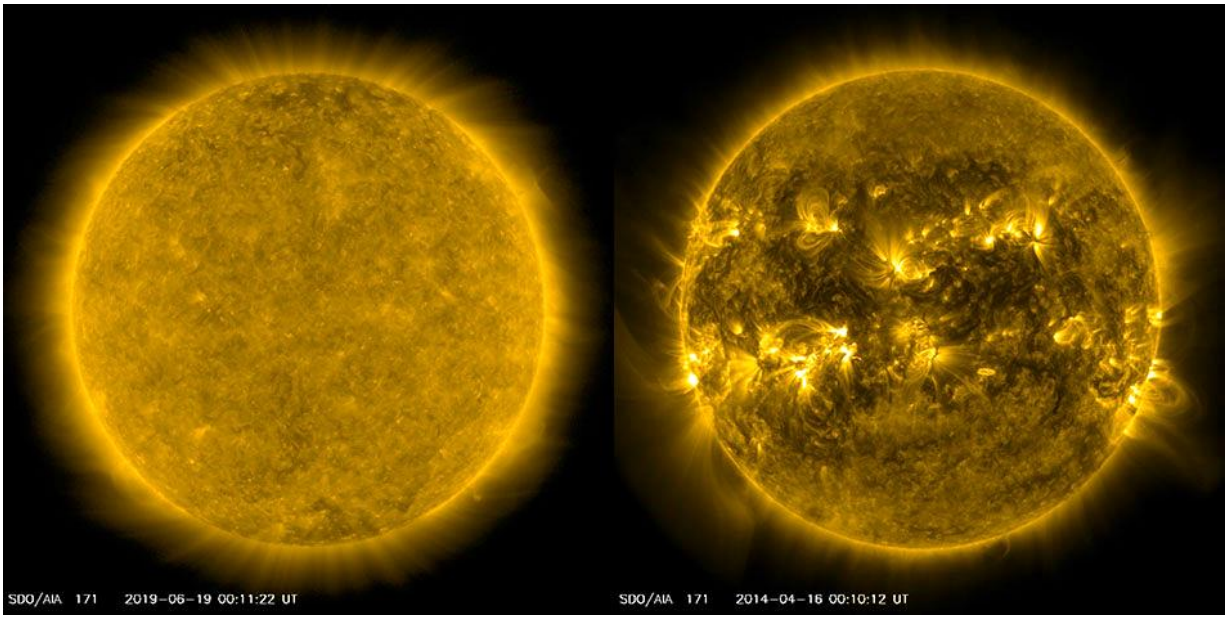
On Mars, the arm and turret will work together, allowing the rover to work as a human geologist would: by reaching out to interesting geologic features, abrading, analyzing and even collecting them for further study via Mars 2020's Sample Caching System, which will collect samples of Martian rock and soil that will be returned to Earth by a future mission.

"This was our first opportunity to watch the arm and turret move in concert with each other, making sure that everything worked as advertised - nothing blocking or otherwise hindering smooth operation of the system," said Dave Levine, integration engineer for Mars 2020. "Standing there, watching the arm and turret go through their motions, you can't help but marvel that the rover will be in space in less than a year from now and performing these exact movements on Mars in less than two."

Mars 2020 will launch from Cape Canaveral Air Force Station in Florida in July 2020. It will land at Jezero Crater on Feb. 18, 2021.

Source: NASA Return to Contents

3. Terminators' on the Sun Trigger Plasma Tsunamis and the Start of New Solar Cycles -- **The next solar cycle is predicted to take off within a year**



Images of the Sun from NASA's Solar Dynamics Observatory. The left image was taken last month during the current solar minimum. The image on the right was taken in April 2014 during the last solar maximum. (Images: NASA)

In a pair of new papers, scientists paint a picture of how solar cycles suddenly die, potentially causing tsunamis of plasma to race through the Sun's interior and trigger the birth of the next sunspot cycle only a few short weeks later. The new findings provide insight into the mysterious timing of sunspot cycles, which are marked by the waxing and waning of sunspot activity on the solar surface. While scientists have long known that these cycles last approximately 11 years, predicting when one cycle ends and the next begins has been challenging to pin down with any accuracy. The new research could change that.

