Space News Update

— August 23, 2019 —

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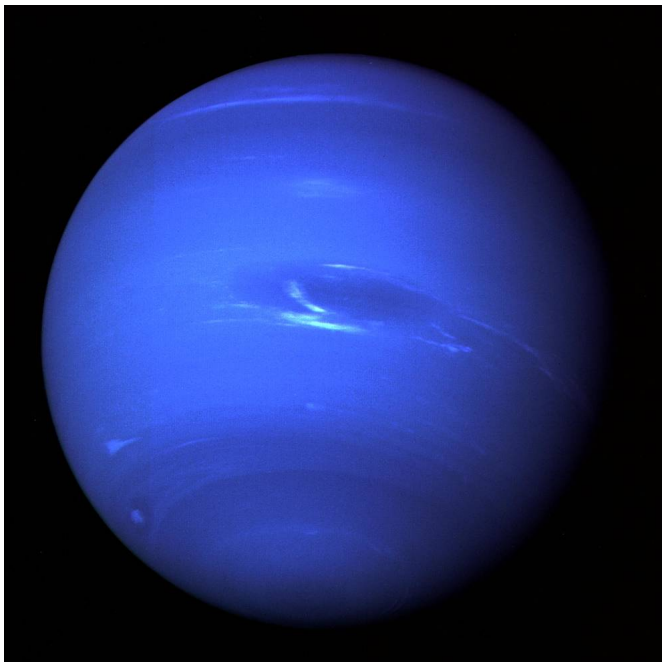
1. 30 Years Ago: Voyager 2's Historic Neptune Flyby



Thirty years ago, on Aug. 25, 1989, NASA's Voyager 2 spacecraft made a close flyby of Neptune, giving humanity its first close-up of our solar system's eighth planet. Marking the end of the Voyager mission's Grand Tour of the solar system's four giant planets — Jupiter, Saturn, Uranus and Neptune — that first was also a last: No other spacecraft has visited Neptune since.

"The Voyager planetary program really was an opportunity to show the public what science is all about," said Ed Stone, a professor of physics at Caltech and Voyager's project scientist since 1975. "Every day we learned something new."

Wrapped in teal- and cobalt-colored bands of clouds, the planet that Voyager 2 revealed looked like a blue-hued sibling to Jupiter and Saturn, the blue indicating the presence of methane. A massive, slate-colored storm was dubbed the "Great Dark Spot," similar to Jupiter's Great Red Spot. Six new moons and four rings were discovered.

During the encounter, the engineering team carefully changed the probe's direction and speed so that it could do a close flyby of the planet's largest moon, Triton. The flyby showed evidence of geologically young surfaces and active geysers spewing material skyward. This indicated that Triton was not simply a solid ball of ice, even though it had the lowest surface temperature of any natural body observed by Voyager: minus 391 degrees Fahrenheit (minus 235 degrees Celsius).

The conclusion of the Neptune flyby marked the beginning of the Voyager Interstellar Mission, which continues today, 42 years after launch. Voyager 2 and its twin, Voyager 1 (which had also flown by Jupiter and Saturn), continue to send back dispatches from the outer reaches of our solar system. At the time of the Neptune encounter, Voyager 2 was about 2.9 billion miles (4.7 billion kilometers) from Earth; today it is 11 billion miles (18 billion kilometers) from us. The faster-moving Voyager 1 is 13 billion miles (21 billion kilometers) from Earth.

Getting There

By the time Voyager 2 reached Neptune, the Voyager mission team had completed five planetary encounters. But the big blue planet still posed unique challenges.

About 30 times farther from the Sun than Earth is, the icy giant receives only about 0.001 times the amount of sunlight that Earth does. In such low light, Voyager 2's camera required longer exposures to get quality images. But because the spacecraft would reach a maximum speed of about 60,000 mph (90,000 kph) relative to Earth, a long exposure time would make the image blurry. (Imagine trying to take a picture of a roadside sign from the window of a speeding car.)

So the team programmed Voyager 2's thrusters to fire gently during the close approach, rotating the spacecraft to keep the camera focused on its target without interrupting the spacecraft's overall speed and direction.

