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When it comes to the distant universe, even the keen vision of NASA's Hubble Space Telescope can only go so far. Teasing out finer details requires clever thinking and a little help from a cosmic alignment with a gravitational lens.

By applying a new computational analysis to a galaxy magnified by a gravitational lens, astronomers have obtained images 10 times sharper than what Hubble could achieve on its own. The results show an edge-on disk galaxy studded with brilliant patches of newly formed stars.

"When we saw the reconstructed image we said, 'Wow, it looks like fireworks are going off everywhere,'" said astronomer Jane Rigby of NASA's Goddard Space Flight Center in Greenbelt, Maryland.

The galaxy in question is so far away that we see it as it appeared 11 billion years ago, only 2.7 billion years after the big bang. It is one of more than 70 strongly lensed galaxies studied by the Hubble Space Telescope, following up targets selected by the Sloan Giant Arcs Survey, which discovered hundreds of strongly lensed galaxies by searching Sloan Digital Sky Survey imaging data covering one-fourth of the sky.

The gravity of a giant cluster of galaxies between the target galaxy and Earth distorts the more distant galaxy's light, stretching it into an arc and also magnifying it almost 30 times. The team had to develop special computer code to remove the distortions caused by the gravitational lens, and reveal the disk galaxy as it would normally appear.
The resulting reconstructed image revealed two dozen clumps of newborn stars, each spanning about 200 to 300 light-years. This contradicted theories suggesting that star-forming regions in the distant, early universe were much larger, 3,000 light-years or more in size.

"There are star-forming knots as far down in size as we can see," said doctoral student Traci Johnson of the University of Michigan, lead author of two of the three papers describing the research.

Without the magnification boost of the gravitational lens, Johnson added, the disk galaxy would appear perfectly smooth and unremarkable to Hubble. This would give astronomers a very different picture of where stars are forming.

While Hubble highlighted new stars within the lensed galaxy, NASA’s James Webb Space Telescope will uncover older, redder stars that formed even earlier in the galaxy’s history. It will also peer through any obscuring dust within the galaxy.

"With the Webb Telescope, we’ll be able to tell you what happened in this galaxy in the past, and what we missed with Hubble because of dust," said Rigby.


The Hubble Space Telescope is a project of international cooperation between NASA and the European Space Agency. NASA's Goddard Space Flight Center in Greenbelt, Maryland, manages the telescope. The Space Telescope Science Institute (STScI) in Baltimore, Maryland, conducts Hubble science operations. STScI is operated for NASA by the Association of Universities for Research in Astronomy in Washington, D.C.

Source: NASA
2. New Mysteries Surround New Horizons’ Next Flyby Target

NASA’s New Horizons spacecraft doesn’t zoom past its next science target until New Year’s Day 2019, but the Kuiper Belt object, known as 2014 MU69, is already revealing surprises.

Scientists have been sifting through data gathered from observing the object’s quick pass in front of a star—an astronomical event known as an occultation—on June 3. More than 50 mission team members and collaborators set up telescopes across South Africa and Argentina, along a predicted track of the narrow shadow of MU69 that the occultation would create on Earth’s surface, aiming to catch a two-second glimpse of the object’s shadow as it raced across the Earth. Accomplishing the observations of that occultation was made possible with the help of NASA’s Hubble Space Telescope and Gaia, a space observatory of the European Space Agency (ESA).

Combined, the pre-positioned mobile telescopes captured more than 100,000 images of the occultation star that can be used to assess the environment around this Kuiper Belt object (KBO). While MU69 itself eluded direct detection, the June 3 data provided valuable and unexpected insights that have already helped New Horizons.

“These data show that MU69 might not be as dark or as large as some expected,” said occultation team leader Marc Buie, a New Horizons science team member from Southwest Research Institute (SwRI) in Boulder, Colorado.

