Space News Update

— July 24, 2018 —

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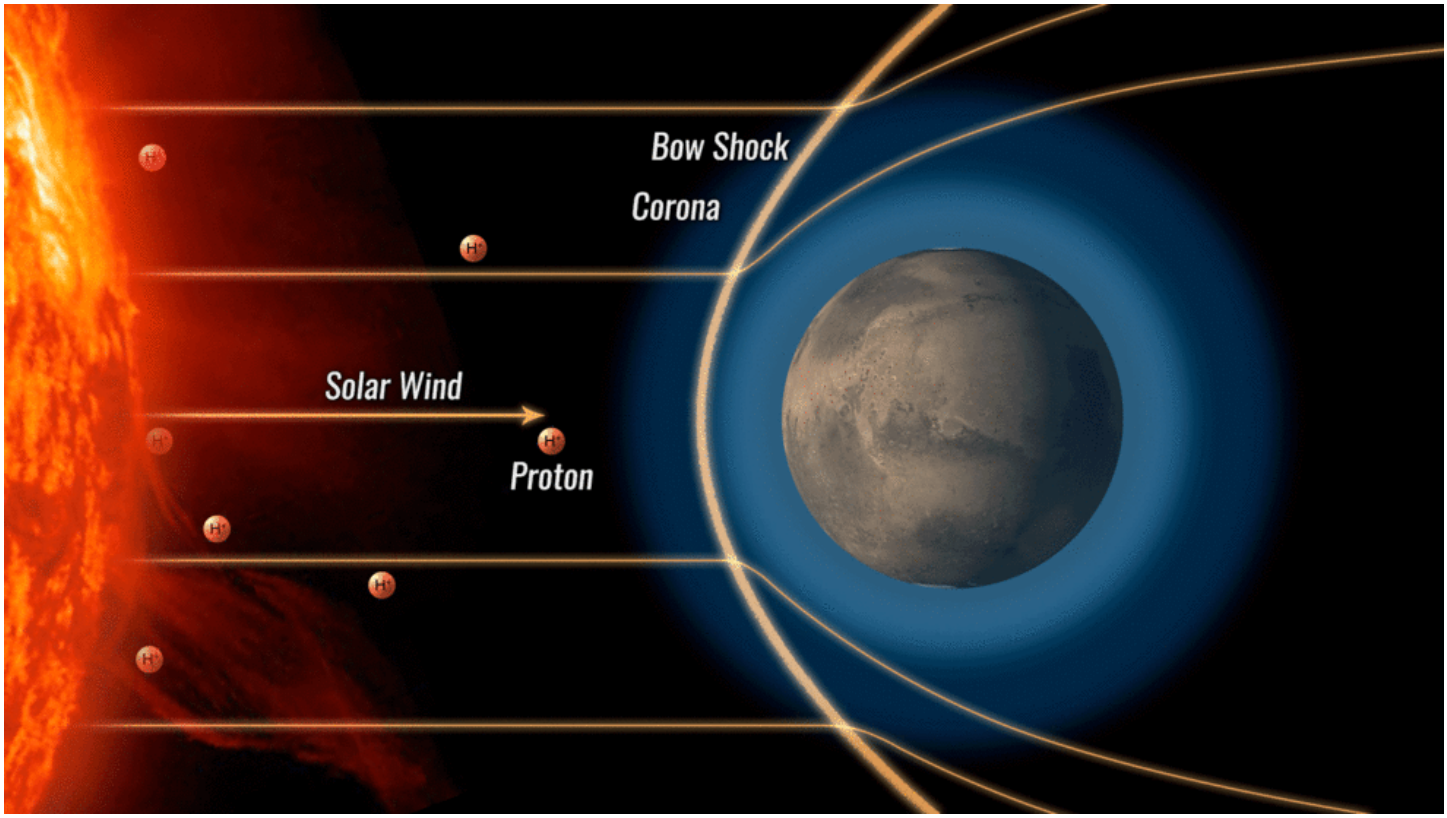
1. MAVEN Spacecraft Finds That “Stolen” Electrons Enable Unusual Aurora on Mars



Auroras appear on Earth as ghostly displays of colorful light in the night sky, usually near the poles. Our rocky neighbor Mars has auroras too, and NASA’s MAVEN spacecraft just found a new type of Martian aurora that occurs over much of the day side of the Red Planet, where auroras are very hard to see.