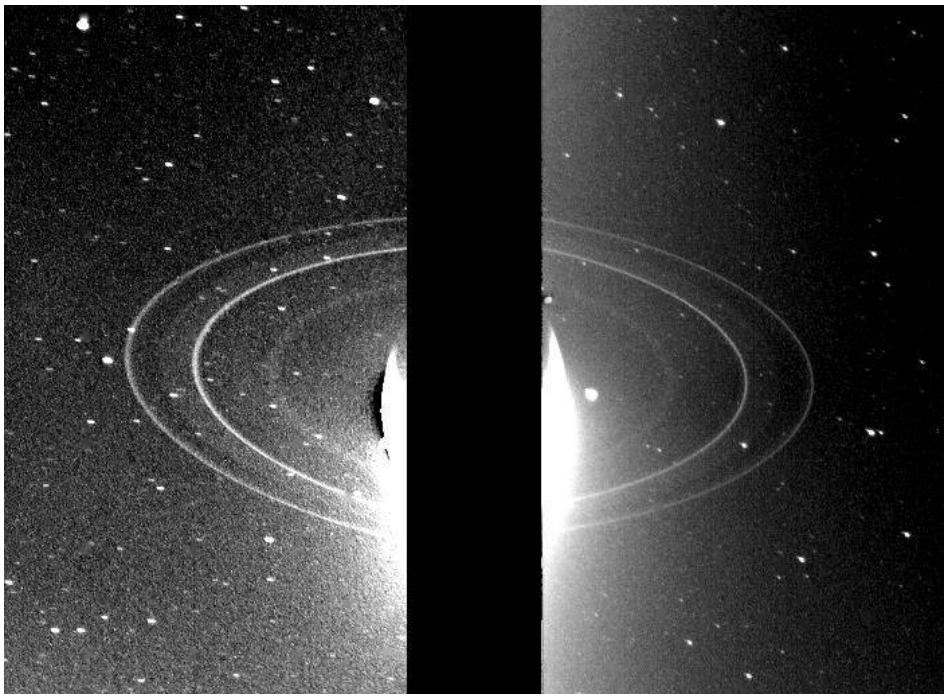
The probe's great distance also meant that by the time radio signals from Voyager 2 reached Earth, they were weaker than those of other flybys. But the spacecraft had the advantage of time: The Voyagers communicate with Earth via the Deep Space Network, or DSN, which utilizes radio antennas at sites in Madrid, Spain; Canberra, Australia; and Goldstone, California. During Voyager 2's Uranus encounter in 1986, the three largest DSN antennas were 64-meters (210 feet) wide. To assist with the Neptune encounter, the DSN expanded the dishes to 70 meters (230 feet). They also included nearby non-DSN antennas to collect data, including another 64-meter (210 feet) dish in Parkes, Australia, and multiple 25-meter (82 feet) antennas at the Very Large Array in New Mexico.

The effort ensured that engineers could hear Voyager loud and clear. It also increased how much data could be sent back to Earth in a given period, enabling the spacecraft to send back more pictures from the flyby.

Being There

In the week leading up to that August 1989 close encounter, the atmosphere was electric at NASA's Jet Propulsion Laboratory in Pasadena, California, which manages the Voyager mission. As images taken by Voyager 2 during its Neptune approach made the four-hour journey to Earth, Voyager team members would crowd around computer monitors around the Lab to see.

"One of the things that made the Voyager planetary encounters different from missions today is that there was no internet that would have allowed the whole team and the whole world to see the pictures at the same time," Stone said. "The images were available in real time at a limited number of locations."



But the team was committed to giving the public updates as quickly as possible, so from Aug. 21 to Aug. 29, they would share their discoveries with the world during daily press conferences. On Aug. 24, a program called "Voyager All Night" broadcast regular updates from the probe's closest encounter with the planet, which took place at 4 a.m. GMT (9 p.m. in California on Aug. 24).

The next morning, Vice President Dan Quayle visited the Lab to commend the Voyager team. That night, Chuck Berry, whose song "Johnny B. Goode" was included on the Golden Record that flew with both Voyagers, played at JPL's celebration of the feat.

Of course, the Voyagers' achievements extend far beyond that historic week three decades ago. Both probes have now entered interstellar space after exiting the heliosphere — the protective bubble around the planets created by a high-speed flow of particles and magnetic fields spewed outward by our Sun.

They are reporting back to Earth on the "weather" and conditions from this region filled with the debris from stars that exploded elsewhere in our galaxy. They have taken humanity's first tenuous step into the cosmic ocean where no other operating probes have flown.

Voyager data also complement other missions, including NASA's Interstellar Boundary Explorer (IBEX), which is remotely sensing that boundary where particles from our Sun collide with material from the rest of the galaxy. And NASA is preparing the Interstellar Mapping and Acceleration Probe (IMAP), due to launch in 2024, to capitalize on Voyager observations.

The Voyagers send their findings back to DSN antennas with 13-watt transmitters — about enough power to run a refrigerator light bulb.

"Every day they travel somewhere that human probes have never been before," said Stone. "Forty-two years after launch, and they're still exploring."

For more information about the Voyager mission visit: https://voyager.jpl.nasa.gov/

Source: NASA Return to Contents

2. Nuclear Propulsion Could Be 'Game-Changer' for Space Exploration, NASA Chief Says

Humanity's next giant leap could be enabled by next-gen nuclear tech, NASA Administrator Jim Bridenstine said.

During the sixth meeting of the National Space Council (NSC) today (Aug. 20), the NASA chief lauded the potential of nuclear thermal propulsion, which would harness the heat thrown off by fission reactions to accelerate propellants such as hydrogen to tremendous speeds.