Initial estimates of MU69’s diameter, based primarily on data taken by the Hubble Space Telescope since the KBO’s discovery in 2014, fall in the 12-25-mile (20-40-kilometer) range—though data from this summer’s ground-based occultation observations might imply it’s at or even below the smallest sizes expected before the June 3 occultation.
Besides MU69’s size, the readings offer details on other aspects of the Kuiper Belt object.

“These results are telling us something really interesting,” said New Horizons Principal Investigator Alan Stern, of SwRI. “The fact that we accomplished the occultation observations from every planned observing site but didn’t detect the object itself likely means that either MU69 is highly reflective and smaller than some expected, or it may be a binary or even a swarm of smaller bodies left from the time when the planets in our solar system formed.”

More data are on the way, with additional occultations of MU69 occurring on July 10 and July 17. On July 10, NASA’s airborne Stratospheric Observatory for Infrared Astronomy (SOFIA) will use its powerful 100-inch (2.5-meter) telescope to probe the space around MU69 for debris that might present a hazard to New Horizons as it flies by in 18 months.

On July 17, the Hubble Space Telescope also will check for debris around MU69, while team members set up another groundbased “fence line” of small mobile telescopes along the predicted ground track of the occultation shadow in southern Argentina to try to better constrain, or even determine, the size of MU69.

Check out the star brightness, predicted shadow path and other tech specs for the July 10 and July 17 occultation events.

Source: NASA
3. How a Speck of Light Becomes an Asteroid

On the first day of the year 1801, Italian astronomer Gioacchino Giuseppe Maria Ubaldo Nicolò Piazzi found a previously uncharted “tiny star” near the constellation of Taurus. The following night Piazzi again observed this newfound celestial object, discovering that the speck had changed its position relative to the nearby stars. Piazzi knew that real stars were so far away that they never wandered -- that they always appeared in the sky as fixed in location relative to each other. Due to the movement of this new object, the astronomer to the king of the two Sicilies suspected he had discovered something much closer -- something within our solar system. Piazzi made history's first asteroid discovery. He named it after the Roman goddess for agriculture: Ceres.

While astronomers of Piazzi's era eventually understood there were many more small rocky bodies to be found, for decades after the Ceres discovery, asteroid detections were few and far between. Even a half-century after Ceres' detection, there were only 15 known asteroids. But as time marched on, so did astronomers' equipment, techniques and interest in hunting asteroids. By 1868 the number of known asteroids had reached 100. By 1923 it was 1,000. Today, it is more than half a million.

As a nod to the importance of these objects, the United Nations has declared June 30 International Asteroid Day.

Most asteroids are farther from the sun than Mars is -- more than 1.5 times farther from the sun than Earth's orbit is. Asteroids that come closer to the sun than about 1.3 times Earth's distance from the sun are called near-Earth asteroids. The term "near" in near-Earth asteroid is actually a bit of a misnomer, since most of these bodies do not come close to Earth at all. As of this month, more than 16,000 of them are known. Near-Earth asteroids and comets that come within the neighborhood of Earth's orbit are, together, classified as near-Earth objects, or NEOs.

Thanks to new technology, better search techniques and a team of professional and dedicated amateur astronomers hunting for them, the number of known NEOs expands by about five every night of the year.

Ever wonder how these small celestial objects are discovered?
"Just as in Piazzi's day, it usually starts with just a speck of light in an astronomer's telescope," said Paul Chodas, manager of the Center for Near-Earth Object Studies (CNEOS) at NASA's Jet Propulsion Laboratory in Pasadena, Calif. "Even with some of the most powerful optical telescopes on the planet tasked with hunting asteroids, they appear as mere specks of light in the sky because they are so small. When an astronomer finds a speck that is moving, that's when the fun begins."

The Planetary Defense Coordination Office at NASA Headquarters in Washington is responsible for finding, tracking and characterizing potentially hazardous asteroids, issuing warnings about possible impacts, and coordinating U.S. government planning for response to an actual impact threat. Almost always, a new asteroid detection is courtesy of telescopes that are sponsored by NASA.