In one of the studies, which relies on nearly 140 years of solar observations from the ground and space, the scientists are able to identify "terminator" events that clearly mark the end of a sunspot cycle. With an understanding of what to look for in the run up to these terminators, the authors predict that the current solar cycle (Solar Cycle 24) will end in the first half of 2020, kicking off the growth of Solar Cycle 25 very shortly after.

In a second study, motivated by the first, scientists explore the mechanism for how a terminator event could trigger the start of a new sunspot cycle using a sophisticated computer model. The resulting simulations show that "solar tsunamis" could provide the connection and explain the Sun's remarkably rapid transition from one cycle to the next.

Both studies were led by the **National Center for Atmospheric Research (NCAR)**. "The evidence for terminators has been hidden in the observational record for more than a century, but until now, we didn't know what we were looking for," said NCAR scientist Scott McIntosh, who directs the center's High Altitude Observatory and worked on both studies. "By combining such a wide variety of observations over so many years, we were able to piece together these events and provide an entirely new look at how the Sun's interior drives the solar cycle."

Flickers of light reveal mysteries

Sunspot cycles are born after solar minimum, a period when the face of the Sun is quiet. As the cycle continues, more and more sunspots emerge, first appearing at about 35 degrees latitude in both hemispheres and slowly marching toward the equator over a decade before they fade again into the next solar minimum. The rough midpoint of this progression is solar maximum, when sunspots are the most abundant.

Predicting the timing of sunspot evolution is a major scientific goal, in part because sunspot activity is tied to the solar storms that can disrupt Earth's upper atmosphere and affect GPS signals, power grids, and other critical technologies. But such predictions have proven challenging.

For example, the Sun is currently in a solar minimum. Scientist know the relative peace means that the current solar cycle is wrapping up, but it has been difficult to say whether the new cycle will begin in a few months or a few years. McIntosh and his colleagues think their studies can provide more clarity, both into the timing of cycles and also into what drives the cycles themselves.

The researchers began by studying the movement of coronal bright points – ephemeral flickers of extreme ultraviolet light in the solar atmosphere. By observing bright points, which occur even in the relative calm of a solar minimum, the scientists think they have gained a more complete view of the solar cycle than if they focused only on sunspot activity.

The bright points first appear at higher latitudes than sunspots (around 55 degrees) and migrate toward the equator at approximately 3 degrees latitude per year, reaching the equator after a couple decades. The paths traced by the bright points overlap with sunspot activity in the mid-latitudes (around 35 degrees) until they both reach the equator and disappear. This disappearance, which the researchers call a terminator event, is followed very shortly after with a large burst of bright point activity at the mid-latitudes, marking the beginning of the next sunspot cycle.

In the new study that identifies terminator events, published in the journal *Solar Physics*, the scientists corroborate the bright point observations with a number of other observations from a variety of spacecraft- and ground-observing facilities stretching back over 13 solar cycles.

"We were able to identify these terminators by looking at data from a whole range of different measures of solar activity – magnetic fields, spectral irradiance, radio flux – in addition to the bright points," said University of Maryland scientist Bob Leamon, a co-author of the paper who is also a researcher at NASA's Goddard Space Flight Center. "The results demonstrate that you really need to be able to step back and use all the available data to appreciate how things work – not just one spacecraft or one observation or one model."

Tsunami connections

McIntosh and his team have identified that coronal bright points allow them to better "see" the solar cycle unfolding. But why does the sunspot cycle start surging in the mid-latitudes a few weeks after the terminator?

The paper on solar tsunamis, led by NCAR scientist Mausumi Dikpati and published in *Scientific Reports*, explores the possible mechanisms behind the observations. It suggests that coronal bright points are markers for the movement of the Sun's "toroidal magnetic fields," which wrap around the Sun like rubber bands stretching in the east-west direction and migrate slowly toward the equator over the same two decades.