Spacecraft powered by such engines could conceivably reach Mars in just three to four months — about half the time of the fastest possible trip in a vehicle with traditional chemical propulsion, said NSC panelist Rex Geveden, the president and CEO of BWX Technologies Inc.

And that's a big deal for NASA, which is working to get astronauts to Mars in the 2030s.

"That is absolutely a game-changer for what NASA is trying to achieve," Bridenstine said. "That gives us an opportunity to really protect life, when we talk about the radiation dose when we travel between Earth and Mars."

That dose increases, of course, the longer astronauts spend in deep space, away from the protective bubble of Earth's magnetosphere. And recent research suggests that the radiation dose accumulated by Mars-bound astronauts could damage their brains, affecting their moods as well as their ability to learn and remember.

Bridenstine also stressed the utility of nuclear thermal propulsion for applications closer to home. For example, the increased power could potentially allow Earth-orbiting craft to steer out of the line of fire of anti-satellite weapons, he said.

Such weapons are being developed by both China and Russia, Joseph Maguire, the U.S. acting Director of National Intelligence, said during the NSC meeting today.

"Both countries view the capability to attack space systems and services as part of their broader efforts to deter or defeat an adversary in combat," Maguire said. "In short, the threat to U.S. and allied space systems continues to grow unabated."

In the national-security realm, Geveden said that small fission reactors could also provide off-grid power for forward and remote military bases.

"You certainly can imagine using a compact, high-temperature gas reactor to power a directed-energy weapon, for example," Geveden said. "[The U.S. is] using diesel fuel now, but that's not sustainable over a sustained battle."

This reference to high-powered lasers caught Bridenstine's attention. He asked Geveden if such tech could be used to deflect an incoming asteroid and to deorbit space junk. The potential is definitely there in both cases, Geveden replied.

Bridenstine then turned to Vice President Mike Pence, who chairs the NSC. "I think, Mr. Vice President, there's an amazing opportunity here that the United States of America should take advantage of," Bridenstine said.

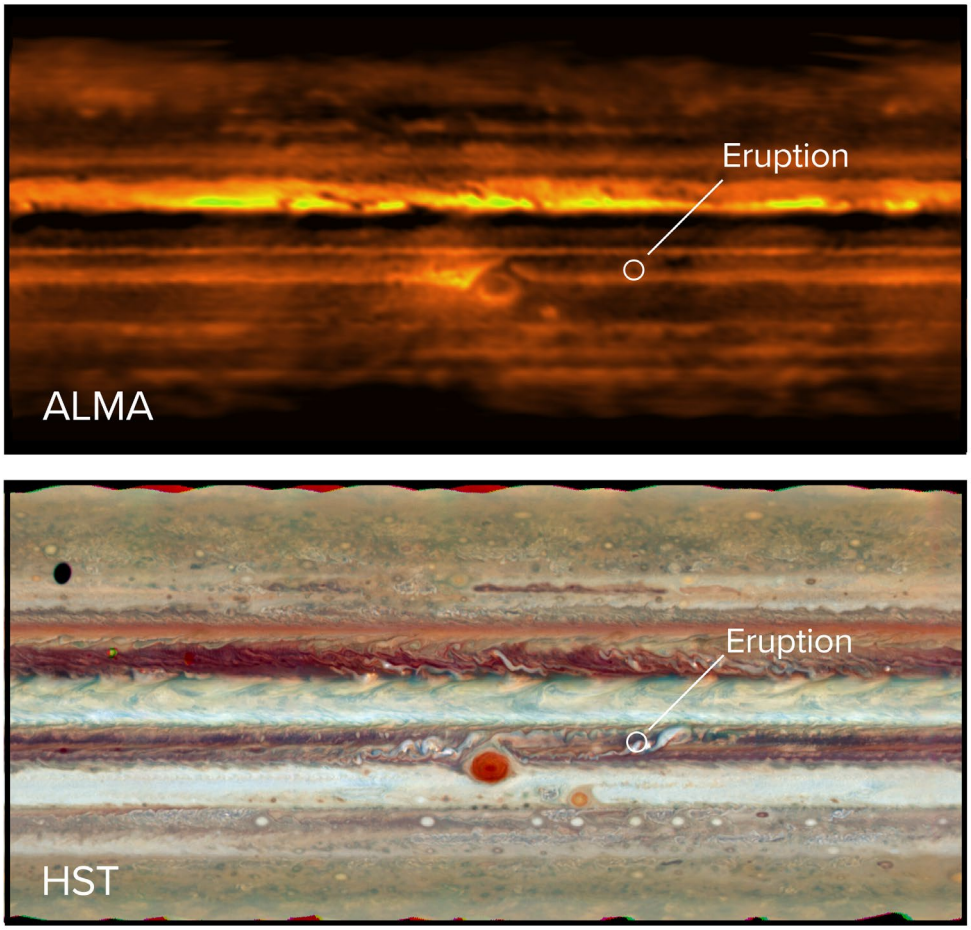
The nation may already be on that path. In May, the House Appropriations Committee approved a bill that allocates $22.3 billion to NASA — including $125 million to develop nuclear thermal propulsion tech. Congress also provided $100 million for the same purpose in fiscal year 2019.