The planetary defense office oversees the Near-Earth Object Observation Program, which in turn funds the Catalina Sky Survey in Arizona and the Panoramic Survey Telescope & Rapid Response System (Pan-STARRS) in Hawaii. Both projects upgraded their telescopes in 2015, significantly improving their asteroid and near-Earth object discovery rates.

"Telescopes funded by outside institutions and even some amateurs are also involved with NEO discovery and do other important asteroid-related work," said Chodas. "But, at present, Catalina and Pan-STARRS are our most powerful asteroid detection instruments. Between these two surveys, four telescopes in all, about 90 percent of all new NEO discoveries are made."

At the heart of each one of these survey telescopes is a hyper-upgraded version of the same kind of camera chip (called a CCD, or charge-coupled device) that is inside our cellphones. With the exception of nights that have too much rain or snow, or several nights surrounding a full moon (when moonlight can drown out the faint light of an asteroid), the dedicated observers of Catalina and Pan-STARRS open up their telescopes every night they can find a hole in the cloud cover and take 30-second exposure after 30-second exposure of the heavens above.

Survey astronomers are on the lookout for points of light that move relative to the more distant and fixed background stars. To find them, they take three or more images of the same region of the sky (called a field), separated by several minutes. On a good night a survey will take several hundred photos of the sky.

When survey astronomers find a point of light that appears to move across the same field in a series of images of the same region of the sky, they check it against the predicted positions of all the known objects in the catalog maintained by the NASA-sponsored Minor Planet Center (MPC) in Cambridge, Massachusetts. If the newfound, moving point of light does not match up with the predicted position and motion of an object in the MPC's database of known asteroids and comets, there is a good chance it's a new discovery -- but there is more work to be done.

Computers do much of this detection work, but a prudent astronomer also double checks the work, making sure the points of light are not some kind of reflection of a nearby star, or perhaps a faulty pixel on the CCD. If confident about the potential space-rock discovery, the astronomer ships the discovery's coordinates (known as the "astrometry") to the MPC's NEO Confirmation Page, where it is given a temporary identifier -- like YL9EOA0. The MPC also computes an initial (approximate) orbit for the still-to-be-confirmed NEO.

CNEOS has a system called Scout, which actively monitors the MPC confirmation page, getting the data from each potential new asteroid discovery and automatically computing the possible range of future motions even before these objects have been confirmed as discoveries.

"If our calculations indicate a new discovery could be coming close by Earth, we call in the reinforcements," said Chodas. "NASA has a worldwide network of astronomers who perform follow-up observations. They take the latest astrometry and try to find the new speck of light, too. If they do find it, they measure its coordinates
and send their follow-up astrometry back to the MPC, where it is added to a table of information about the object. This follow-up is extremely important. It really helps expand our understanding of a new discovery's orbit."

Usually it takes two to three nights of observations for enough information to be collected on a new discovery for the MPC to verify that a speck of light is indeed a near-Earth object. When that transformation occurs, the MPC removes it from its confirmation page and replaces its temporary tag with a more permanent name, which always starts out with the year it was discovered and then an alphanumeric code indicating the half-month of discovery and the sequence within that half-month. The MPC then generates a *Minor Planet Electronic Circular* which contains all known astrometry and the preliminary orbit of the object. The MPC announces the new asteroid discovery in an email to those who are interested in that sort of thing.

"We are interested all right," said Chodas. "And we stay interested even after a discovery is announced, because we are in the asteroid- and comet-hunting game for the long run. The more information we get on a celestial object -- new discovery or old -- the more we refine our knowledge of its orbit."

All the new orbits are automatically picked up by a computer system at JPL called Sentry, where all asteroid and comet orbits, including those with future close-Earth approaches, are calculated and impact probabilities are assessed daily.

"While NASA is leading the way in near-Earth object survey, we are not resting on our laurels," said Lindley Johnson, NASA's planetary defense officer. "New optical systems are coming on line, new computer programs are being created, and we are exploring new technologies both ground- and space-based that will further accelerate our discovery, characterization and orbital analysis of these potential threats."