When these toroidal magnetic fields bob to the surface, they create sunspots along with the bright points they were already producing. As they travel, they also act as magnetic dams, trapping plasma behind them. When the toroidal magnetic fields from the Sun's northern and southern hemispheres touch in the middle, their opposing charges cause their mutual annihilation, releasing the pent-up fluid behind them in a tsunami. This fluid rushes forward, collides, and then ripples backward, traveling toward the poles at a rate of about 300 meters per second.

As the solar tsunami reaches the Sun's mid-latitudes, it encounters the toroidal magnetic fields of the next cycle, which are already marching toward the equator (this progression is marked by the path of coronal bright points) but traveling deeper within the Sun's interior. The tsunami buoys those magnetic fields, lifting them toward the surface and producing the remarkable surge of bright points – and accompanying sunspot activity – that marks the beginning of the new sunspot cycle. (See animation at the link below.)

Source: National Center for Atmospheric Research (NCAR) Return to Contents

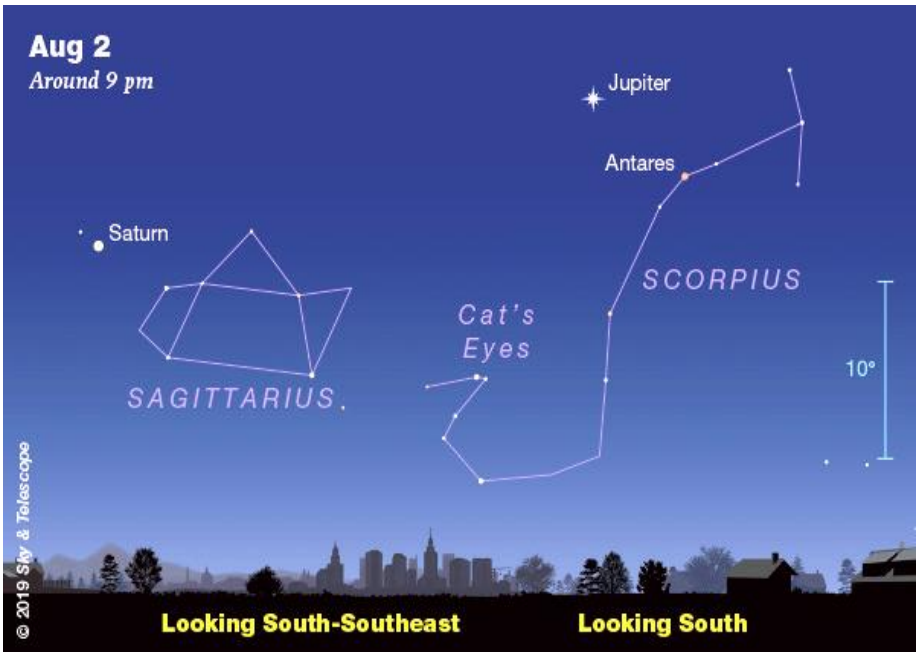
The Night Sky

Tuesday, July 30

• The tail of Scorpius is low due south right after dark. *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 west (right) by nearly a fist-width toward Mu Scorpii, a much tighter pair known as the Little Cat's Eyes. They're oriented almost exactly the same way as Lambda and Upsilon but are only one-sixth as far apart. Bring binoculars!



All week, Jupiter and Saturn remain by Scorpius and Sagittarius at nightfall.

Wednesday, July 31

• **Fourth star of the Summer Triangle.** The next-brightest star near the Summer Triangle, if you want to turn it into a quadrilateral, is Rasalhague, the head of Ophiuchus. Face south soon after dark. You'll find Rasalhague about equally far right of Altair and lower right of Vega. Altair is the Summer Triangle's lowest star now. Vega, nearly overhead, is its brightest.