Nuclear thermal propulsion is not to be confused with radioisotope thermoelectric generator (RTG) tech. RTGs convert the heat generated by the radioactive decay of plutonium into electricity, which then powers spacecraft instruments and other gear. NASA has been using RTGs for decades; they've powered some of the agency's most famous planetary explorers, including the twin Voyager probes, the Cassini Saturn spacecraft and the Curiosity Mars rover.

Other nuclear tech could aid exploration in the future as well. For example, researchers are developing a small fission reactor that could power crewed outposts on the moon and Mars. This "Kilopower reactor" could be ready for a flight demonstration in 2022 if NASA so desires, project team members said recently.

Source: Space.com Return to Contents

3. Storms on Jupiter are disturbing the planet's colorful belts



Storm clouds rooted deep in Jupiter's atmosphere are affecting the planet's white zones and colorful belts, creating disturbances in their flow and even changing their color.

Thanks to coordinated observations of the planet in January 2017 by six ground-based optical and radio telescopes and NASA's Hubble Space Telescope, a University of California, Berkeley, astronomer and her colleagues have been able to track the effects of these storms—visible as bright plumes above the planet's ammonia ice clouds—on the belts in which they appear.

The observations will ultimately help planetary scientists understand the complex atmospheric dynamics on Jupiter, which, with its Great Red Spot and colorful, layer cake-like bands, make it one of the most beautiful and changeable of the giant gas planets in the solar system.

One such plume was noticed by amateur astronomer Phil Miles in Australia a few days before the first observations by the Atacama Large Millimeter/Submillimeter Array (ALMA) in Chile, and photos captured a week later by Hubble showed that the plume had spawned a second plume and left a downstream disturbance in the band of clouds, the South Equatorial Belt. The rising plumes then interacted with Jupiter's powerful winds, which stretched the clouds east and west from their point of origin.

Three months earlier, four bright spots were seen slightly north of the North Equatorial Belt. Though those plumes had disappeared by 2017, the belt had since widened northward, and its northern edge had changed color from white to orangish brown.

"If these plumes are vigorous and continue to have convective events, they may disturb one of these entire bands over time, though it may take a few months," said study leader Imke de Pater, a UC Berkeley professor emerita of astronomy. "With these observations, we see one plume in progress and the aftereffects of the others."

The analysis of the plumes supports the theory that they originate about 80 kilometers below the cloud tops at a place dominated by clouds of liquid water. A paper describing the results has been accepted for publication in the *Astronomical Journal* and is now online.

Into the stratosphere

Jupiter's atmosphere is mostly hydrogen and helium, with trace amounts of methane, ammonia, hydrogen sulfide and water. The top-most cloud layer is made up of ammonia ice and comprises the brown belts and white zones we see with the naked eye. Below this outer cloud layer sits a layer of solid ammonium hydrosulfide particles. Deeper still, at around 80 kilometers below the upper cloud deck, is a layer of liquid water droplets.

The storm clouds de Pater and her team studied appear in the belts and zones as bright plumes and behave much like the cumulonimbus clouds that precede thunderstorms on Earth. Jupiter's storm clouds, like those on Earth, are often accompanied by lightning.

Optical observations cannot see below the ammonia clouds, however, so de Pater and her team have been probing deeper with radio telescopes, including ALMA and also the Very Large Array (VLA) in New Mexico, which is operated by the National Science Foundation-funded National Radio Astronomy Observatory.

ALMA array's first observations of Jupiter were between Jan. 3 and 5 of 2017, a few days after one of these bright plumes was seen by amateur astronomers in the planet's South Equatorial Belt. A week later, Hubble, the VLA, the Gemini, Keck and Subaru observatories in Hawaii and the Very Large Telescope (VLT) in Chile captured images in the visible, radio and mid-infrared ranges.

De Pater combined the ALMA radio observations with the other data, focused specifically on the newly brewed storm as it punched through the upper deck clouds of ammonia ice.

The data showed that these storm clouds reached as high as the tropopause—the coldest part of the atmosphere—where they spread out much like the anvil-shaped cumulonimbus clouds that generate lightning and thunder on Earth.

"Our ALMA observations are the first to show that high concentrations of ammonia gas are brought up during an energetic eruption," de Pater said.

The observations are consistent with one theory, called moist convection, about how these plumes form. According to this theory, convection brings a mix of ammonia and water vapor high enough—about 80 kilometers below the cloud tops—for the water to condense into liquid droplets. The condensing water releases heat that expands the cloud and buoys it quickly upward through other cloud layers, ultimately breaking through the ammonia ice clouds at the top of the atmosphere.