Source:  [NASA](https://www.nasa.gov)
The Night Sky

Friday, July 7

• The nearly full Moon shines over the Sagittarius Teapot after dark tonight. Look carefully for the Teapot's stars through the moonlight. The Teapot is about the size of your fist at arm's length, with its handle to the left and its spout to the right. Binoculars may help.

Saturday, July 8

• The full Moon is low in the southeast as the stars come out. Look far to the Moon's upper left for Altair, and far to the Moon's upper right for Saturn.

Sunday, July 9

• The Big Dipper, still high in the northwest after dark, is turning around to "scoop up water" through the evenings of summer and early fall.

Monday, July 10

• In very early dawn Tuesday morning, you'll find Venus lined up with the Pleiades above it and Aldebaran below it.

Tuesday, July 11

• **Double stars in the top of Scorpius.** The two brightest points due south after twilight ends are Saturn and, right or lower right of it, Antares. To the right and upper right of Antares is the nearly vertical row of three stars marking the head of Scorpius. The top star of the row is Beta Scorpii or Graffias, a fine double star for telescopes.

Just 1° lower left of Beta Sco is the fainter, very wide naked-eye pair Omega¹ and Omega² Scorpii, oriented diagonally. Binoculars may show their slight color difference.

Upper left of Beta by 1.6° is Nu Scorpii, another fine telescopic double. High power in good seeing reveals that Nu's brighter component is itself a close binary, separation 2 arcseconds.

Source: [Sky & Telescope](http://www.skyandtelescope.com)
ISS Sighting Opportunities

For Denver:

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Sighting information for other cities can be found at NASA’s [Satellite Sighting Information](https://www.nasa.gov/mission_pages/station/ quickestsat.html).

**NASA-TV Highlights**

*(all times Eastern Daylight Time)*

**Monday, July 10**

11 a.m., ISS Expedition 52 In-Flight Interviews with the CBS Radio Network and WBZ Radio, Boston and NASA Flight Engineer Jack Fischer (starts at 11:20 a.m.) (all channels)

4 p.m., Replay of the ISS Expedition 52-53 Crew News Conference at the Gagarin Cosmonaut Training Center in Star City, Russia (Ryazanskiy, Bresnik, Nespoli) (all channels)

4:30 p.m., Video File of the ISS Expedition 52-53 Crew’s Ceremonial Visit to the Gagarin Museum at the Gagarin Cosmonaut Training Center and Visit to Red Square and the Kremlin in Moscow (Ryazanskiy, Bresnik, Nespoli) (starts at 4:45 p.m.) (all channels)

Watch NASA TV on the Net by going to the [NASA website](https://www.nasa.gov/).
Space Calendar