Auroras flare up when energetic particles plunge into a planet’s atmosphere, bombarding gases and making them glow. While electrons generally cause this natural phenomenon, sometime protons can elicit the same response, although it’s more rare. Now, the MAVEN team has learned that protons were doing at Mars the same thing as electrons usually do at Earth—create aurora. This is especially true when the Sun ejects a particularly strong pulse of protons, which are hydrogen atoms stripped of their lone electrons by intense heat. The Sun ejects protons at speeds up to two million miles per hour (more than 3 million kilometers per hour) in an erratic flow called the solar wind.

The MAVEN (Mars Atmosphere and Volatile Evolution mission) team was studying Mars’ atmosphere with the Imaging UltraViolet Spectrograph (IUVS), and observed that on occasion, the ultraviolet light coming from hydrogen gas in Mars' upper atmosphere would mysteriously brighten for a few hours. They then noticed that the brightening events occurred when another MAVEN instrument, the Solar Wind Ion Analyzer (SWIA), measured enhanced solar wind protons.

But two puzzles make this type of aurora seem impossible at first glance: how did these protons get past the planet’s “bow shock,” a magnetic obstacle which normally diverts the solar wind’s charged particles around the planet? And how could the protons give off light, since atoms need electrons to do so?

“The answer was thievery,” said Justin Deighan, of the Laboratory for Atmospheric and Space Physics at the University of Colorado, Boulder, lead author of a paper on this research appearing July 23 in Nature

Astronomy. “As they approach Mars, the protons coming in with the solar wind transform into neutral atoms by stealing electrons from the outer edge of the huge cloud of hydrogen surrounding the planet. The bow shock can only divert charged particles, so these neutral atoms continue right on through.” When those high-speed incoming atoms hit the atmosphere, some of their energy was emitted as ultraviolet light, which is invisible to the human eye but detectable to instruments like the IUVS on MAVEN. In fact, one incoming atom can collide with molecules in the atmosphere hundreds of times before it slows down, giving off a slew of ultraviolet photons.

“The Martian proton auroras are more than a light show,” said Jasper Halekas of the University of Iowa, responsible for the SWIA instrument. “They reveal that the solar wind is not completely diverted around Mars, by showing how solar wind protons can sneak past the bow shock and impact the atmosphere, depositing energy and even enhancing the hydrogen content there.”

Proton auroras do occur at Earth, but not as often as at Mars. One key difference is Earth’s strong magnetic field, which diverts the solar wind away from Earth to a much greater degree than at Mars. On Earth, proton auroras only occur in very small regions near the poles, whereas at Mars they can happen everywhere.

However, proton auroras could be common on Venus and on Saturn’s moon Titan. Like Mars, these two worlds lack their own magnetic fields, and have lots of hydrogen in their upper atmospheres—with plenty of electrons to share. Looking further, it’s likely that many planets orbiting other stars have the same favorable conditions, and would be likely to have proton auroras too.

This research was funded by the MAVEN mission. MAVEN's principal investigator is based at the University of Colorado's Laboratory for Atmospheric and Space Physics, Boulder, and NASA Goddard manages the MAVEN project.

Source: NASA Return to Contents

2. The Milky Way's long-lost sibling finally found

Scientists at the University of Michigan have deduced that the Andromeda galaxy, our closest large galactic neighbor, shredded and cannibalized a massive galaxy two billion years ago.

Even though it was mostly shredded, this massive galaxy left behind a rich trail of evidence: an almost invisible halo of stars larger than the Andromeda galaxy itself, an elusive stream of stars and a separate enigmatic compact galaxy, M32. Discovering and studying this decimated galaxy will help astronomers understand how disk galaxies like the Milky Way evolve and survive large mergers.

This disrupted galaxy, named M32p, was the third-largest member of the Local Group of galaxies, after the Milky Way and Andromeda galaxies. Using computer models, Richard D'Souza and Eric Bell of the University of Michigan's Department of Astronomy were able to piece together this evidence, revealing this long-lost sibling of the Milky Way. Their findings were published in *Nature Astronomy*.

Scientists have long known that this nearly invisible large halo of stars surrounding galaxies contains the remnants of smaller cannibalized galaxies. A galaxy like Andromeda was expected to have consumed hundreds of its smaller companions. Researchers thought this would make it difficult to learn about any single one of them.

Using new computer simulations, the scientists were able to understand that even though many companion galaxies were consumed by Andromeda, most of the stars in the Andromeda's outer faint halo were mostly contributed by shredding a single large galaxy.

"It was a 'eureka' moment. We realized we could use this information of Andromeda's outer stellar halo to infer the properties of the largest of these shredded galaxies," said lead author D'Souza, a postdoctoral researcher at U-M.

"Astronomers have been studying the Local Group--the Milky Way, Andromeda and their companions--for so long. It was shocking to realize that the Milky Way had a large sibling, and we never knew about it," said co-author Bell, U-M professor of astronomy.