The plume's momentum carries the supercooled ammonia cloud above the existing ammonia-ice clouds until the ammonia freezes, creating a bright, white plume that stands out against the colorful bands encircling Jupiter.

"We were really lucky with these data, because they were taken just a few days after amateur astronomers found a bright plume in the South Equatorial Belt," said de Pater. "With ALMA, we observed the whole planet and saw that plume, and since ALMA probes below the cloud layers, we could actually see what was going on below the ammonia clouds."

Hubble took images a week after ALMA and captured two separate bright spots, which suggests that the plumes originate from the same source and are carried eastward by the high altitude jet stream, leading to the large disturbances seen in the belt.

Coincidentally, three months before, bright plumes had been observed north of the Northern Equatorial Belt. The January 2017 observations showed that that belt had expanded in width, and the band where the plumes had first been seen turned from white to orange. De Pater suspects that the northward expansion of the North Equatorial Belt is a result of gas from the ammonia-depleted plumes falling back into the deeper atmosphere.

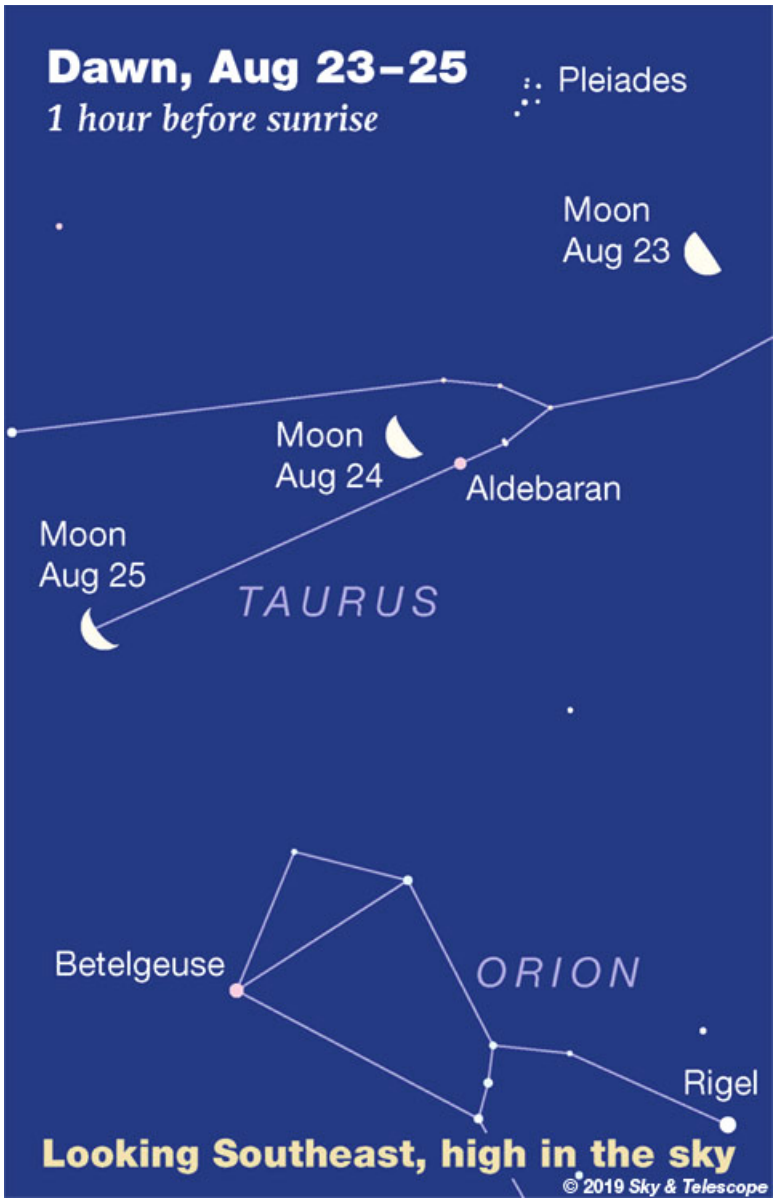
De Pater's colleague and co-author Robert Sault of the University of Melbourne in Australia used special computer software to analyze the ALMA data to obtain radio maps of the surface that are comparable to visible-light photos taken by Hubble.

"Jupiter's rotation once every 10 hours usually blurs radio maps, because these maps take many hours to observe," Sault said. "In addition, because of Jupiter's large size, we had to 'scan' the planet, so we could make a large mosaic in the end. We developed a technique to construct a full map of the planet."

Source: Phys.org Return to Contents

The Night Sky

Friday, August 23



• Last-quarter Moon; exactly so at 10:56 a.m. on this date. The Moon rises tonight around midnight (depending on your location), below the Pleiades. Accompanying the Moon will be orange Aldebaran. By the beginning of dawn on Saturday morning the 24th they stand high in the southeast, as shown here.