• New Moon (exact at 11:12 p.m. EDT)

Thursday, August 1

• The Sagittarius Teapot hangs in the south these evenings, to the lower right of Saturn. It's beginning to tilt to pour from its spout to the right. The Teapot will tilt further for the rest of the summer — and for much of the night if you stay out late.

• Today is Lammas Day or Lughnasadh, one of the four traditional "cross-quarter" days midway between the solstices and equinoxes. Sort of. The actual midpoint between the June solstice and the September equinox this year comes at 7:52 a.m. August 7th Eastern Daylight Time (11:52 UT). That is the exact center-balance of astronomical summer: the very height of the year. (Although the height of heat in the Northern Hemisphere generally come earlier, in July.)

Friday, August 2

• Bright Vega passes closest to overhead around 11 p.m., depending on how far east or west you live in your time zone. How closely it *misses* your zenith depends on how far north or south you are. It passes right through your zenith if you're at latitude 39° north (Washington DC, Cincinnati, Kansas City, and Lake Tahoe). How closely can you judge this just by looking?

Deneb crosses closest to the zenith almost exactly two hours after Vega.

Source: Sky and Telescope

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ISS Sighting Opportunities (from Denver)

Date	Visible	Max Height	Appears	Disappears
Tue Jul 30, 9:02 PM	3 min	13°	11° above NNW	10° above NE
Tue Jul 30, 10:40 PM	1 min	40°	25° above NNW	40° above N
Wed Jul 31, 9:50 PM	3 min	28°	19° above NNW	23° above ENE
Wed Jul 31, 11:26 PM	< 1 min	11°	11° above WNW	11° above WNW
Thu Aug 1, 9:01 PM	4 min	20°	14° above NNW	11° above ENE
Thu Aug 1, 10:37 PM	1 min	41°	18° above WNW	41° above WNW
Fri Aug 2, 9:48 PM	2 min	67°	27° above NW	47° above E

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

NASA-TV Highlights (all times Eastern Time Zone)

July 30, Tuesday

- 2 p.m. – NASA in Silicon Valley Live: How to Get an Internship at NASA (All Channels)
- 7 p.m. – Replay of NASA in Silicon Valley Live: How to Get an Internship at NASA (All Channels)

July 31, Wednesday

- 7:30 a.m. – Coverage of the Launch of the International Space Station Progress 73 Cargo Craft from the Baikonur Cosmodrome in Kazakhstan; launch scheduled at 8:10 a.m. EDT – Johnson Space Center via Baikonur (All Channels)
- 10:45 a.m. – Coverage of the Rendezvous ad Docking of the International Space Station Progess 73 Cargo Craft to the Pirs Docking Compartment; docking scheduled at 11:35 a.m. EDT (All Channels)
- 2:10 p.m. – Expedition 60 In-Flight Event for the International Space Station Program's Research and Development Conference in Atlanta with NASA astronauts Nick Hague, Christina Koch and Andrew Morgan and ESA astronaut Luca Parmitano (All Channels)

Watch NASA TV online by going to the NASA website.