This galaxy, called M32p, which was shredded by the Andromeda galaxy, was at least 20 times larger than any galaxy which merged with the Milky Way over the course of its lifetime. M32p would have been massive, making it the third largest galaxy in the Local Group after the Andromeda and the Milky Way galaxies.

This work might also solve a long-standing mystery: the formation of Andromeda's enigmatic M32 satellite galaxy, the scientists say. They suggest that the compact and dense M32 is the surviving center of the Milky Way's long-lost sibling, like the indestructible pit of a plum.

"M32 is a weirdo," Bell said. "While it looks like a compact example of an old, elliptical galaxy, it actually has lots of young stars. It's one of the most compact galaxies in the universe. There isn't another galaxy like it."

Their study may alter the traditional understanding of how galaxies evolve, the researchers say. They realized that the Andromeda's disk survived an impact with a massive galaxy, which would question the common wisdom that such large interactions would destroy disks and form an elliptical galaxy.

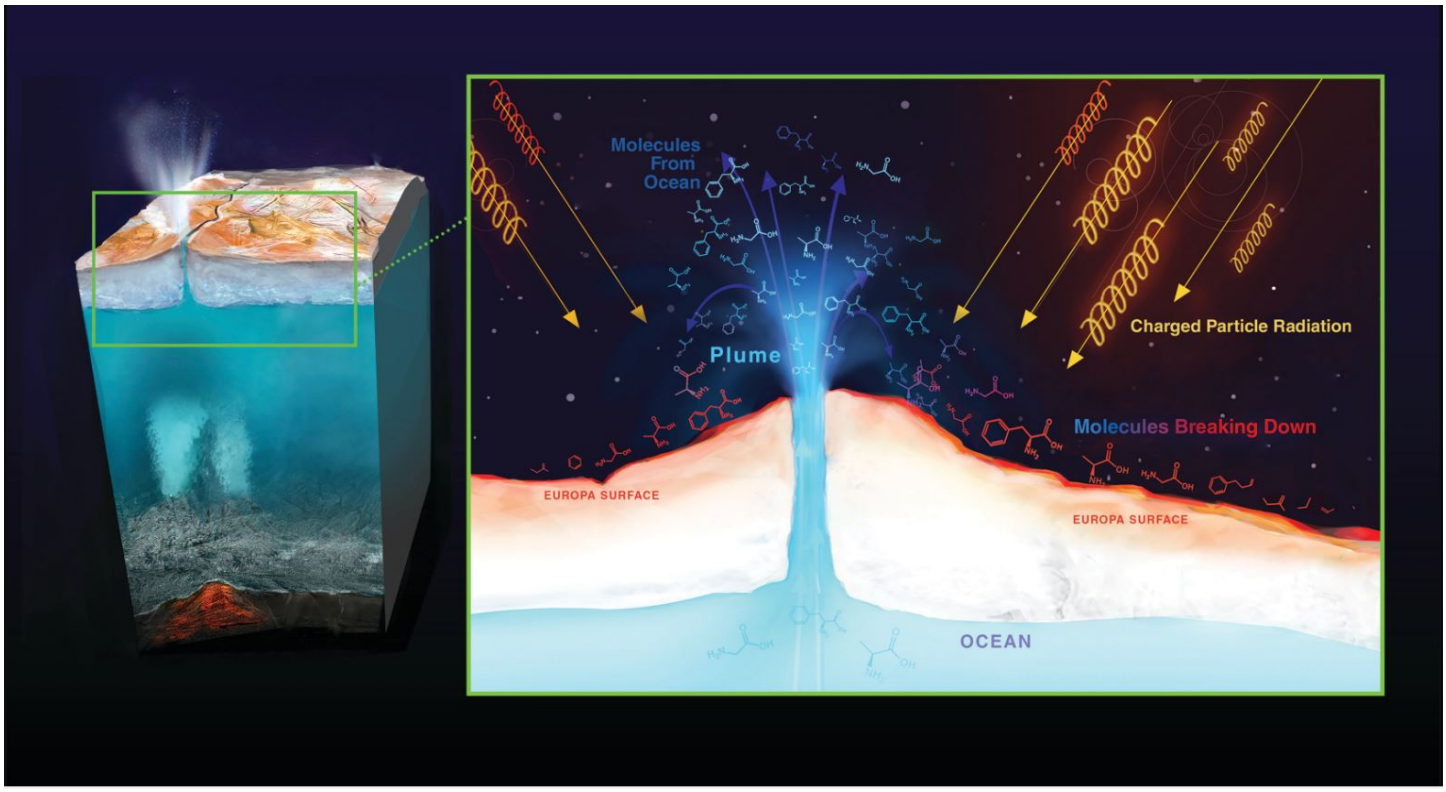
The timing of the merger may also explain the thickening of the disk of the Andromeda galaxy as well as a burst of star formation two billion years ago, a finding which was independently reached by French researchers earlier this year.