Saturday, August 24

• In the early-morning hours of Sunday the 25th, the waning Moon is quite close to 3rd-magnitude Zeta Tauri, one of the Taurus horn-tips, as indicated here. The Moon's bright limb occults the star for the western US and Mexico before or during dawn. Zeta's reappearance from behind the dark limb, up to an hour or more later, will be much easier to witness in a scope or even binoculars. In these detailed timetables, scroll about 40% of the way down for the beginning of the Reappearance timetable. ("CA" under Location means Canada.)

Sunday, August 25

• Jupiter's Great Red Spot should cross the planet's central meridian tonight around 11:37 p.m. EDT; 8:37 p.m. PDT.

Then 46 minutes later, watch Ganymede disappear behind Jupiter's preceding limb.

Monday, August 26

• Whenever bright Vega crosses nearest your zenith, as it does at nightfall now, you know that the Sagittarius Teapot must be at its highest due south even if it's hidden by buildings or trees. The Teapot is currently marked by Saturn.

Two hours later when Deneb crosses closest to the zenith, it's the turn of Delphinus and boat-shaped Capricornus down below to stand at their highest due south.

Tuesday, August 27

• August is prime Milky Way time now that the Moon is out of the evening sky. Once twilight fully ends, the Milky Way runs from Sagittarius in the south, up and left across Aquila and through the big Summer Triangle overhead, and on down through Cassiopeia to Perseus in the northeast.

Source: Sky & Telescope

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ISS Sighting Opportunities

For Denver:

Date	Visible	Max Height	Appears	Disappears
Mon Aug 26, 5:21 AM	4 min	25°	11° above S	20° above E
Tue Aug 27, 4:33 AM	3 min	14°	12° above SSE	10° above E

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

NASA-TV Highlights

(all times Eastern Daylight Time)

August 24, Saturday
12:45 a.m. – Coverage of the docking of the unpiloted Soyuz MS-14 spacecraft to the International Space Station; docking scheduled at 1:31 a.m. ET (All Channels)

August 26, Monday
6:45 a.m.-7:15 a.m. – International Space Station Expedition 60 in-flight Interviews with NASA astronaut Christina Koch (All Channels)

August 27, Tuesday
10:15 a.m. – Coverage of the release of the SpaceX/Dragon CRS-18 cargo craft from the International Space Station; release scheduled at 10:42 a.m. EDT (All Channels)

Watch NASA TV on the Net by going to the NASA website.

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Space Calendar

- Aug 23 - Asteroid 21 Lutetia Occults UCAC5 447-000892 (12.0 Magnitude Star)
- Aug 23 - Asteroid 3635 Kreutz Closest Approach To Earth (1.032 AU)
- Aug 23 - Asteroid 3494 Purple Mountain Closest Approach To Earth (1.066 AU)
- Aug 23 - Asteroid 25399 Vonnegut Closest Approach To Earth (1.820 AU)
- Aug 23 - Asteroid 70713 Sethmacfarlane Closest Approach To Earth (1.912 AU)
- Aug 24 - Venus Passes 0.3 Degrees From Mars
- Aug 24 - Comet P/2013 TL117 At Opposition (3.404 AU)
- Aug 24 - Comet 94P/Russell At Opposition (3.716 AU)
- Aug 24 - Apollo Asteroid 162173 Ryugu Closest Approach To Earth (1.566 AU)
- Aug 24 - Asteroid 203 Pompeja Closest Approach To Earth (1.684 AU)
- Aug 24 - Asteroid 8734 Warner Closest Approach To Earth (1.783 AU)
- Aug 24 - Jupiter Trojan 911 Agamemnon At Opposition (4.239 AU)
- Aug 24 - Anna Lee Fisher's 70th Birthday (1949)
- Aug 24 - Greg Jarvis' 75th Birthday (1944)
- Aug 25 - Northern Iota Aquarids Meteor Shower Peak
- Aug 25 - Comet P/2015 X6 (PANSTARRS) Closest Approach To Earth (1.833 AU)
- Aug 25 - Comet C/2019 LB7 (Kleyna) Closest Approach To Earth (1.950 AU)
- Aug 25 - Comet 180P/NEAT At Opposition (3.957 AU)
- Aug 25 - NEW [Aug 23] Apollo Asteroid 2019 QQ Near-Earth Flyby (0.026 AU)
- Aug 25 - Aten Asteroid 2003 YG136 Near-Earth Flyby (0.051 AU)
- Aug 25 - Aten Asteroid 66146 (1998 TU3) Near-Earth Flyby (0.074 AU)
- Aug 25 - Asteroid 28600 Georgelucas Closest Approach To Earth (1.042 AU)
- Aug 25 - Asteroid 1284 Latvia Closest Approach To Earth (1.574 AU)
- Aug 25 - Jupiter Trojan 2797 Teucer At Opposition (4.548 AU)
- Aug 25 - 30th Anniversary (1989), Voyager 2, Neptune Flyby
- Aug 25 - Vincenzo Silvano Casulli's 75th Birthday (1944)
- Aug 25 - Ron Greeley's 80th Birthday (1939)
- Aug 26 - Amor Asteroid 2016 PD1 Near-Earth Flyby (0.029 AU)
- Aug 26 - Apollo Asteroid 2015 TY237 Near-Earth Flyby (0.086 AU)
- Aug 26 - Apollo Asteroid 2005 QQ87 Near-Earth Flyby (0.091 AU)
- Aug 26 - Atira Asteroid 413563 (2005 TG45) Closest Approach To Earth (0.822 AU)
- Aug 26 - Asteroid 21459 Chrisrussell Closest Approach To Earth (1.048 AU)
- Aug 26 - Asteroid 11246 Orvillewright Closest Approach To Earth (1.082 AU)
- Aug 26 - Asteroid 224693 Morganfreeman Closest Approach To Earth (1.935 AU)
- Aug 27 - HOT [Aug 20] CRS-18 Dragon Capsule Returns to Earth
- Aug 27 - Comet 322P/SOHO Closest Approach To Earth (0.883 AU)
- Aug 27 - Comet 36P/Whipple Closest Approach To Earth (2.325 AU)
- Aug 27 - NEW [Aug 23] Apollo Asteroid 2019 QR Near-Earth Flyby (0.030 AU)
- Aug 27 - Aten Asteroid 2002 JR100 Near-Earth Flyby (0.050 AU)
- Aug 27 - Apollo Asteroid 153814 (2001 WN5) Near-Earth Flyby (0.098 AU)
- Aug 27 - Asteroid 274301 Wikipedia Closest Approach To Earth (1.031 AU)
- Aug 27 - Asteroid 13010 Germantitov Closest Approach To Earth (2.216 AU)
- Aug 27 - 20th Anniversary (1999), Discovery of Salty Water in Monahans Meteorite