- Jul 07 - Comet 253P/PANSTARRS At Opposition (1.930 AU)
- Jul 07 - Comet 243P/NEAT Closest Approach To Earth (2.463 AU)
- Jul 07 - Asteroid 336698 Melbourne Closest Approach To Earth (2.069 AU)
- Jul 07 - Asteroid 10552 Stockholm Closest Approach To Earth (2.719 AU)
- Jul 07 - Kuiper Belt Object 2014 MU69 At Opposition (42.275 AU)
- Jul 07 - Robert Heinlein's 110th Birthday (1907)
- Jul 08 - Comet 213P/Van Ness At Opposition (1.063 AU)
- Jul 08 - Comet 213P-B/Van Ness At Opposition (1.065 AU)
- Jul 08 - Comet 336P/McNaught At Opposition (1.962 AU)
- Jul 08 - Comet 322P-G/Ikeya-Murakami Closest Approach To Earth (2.685 AU)
- Jul 08 - [Jul 03] Comet C/2017 M5 (TOTAS) Closest Approach To Earth (5.480 AU)
- Jul 08 - Amor Asteroid 2017 MP7 Near-Earth Flyby (0.028 AU)
- Jul 08 - Asteroid 757 Portlandia Closest Approach To Earth (1.568 AU)
- Jul 08 - Asteroid 624 Hektor (Jupiter Trojan) Closest Approach To Earth (4.339 AU)
- Jul 08 - 25th Anniversary (1992), Comet Shoemaker-Levy 9 Near-Jupiter Flyby (0.0008 AU), Comet Breakup
- Jul 09 - Apollo Asteroid 2008 HU4 Closest Approach To Earth (0.641 AU)
- Jul 09 - Asteroid 434 Hungaria Closest Approach To Earth (0.939 AU)
- Jul 09 - Apollo Asteroid 1566 Icarus Closest Approach To Earth (1.005 AU)
- Jul 09 - Apollo Asteroid 37655 Illapa Closest Approach To Earth (1.447 AU)
- Jul 09 - Asteroid 3156 Ellington Closest Approach To Earth (2.415 AU)
- Jul 10 - [Jul 03] Juno, Jupiter Flyby
- Jul 10 - Cassini, Distant Flyby of Titan
- Jul 10 - Asteroid 365159 Garching Closest Approach To Earth (1.344 AU)
- Jul 10 - Asteroid 10806 Mexico Closest Approach To Earth (2.274 AU)
- Jul 10 - Dwarf Planet 134340 Pluto At Opposition (32.347 AU)
- Jul 10 - [Jul 03] 34th Mars Exploration Program Analysis Group (MEPAG) Virtual Meeting
- Jul 10 - Jorge Fest Conference Lisbon, Portugal
- Jul 10 - 25th Anniversary (1992), Giotto, Comet Grigg-Skjellerup Flyby
- Jul 10 - 55th Anniversary (1962), Telstar 1 Launch
- Jul 10 - Paolo Holvorcem's 50th Birthday (1967)
- Jul 10 - Alvan Clark's 180th Birthday (1832)
- Jul 10 - Roger Cotes' 335th Birthday (1682)

Source: JPL Space Calendar
This week in NASA History: Apollo AS-203 Launches -- July 5, 1966

This week in 1966, the AS-203 rocket launched from NASA’s Kennedy Space Center. The Apollo AS-203 mission was an uncrewed test of the vehicle’s second stage, the S-IVB stage, and the instrument unit of the Saturn V to obtain flight information under orbital conditions. The configuration of the Saturn IB was designed to match the Saturn V as closely as possible. NASA’s Marshall Space Flight Center designed, developed and managed the production of the Saturn I and the Saturn V rocket that took astronauts to the moon.

Today Marshall is developing NASA’s Space Launch System, the most powerful rocket ever built, that will be capable of sending astronauts deeper into space than ever before, including to Mars.

The NASA History Program is responsible for generating, disseminating, and preserving NASA’s remarkable history and providing a comprehensive understanding of the institutional, cultural, social, political, economic, technological, and scientific aspects of NASA’s activities in aeronautics and space. For more pictures like this one and to connect to NASA’s history, visit the Marshall History Program’s webpage.

Source: NASA
Space Image of the Week

Aphelion Sunrise

**Explanation:** On July 3rd, planet Earth reached aphelion, the farthest point in its elliptical orbit around the Sun. Each year, this day of the most distant Sun happens to occur during winter in the southern hemisphere. That's where this aphelion sunrise from 2015 was captured in a time series composite against the skyline of Brisbane, Australia. Of course, seasons for our fair planet are not determined by distance to the Sun, but by the tilt of Earth's rotational axis with respect to the ecliptic, the plane of its orbit. Fondly known as the **obliquity of the ecliptic**, the angle of the tilt is about 23.4 degrees from perpendicular to the orbital plane. So the most distant sunrise occurs during northern summer, when the planet's north pole is tilted toward the Sun and the north enjoys longer, warmer days.

**Image Credit & Copyright:** Stephen Mudge

Source: APOD