"The Andromeda Galaxy, with a spectacular burst of star formation, would have looked so different 2 billion years ago," Bell said. "When I was at graduate school, I was told that understanding how the Andromeda Galaxy and its satellite galaxy M32 formed would go a long way towards unraveling the mysteries of galaxy formation."

The method used in this study can be used for other galaxies, permitting measurement of their most massive galaxy merger, the researchers say. With this knowledge, scientists can better untangle the complicated web of cause and effect that drives galaxy growth and learn about what mergers do to galaxies.

Source: EurekAlert Return to Contents

3. Radiation Maps of Jupiter's Moon Europa: Key to Future Missions



New comprehensive mapping of the radiation pummeling Jupiter's icy moon Europa reveals where scientists should look -- and how deep they'll have to go -- when searching for signs of habitability and biosignatures.

Since NASA's Galileo mission yielded strong evidence of a global ocean underneath Europa's icy shell in the 1990s, scientists have considered that moon one of the most promising places in our solar system to look for ingredients to support life. There's even evidence that the salty water sloshing around the moon's interior makes its way to the surface.

By studying this material from the interior, scientists developing future missions hope to learn more about the possible habitability of Europa's ocean.However, Europa's surface is bombarded by a constant and intense blast of radiation from Jupiter. This radiation can destroy or alter material transported up to the surface, making it more difficult for scientists to know if it actually represents conditions in Europa's ocean.

As scientists plan for upcoming exploration of Europa, they have grappled with many unknowns: Where is the radiation most intense? How deep do the energetic particles go? How does radiation affect what's on the surface and beneath - including potential chemical signs, or biosignatures, that could imply the presence of life.

A new scientific study, published today in Nature Astronomy, represents the most complete modeling and mapping of radiation at Europa and offers key pieces to the puzzle. The lead author is Tom Nordheim, research scientist at NASA's Jet Propulsion Laboratory, Pasadena, California.

"If we want to understand what's going on at the surface of Europa and how that links to the ocean underneath, we need to understand the radiation," Nordheim said. "When we examine materials that have come up from the subsurface, what are we looking at? Does this tell us what is in the ocean, or is this what happened to the materials after they have been radiated?"

Using data from Galileo's flybys of Europa two decades ago and electron measurements from NASA's Voyager 1 spacecraft, Nordheim and his team looked closely at the electrons blasting the moon's surface. They found that the radiation doses vary by location. The harshest radiation is concentrated in zones around the equator, and the radiation lessens closer to the poles.

Mapped out, the harsh radiation zones appear as oval-shaped regions, connected at the narrow ends, that cover more than half of the moon.

"This is the first prediction of radiation levels at each point on Europa's surface and is important information for future Europa missions," said Chris Paranicas, a co-author from the Johns Hopkins Applied Physics Laboratory in Laurel, Maryland.

Now scientists know where to find regions least altered by radiation, which could be crucial information for the JPL-led Europa Clipper, NASA's mission to orbit Jupiter and monitor Europa with about 45 close flybys. The spacecraft may launch as early as 2022 and will carry cameras, spectrometers, plasma and radar instruments to investigate the composition of the moon's surface, its ocean, and material that has been ejected from the surface.

In his new paper, Nordheim didn't stop with a two-dimensional map. He went deeper, gauging how far below the surface the radiation penetrates, and building 3D models of the most intense radiation on Europa. The results tell us how deep scientists need to dig or drill, during a potential future Europa lander mission, to find any biosignatures that might be preserved.

The answer varies, from 4 to 8 inches (10 to 20 centimeters) in the highest-radiation zones - down to less than 0.4 inches (1 centimeter) deep in regions of Europa at middle- and high-latitudes, toward the moon's poles.

To reach that conclusion, Nordheim tested the effect of radiation on amino acids, basic building blocks for proteins, to figure out how Europa's radiation would affect potential biosignatures. Amino acids are among the simplest molecules that qualify as a potential biosignature, the paper notes.

"The radiation that bombards Europa's surface leaves a fingerprint," said Kevin Hand, co-author of the new research and projectscientist for the potential Europa Lander mission. "If we know what that fingerprint looks like, we can better understand the nature of any organics and possible biosignatures that might be detected with future missions, be they spacecraft that fly by or land on Europa.