Source: JPL Space Calendar

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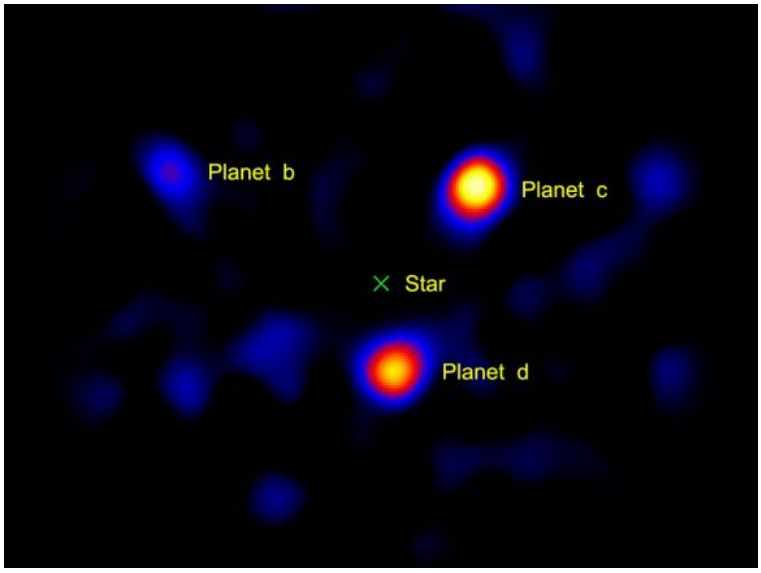
Food for Thought

Earth is an Exoplanet to Aliens. This is What They'd See



The study of exoplanets has matured considerably in the last ten years. During this time, the majority of the over 4000 exoplanets that are currently known to us were discovered. It was also during this time that the process has started to shift from the process of discovery to characterization. What's more, next-generation instruments will allow for studies that will reveal a great deal about the surfaces and atmospheres of exoplanets.

This naturally raises the question: what would a sufficiently-advanced species see if they were studying our planet? Using multi-wavelength data of Earth, a team of Caltech scientists was able to construct a map of what Earth would look like to distant alien observers. Aside from addressing the itch of curiosity, this study could also help astronomers reconstruct the surface features of "Earth-like" exoplanets in the future.

The study that describes the team's findings, titled "Earth as an Exoplanet: A Two-dimensional Alien Map", recently appeared in the journal *Science Mag* and is scheduled for publication in *The Astrophysical Journal Letters*. The study was led by Siteng Fan and included multiple researchers from the California Institute of Technology's Division of Geological and Planetary Sciences (GPS) and the NASA Jet Propulsion Laboratory.

When looking for potentially habitable planets beyond our Solar System, scientists are forced to take the indirect approach. Given that most exoplanets cannot be observed directly to learn of their atmospheric composition or surface features (aka. Direct Imaging), scientists must be satisfied with indications that show how "Earth-like" a planet is.