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Space Calendar

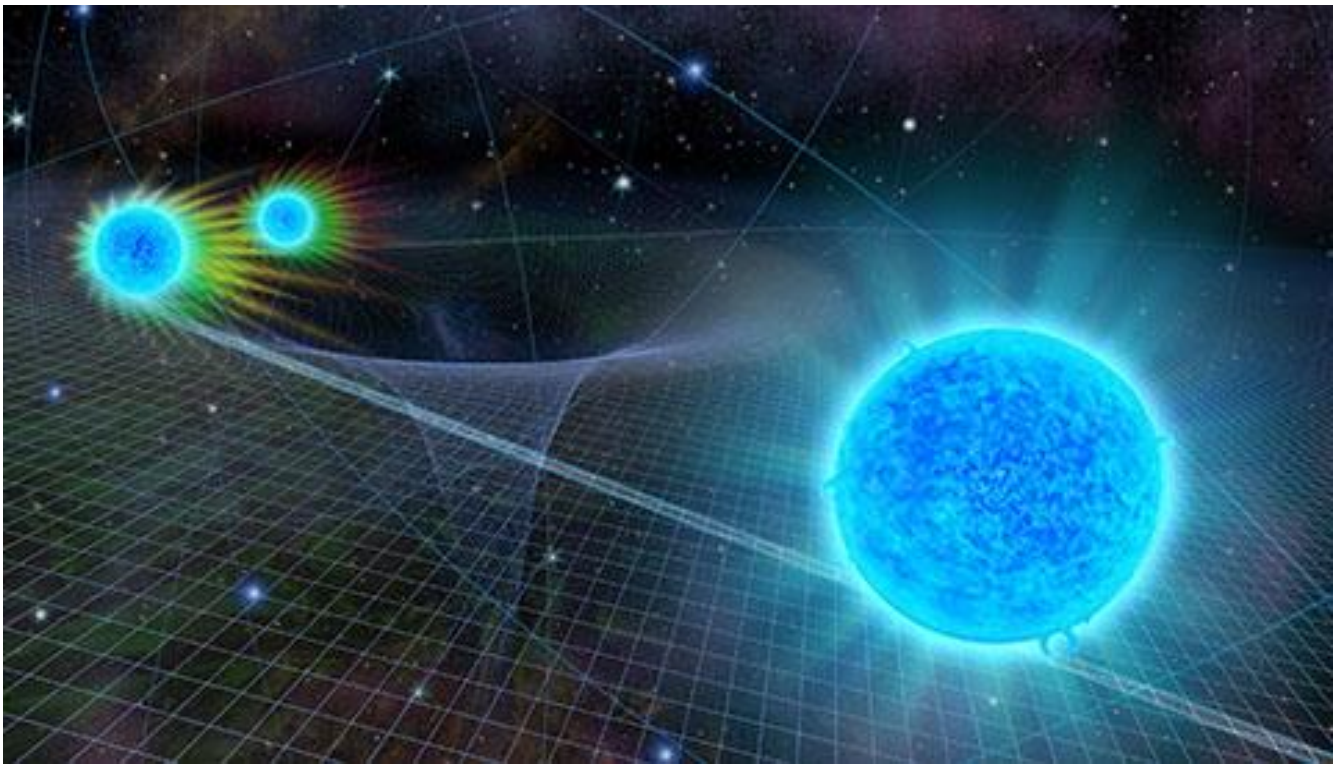
- Jul 29-Aug 01 - International Space Station R&D Conference, Atlanta Georgia
- Jul 29-Aug 02 - Transiting Exoplanet Survey Satellite (TESS) Science Conference, Cambridge, Massachusetts
- Jul 29-Aug 02 - Conference: Small Galaxies, Cosmic Questions, Durham, United Kingdom
- Jul 29-Aug 02 - 5th Python in Astronomy Conference 2019, Baltimore, Maryland
- Jul 29-Aug 02 - 27th International Nuclear Physics Conference (INPC 2019), Glasgow, United Kingdom
- Jul 29-Aug 02 - 2019 Meeting of the Division of Particles and Fields of the American Physical Society (DPF2019), Boston, Massachusetts
- Jul 29-Aug 02 - 9th East-Asia School and Workshop on Laboratory, Space, and Astrophysical Plasmas, Nagoya, Japan
- Jul 29-Aug 23 - Workshop: Galaxy Evolution in a New Era of HI Surveys, Munich, Germany
- Jul 30 - Event: Swiss Touch - To the Moon and Beyond — 50th Anniversary of Humankind on the Moon, San Francisco, California
- Jul 30-Aug 01 - 7th International Conference on Space Mission Challenges for Information Technology (SMC-IT), Pasadena, California
- Jul 31 - 50th Anniversary (1969), Mariner 6, Mars Flyby
- **Jul 31 - Progress MS-12 Soyuz-2.1a Launch (International Space Station 73P)**
- Jul 31 - Comet P/2012 SB6 (Lemmon) Closest Approach To Earth (2.173 AU)
- Jul 31 - Asteroid 1430 Somalia Closest Approach To Earth (1.047 AU)
- Jul 31 - Asteroid 16260 Sputnik Closest Approach To Earth (1.135 AU)
- Jul 31 - Webinar: OSIRIS-REx
- Jul 31 - Colloquium: Multi-frequency Polarimetry of a Complete Sample of Faint PACO Sources, Sydney, Australia
- Jul 31 - 20th Anniversary (1999), Lunar Prospector, Moon Impact
- Jul 31-Aug 02 - Aerospace Bolivian Conference (ABC) & IEEE International Conference on Aerospace and Signals (INCAS), La Paz, Bolivia
- Aug 01 - Alpha Capricornids Meteor Shower Peak
- Aug 01 - Aten Asteroid 2019 ON Near-Earth Flyby (0.017 AU)
- Aug 01 - Apollo Asteroid 2012 DT32 Near-Earth Flyby (0.084 AU)
- Aug 01 - Asteroid 3306 Byron Closest Approach To Earth (0.957 AU)
- Aug 01 - Asteroid 5000 IAU Closest Approach To Earth (1.295 AU)
- Aug 01-02 - Meeting: Review of the NASA Science Mission Directorate Science Plan, Washington DC
- **Aug 01-02 - Rocky After Dark Star Party, Rocky Mountain National Park, Estes Park, Colorado**
- Aug 01-03 - Long Wavelength Array Users Meeting, Albuquerque, New Mexico
- **Aug 02 - EDRS-C/HYLAS-3/ Intelsat 39 Ariane 5 Launch**
- Aug 02-03 - Mount Carleton Star Party, Mount Carleton Provincial Park, Canada
- Aug 02-04 - Dark Sky Festival, Lassen Volcanic National Park, Mineral, California
- **Aug 03 - AMOS 17 Falcon 9 Launch**