Europa Clipper's mission team is examining possible orbit paths, and proposed routes pass over many regions of Europa that experience lower levels of radiation, Hand said. "That's good news for looking at potentially fresh ocean material that has not been heavily modified by the fingerprint of radiation."

Source: JPL Return to Contents

The Night Sky

Tuesday, July 24

• The Moon shines with Saturn tonight, as shown here. Saturn, the most distant bright planet, is 3,420 times farther away and 35 times as wide.

Wednesday, July 25

• The nearly full Moon shines between Saturn, about a fist at arm's length to its right after darkness is complete, and bright Mars about two fists to the Moon's lower left (for North America).

Thursday, July 26

• **Mars is at opposition tonight,** opposite the Sun as seen from Earth. It will actually be closest to Earth, and its absolute biggest and brightest, four days from now on the night of the 30th. But really, the difference between now and then is so tiny it'll be undetectable. Enjoy!

Friday, July 27

• Full Moon (exact at 4:20 p.m. EDT). Full Moon is opposition Moon, so it shines with brilliant Mars, which is just a day past its opposition.

Mars is 143 times farther from us than the Moon (and twice as large). It's covered with rusty dark brown dust compared to the Moon's dark gray dust. So why do they look orange and white in our night sky? That's because they're illuminated brilliantly by direct sunlight while the rest of the nighttime scenery around us, to which our eyes adapt, is much dimmer.

• **Total eclipse of the Moon, but not for the Americas!** (or Hawai`i). The best views will be from Europe, Africa, and much of Asia. This will be the *longest* total lunar eclipse of the 21st century, with totality lasting 1 hour 43 minutes. Next to reddish Mars, the Moon will turn from white to (presumably) much redder to white.

Source: Sky & Telescope

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ISS Sighting Opportunities

For Denver:

Date	Visible	Max Height	Appears	Disappears
Tue Jul 24, 00:10 AM	< 1 min	10°	10° above N	10° above NNE
Tue Jul 24, 9:40 PM	2 min	18°	18° above NNW	10° above NNE
Tue Jul 24, 11:18 PM	< 1 min	10°	10° above N	10° above N
Wed Jul 25, 8:48 PM	3 min	27°	27° above NNW	10° above NNE
Wed Jul 25, 10:25 PM	< 1 min	11°	11° above N	10° above N
Thu Jul 26, 00:02 AM	< 1 min	12°	12° above N	12° above NNE
Thu Jul 26, 9:33 PM	2 min	13°	13° above NNW	10° above NNE
Thu Jul 26, 11:10 PM	1 min	11°	10° above N	10° above NNE
Fri Jul 27, 00:45 AM	< 1 min	10°	10° above NNW	10° above NNW
Fri Jul 27, 8:41 PM	2 min	16°	16° above NNW	10° above NNE
Fri Jul 27, 10:18 PM	1 min	10°	10° above N	10° above NNE
Fri Jul 27, 11:54 PM	< 1 min	15°	15° above N	15° above N

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

NASA-TV Highlights

(all times Eastern Daylight Time)

July 24, Tuesday
11 a.m. – Opening session of the International Space Station Research and Development Conference in San Francisco (All Channels)

July 25, Wednesday
4:15 p.m. – "Orbital Perspectives with Astronaut Mark Vande Hei," from the International Space Station Research and Development Conference (All Channels)

July 26, Thursday
11:15 a.m. – Space Station In-Flight Event for the European Space Agency with the City of Kunzelsau, Germany, and astronaut Alexander Gerst of ESA (English interpretation on Public Channel; native language on Media Channel)
1 p.m. - NASA Celebrates National Intern Day at Goddard Space Flight Center, with Administrator Jim Bridenstine (All Channels)
2:30 p.m. – Space Station In-Flight Event for the ISS Research and Development Conference in San Francisco with Space Station Commander Drew Feustel (All Channels)
3:45 p.m. – Astronaut Keynote with Randy Bresnik and award presentations from the International Space Station Research and Development Conference (All Channels)