As Fan told Universe Today via email, this reflects the limitations that astronomers and exoplanet studies are currently forced to contend with:

"Firstly, current exoplanet studies have not figured out what the least requirements are for habitability. There are some proposed criterions, but we are not sure if they are either sufficient or necessary. Secondly, even with these criterions, current observation techniques are not good enough to confirm the habitability, especially on Earth-like exoplanets due to the difficulty of detecting and constraining them."

Given that Earth is the only planet we know of that is capable of supporting life, the team theorized that remote observations of Earth could act as a proxy for a habitable exoplanet as observed by a distant civilization. "Earth is the only planet we know that contains life," said Fan. "Studying what the Earth looks like to distant observers would give us the direction of how to find potential habitable exoplanets."

One of the most important elements of Earth's climate (and which is critical to all life on its surface) is the water cycle, which has three distinct phases. These include the presence of water vapor in the atmosphere, clouds of condensed water and ice particles, and the presence of bodies of water on the surface.

Therefore, the presence of these could be considered potential indications of habitability and even indications of life (aka. biosignatures) that could be observed from a distance. Ergo, being able to identify surface features and clouds on exoplanets would be essential in order to place constraints on their habitability.

To determine what Earth would look like to distant observers, the team compiled 9740 images of Earth that were taken by NASA's Deep Space Climate Observatory (DSCOVR) satellite. The images were taken every 68 to 110 minutes over a two year period (2016 and 2017) and managed to capture light reflected from Earth's atmosphere at multiple wavelengths.

Fan and his colleagues then combined the images to form a 10-point reflection spectrum plotted over time, which were then integrated over the Earth's disk. This effectively reproduced what Earth might look like to an observer many light-years away if they were to observe Earth over a two year period.

"We found that the second principal component of Earth's light curve is strongly correlated to the land fraction of the illuminated hemisphere (r^2=0.91)," Fan said. "Combining with the viewing geometry, reconstructing the map becomes a linear regression problem."

After analyzing the resulting curves and comparing them with the original images, the research team discovered which parameters of the curves corresponded to land and cloud cover. They then picked out the parameters that most closely related to land area and adjusted it to the 24-hour rotation of the Earth, which gave them a contoured map (shown above) that represented what Earth's light curve would look like from light years away.

The black lines represent the surface feature parameter and correspond roughly to the coastlines of the major continents. These are further colored in green to provide a rough representation of Africa (center), Asia (top right), North and South America (left), and Antarctica (bottom). What lies in between represents the Earth's oceans, with the shallower sections denoted in red and the deeper ones in blue.

These kinds of representations, when applied to the light curves of distant exoplanets, could allow astronomers to assess whether an exoplanet has the oceans, clouds, and icecaps – all necessary elements of an "Earth-like" (aka. habitable) exoplanet. As Fan concluded:

"The analysis of light curves in this work have implications for determining geological features and climate systems on exoplanet. We found that the variation of light curve of Earth is dominated by clouds and land/ocean, which are both crucial to the life on Earth. Therefore, Earth-like exoplanets which harbor this kind of features would be more likely to host life."

In the near-future, next-generation instruments like the *James Webb Space Telescope* (JWST) will allow for the most detailed exoplanet surveys to date. In addition, ground-based instruments that are coming online in the next decade – like the *Extremely Large Telescope*(ELT), the *Thirty Meter Telescope* (TMT), and the *Giant Magellan Telescope* (GMT) – are expected to enable direct imaging studies of smaller, rocky planets that orbit closer to their stars.

Aided by studies that help to resolve surface features and atmospheric conditions, astronomers may be finally able to say with confidence which exoplanets are habitable and which ones aren't. With luck, the discovery of an Earth 2.0 (or several Earths for that matter) could be right around the corner!

Source: Universe Today Return to Contents

Space Image of the Week

Hubble Captures Dynamic Dying Star

This atmospheric image taken with the NASA/ESA Hubble Space Telescope shows a dark, gloomy scene in the constellation of Gemini (the Twins). The subject of this image confused astronomers when it was first studied — rather than being classified as a single object, it was instead recorded as two objects, owing to its symmetrical lobed structure (known as NGC 2371 and NGC 2372, though sometimes referred to together as NGC 2371/2).

These two lobes are visible to the lower left and upper right of the frame, and together form something known as a planetary nebula. Despite the name, such nebulas have nothing to do with planets; NGC 2371/2 formed when a Sun-like star reached the end of its life and blasted off its outer layers, shedding the constituent material and pushing it out into space to leave just a superheated stellar remnant behind. This remnant is visible as the bright star at the center of the frame, sitting neatly between the two lobes.

The structure of this region is complex. It is filled with dense knots of gas, fast-moving jets that appear to be changing direction over time, and expanding clouds of material streaming outwards on diametrically opposite sides of the remnant star. Patches of this scene glow brightly as the remnant star emits energetic radiation that excites the gas within these regions, causing it to light up. This scene will continue to change over the

next few thousand years. Eventually the knotty lobes will dissipate completely, and the remnant star will cool and dim to form a white dwarf.

Source: NASA Return to Contents