Source: JPL Space Calendar Return to Contents

Food for Thought

Galactic Center Gravity Test Confirmed

A second team of astronomers has now confirmed the light from a star passing near our galaxy's central black hole behaved as predicted by Einstein's theory of gravity.



Artist's concept of the star S0-2 going through stages of its pass around the Milky Way's central black hole (deep in the pit). S0-2 actually dips into the gravitational well when at its closest, and its light shifts from blue, to green, to red (indicated by the light beams).
Credit: Nicolle R. Fuller / NSF

In May 2018, the island of Hawai'i shook in travail. Lava poured from a rift in the side of the volcano Kilauea, and two earthquakes rattled people and buildings, triggering the evacuation not only of houses in the lava's path but also the staff at the neighboring summit of Mauna Kea and the Keck Observatory's headquarters in Waimea.

Although the mountain was losing its cool, astronomer Andrea Ghez (University of California, Los Angeles) wasn't. She and her team had spent more than two decades using the Keck telescopes and other facilities to watch stars loop around Sgr A*, the black hole in our galaxy's center. That month a big, bluish star was whizzing through its closest pass of the leviathan, at a fair fraction of the speed of light. The astronomers had carefully calculated exactly which days were most important for their observations, and Ghez knew they could afford to lose one to the volcano — which they did.

Ghez's team is one of two — the other led by Reinhard Genzel (Max Planck Institute for Extraterrestrial Physics, Germany) — that have followed the stars in the galactic center since the 1990s. These stars are an oddball group of large, young suns, whizzing through a region where star formation should be impossible.

Astronomers care about these stars for many reasons, but the most recent observing runs focused on a single member of the troupe and what it can tell us about gravity. Called S2 by the German team and S0-2 by the American one, the star that made its mad dash in 2018 comes closer to Sgr A* than any other star we've detected — about 120 astronomical units, or four times Neptune's distance from the Sun. That's so close that the star zips inside the edge of the dip the black hole makes in the fabric of spacetime, like a fearless cosmic skateboarder going

sideways on a ramp. As S2 dives in, its photons have to climb out in order to reach us. The climb robs them of energy, which shifts them to longer, redder wavelengths.