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

Space Calendar

- Jul 24 - Comet C/2018 M1 (Catalina) Closest Approach To Earth (1.229 AU)
- Jul 24 - Asteroid 253 Mathilde Closest Approach To Earth (1.068 AU)
- Jul 24 - Asteroid 7367 Giotto Closest Approach To Earth (2.289 AU)
- Jul 24 - 70th Anniversary (1948), Marvin the Martian Debut on Looney Tunes
- Jul 24 - Henri-Alexandre Deslandres' 165th Birthday (1853)
- Jul 25 - Galileo 23-26 Ariane 5 Launch
- Jul 25 - Iridium Next 56-65 Falcon 9 Launch
- Jul 25 - Apollo Asteroid 2014 WO371 Near-Earth Flyby (0.060 AU)
- Jul 25 - Aten Asteroid 2018 GR4 Near-Earth Flyby (0.098 AU)
- Jul 25 - Asteroid 125071 Lugosi Closest Approach To Earth (1.453 AU)
- Jul 25 - Asteroid 8373 Stephengould Closest Approach To Earth (4.136 AU)
- Jul 25 - 45th Anniversary (1973), Mars 5 Launch (USSR Mars Orbiter)
- Jul 25-27 - interNational Astronomy Teach Summit (iNATS), Hilo, Hawaii
- Jul 26 - Comet 49P/Arend-Rigaux Closest Approach To Earth (2.401 AU)
- Jul 26 - Comet 150P/LONEOS At Opposition (3.979 AU)
- Jul 26 - Asteroid 30928 Jefferson Closest Approach To Earth (2.095 AU)
- Jul 26 - Lenka Kotkova's 45th Birtday (1973)
- Jul 26 - 55th Anniversary (1963), Syncom 2 Launch, 1st Geosynchronous Satellite
- Jul 27 - Total Lunar Eclipse
- Jul 27 - Mars At Opposition
- Jul 27 - Comet C/2018 N1 (NEOWISE) Closest Approach To Earth (0.306 AU)
- Jul 27 - Comet C/2018 N1 (NEOWISE) At Opposition (0.306 AU)
- Jul 27 - Comet P/2007 T2 (Kowalski) Perihelion (0.655 AU)
- Jul 27 - Comet 138P/Shoemaker-Levy At Opposition (1.894 AU)
- Jul 27 - Comet 114P/Wiseman-Skiff At Opposition (3.197 AU)
- Jul 27 - Aten Asteroid 2018 NR1 Near-Earth Flyby (0.044 AU)
- Jul 27 - Atira Asteroid 1998 DK36 Closest Approach To Earth (0.594 AU)
- Jul 27 - Asteroid 6563 Steinheim Closest Approach To Earth (1.424 AU)
- Jul 27 - Asteroid 6433 Enya Closest Approach To Earth (1.424 AU)
- Jul 27 - Asteroid 8129 Michaelbusch Closest Approach To Earth (1.450 AU)
- Jul 27 - Kuiper Belt Object 2017 OF69 At Opposition (42.789 AU)

Source: JPL Space Calendar

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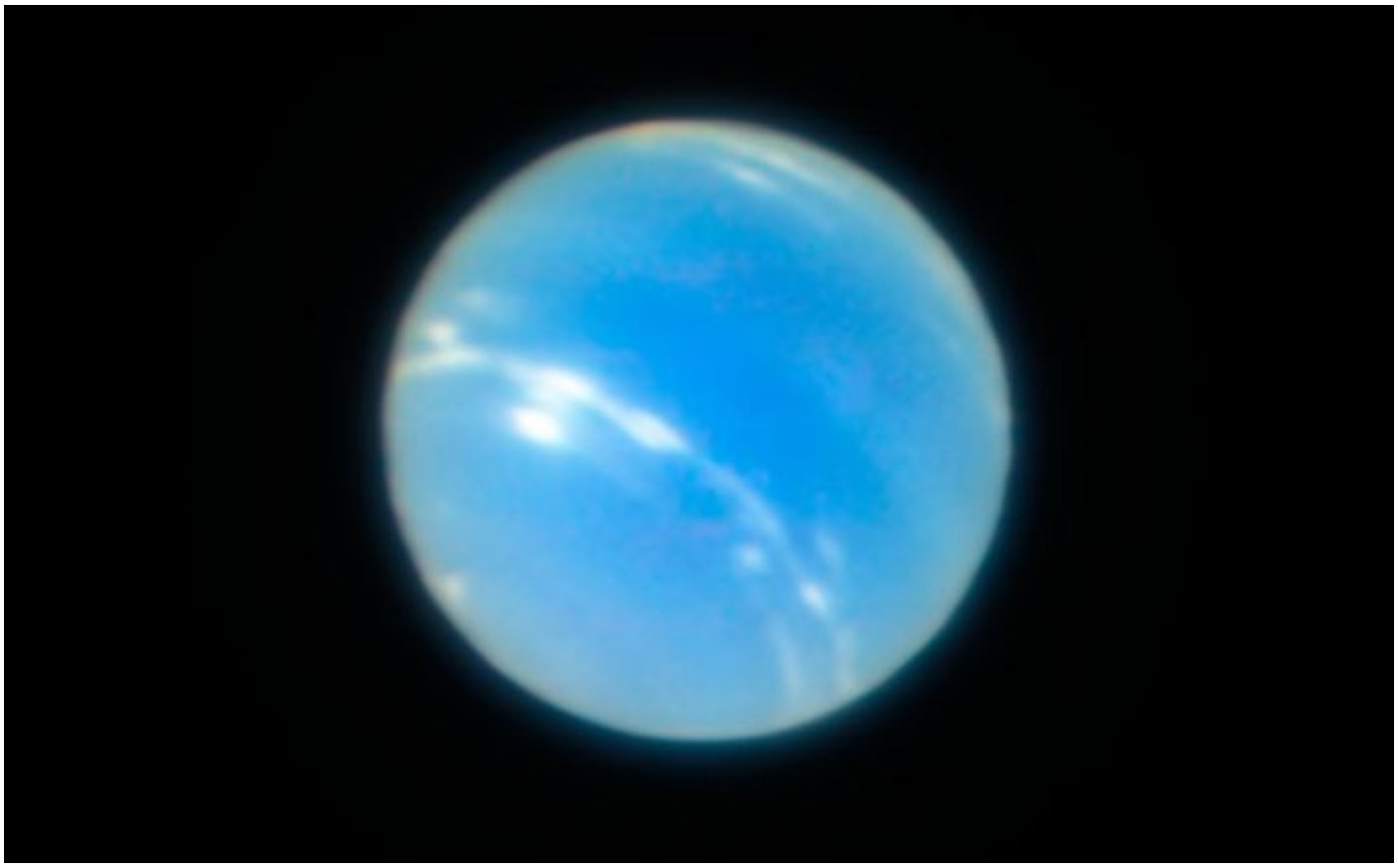
Food for Thought

This is a Photo of Neptune from the Ground!



In 2007, the European Southern Observatory (ESO) completed work on the Very Large Telescope (VLT) at the Paranal Observatory in northern Chile. This ground-based telescope is the world's most advanced optical instrument, consisting of four Unit Telescopes with main mirrors (measuring 8.2 meters in diameter) and four movable 1.8-meter diameter Auxiliary Telescopes.

Recently, the VLT was upgraded with a new instrument known as the Multi Unit Spectroscopic Explorer (MUSE), a panoramic integral-field spectrograph that works at visible wavelengths. Thanks to the new adaptive optics mode that this allows for (known as laser tomography) the VLT was able to recently acquire some images of Neptune, star clusters and other astronomical objects with impeccable clarity.

In astronomy, adaptive optics refers to a technique where instruments are able to compensate for the blurring effect caused by Earth's atmosphere, which is a serious issue when it comes to ground-based telescopes. Basically, as light passes through our atmosphere, it becomes distorted and causes distant objects to become blurred (which is why stars appear to twinkle when seen with the naked eye).

One solution to this problem is to deploy telescopes into space, where atmospheric disturbance is not an issue. Another is to rely on advanced technology that can artificially correct for the distortions, thus resulting in much clearer images. One such technology is the MUSE instrument, which works with an adaptive optics unit called a GALACSI – a subsystem of the Adaptive Optics Facility (AOF).

The instrument allows for two adaptive optics modes – the Wide Field Mode and the Narrow Field Mode. Whereas the former corrects for the effects of atmospheric turbulence up to one km above the telescope over a comparatively wide field of view, the Narrow Field mode uses laser tomography to correct for almost all of

the atmospheric turbulence above the telescope to create much sharper images, but over a smaller region of the sky.

This consists of four lasers that are fixed to the fourth Unit Telescope (UT4) beaming intense orange light into the sky, simulating sodium atoms high in the atmosphere and creating artificial "Laser Guide Stars". Light from these artificial stars is then used to determine the turbulence in the atmosphere and calculate corrections, which are then sent to the deformable secondary mirror of the UT4 to correct for the distorted light.

Using this Narrow Field Mode, the VLT was able to capture remarkably sharp test images of the planet Neptune, distant star clusters (such as the globular star cluster NGC 6388), and other objects. In so doing, the VLT demonstrated that its UT4 mirror is able to reach the theoretical limit of image sharpness and is no longer limited by the effects of atmospheric distortion.

This essentially means that it is now possible for the VLT to capture images from the ground that are sharper than those taken by the *Hubble Space Telescope*. The results from UT4 will also help engineers to make similar adaptations to the ESO's Extremely Large Telescope (ELT), which will also rely on laser tomography to conduct its surveys and accomplish its scientific goals.