This relativistic redshift doesn't happen in Newtonian gravity. Mind you, there *is* a redshift in Newton's version, but it's only due to the star moving along our line of sight. Einstein's general theory of relativity (GR) tacks on an extra shift that's roughly one-tenth as big — not the easiest thing to see when you're tracking stars 26,000 light-years away, all crowded into your field of view like dancing polka dots.

But last July, Genzel and his colleagues announced that they had finally detected this relativistic redshift, using the superb capabilities of the Gravity interferometric instrument at the Very Large Telescope in Chile to watch S2 skirt past the black hole.

Before going public, Genzel asked Ghez if she'd like to do a joint announcement of both groups' results. But Ghez demurred. There were three key points in S2's closest approach: first in April, when the star's motion away from us along our line of sight escalated, then turned and plunged back toward us; second, in mid-May, when the star came closest to the black hole as seen in the plane of the sky; third, in September, when the star pulled out of its headlong rush toward us and slowed. Ghez wanted to observe the star's last turn before she analyzed her data.

Those data, scrupulously checked for inconsistencies, now appear July 25th in *Science*. The analysis by Ghez, deputy director Tuan Do (also UCLA), and their colleagues confirms that of the Gravity Collaboration, clearly showing a relativistic redshift of about 200 km/s and ruling out Newtonian gravity. (Genzel's group has also published a follow-up paper including their observations through September 2018.)

Although a confirmation result often has trouble grabbing headlines, this is science at its best: two independent teams, using different telescopes and instruments and analysis methods, finding the same thing.

Well, not quite the same thing. What has both teams puzzled is that, although they see the same redshift, other, more prosaic parameters they calculate from their observations don't quite match. For example, their measurements of Sgr A*'s distance differ by some 600 light-years. "The two results should agree, we're looking at the same black hole!" Ghez says.

The discrepancies are "a very interesting question," Genzel agrees. It's unclear what about the teams' distinct methods of measurement and analysis leads to them. Since the researchers construct their frameworks of S2's orbit using data spanning multiple decades and instrument capabilities, there are a lot of aspects to check.

While the discrepancies aren't an issue for the redshift measurement, whatever underlies the small differences *will* matter for the next step in using the galactic center's stars to test GR: looking for precession. Due to the vagaries of warped spacetime, S2 shouldn't come back to the exact same spot when it completes an orbit. Instead, it'll precess, drawing out a Spirograph-like pattern around the black hole as it finishes each 16-year lap. Explaining how much Mercury's orbit precesses around the Sun was one of the original selling points for GR; now, astronomers want to see if the physics works the same way in the most extreme gravitational environments we can probe. Detecting the precession is a far more challenging measurement that ups the ante on precision. The teams may have results on that front within a year or so.

References:

T. Do et al. "Relativistic Redshift of the Star S0-2 Orbiting the Galactic Center Supermassive Black Hole." *Science*. August 16, 2019 (announced July 25, 2019).

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Source: Sky and Telescope Return to Contents

Space Image of the Week

M82: Galaxy with a Supergalactic Wind

Image Credit: NASA, ESA, Hubble; Processing & Copyright: Daniel Nobre

Explanation: Why is the Cigar Galaxy billowing red smoke? M82, as this starburst galaxy is also known, was stirred up by a recent pass near large spiral galaxy M81. This doesn't fully explain the source of the red-glowing outwardly expanding gas and dust, however. Evidence indicates that this gas and dust is being driven out by the combined emerging particle winds of many stars, together creating a galactic superwind. The dust particles are thought to originate in M82's interstellar medium and are actually similar in size to particles in cigar smoke.

The featured photographic mosaic highlights a specific color of red light strongly emitted by ionized hydrogen gas, showing detailed filaments of this gas and dust. The filaments extend for over 10,000 light years. The 12-million light-year distant Cigar Galaxy is the brightest galaxy in the sky in infrared light, and can be seen in visible light with a small telescope towards the constellation of the Great Bear (Ursa Major).

Source: NASA APOD

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