These goals include the study of supermassive black holes (SMBHs) at the centers of distant galaxies, jets from young stars, globular clusters, supernovae, the planets and moons of the Solar System, and extra-solar planets. In short, the use of adaptive optics – as tested and confirmed by the VLT's MUSE – will allow astronomers to use ground-based telescopes to study the properties of astronomical objects in much greater detail than ever before.

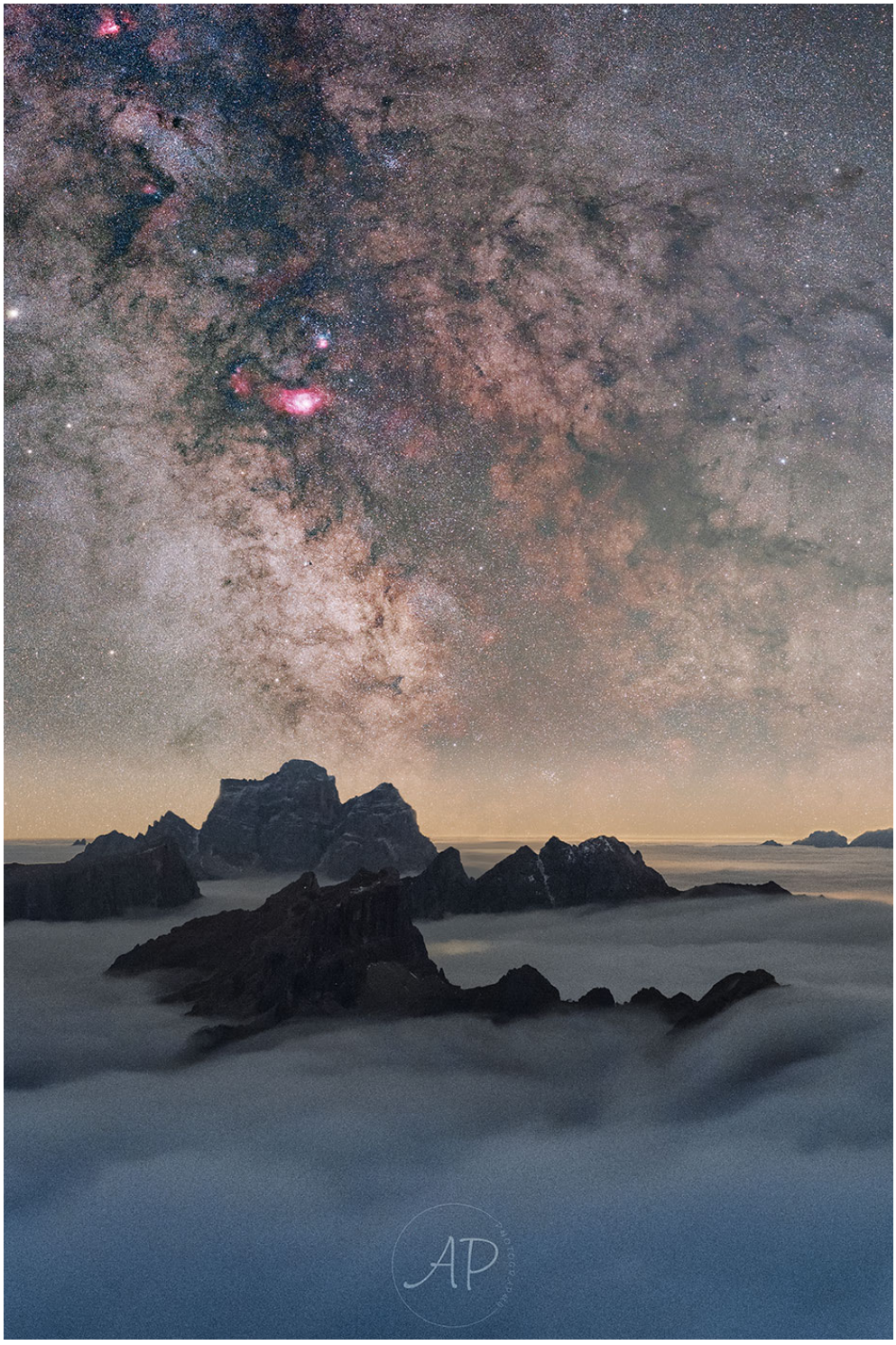
In addition, other adaptive optics systems will benefit from work with the Adaptive Optics Facility (AOF) in the coming years. These include the ESO's GRAAL, a ground layer adaptive optics module that is already being used by the Hawk-I infrared wide-field imager. In a few years, the powerful Enhanced Resolution Imager and Spectrograph (ERIS) instrument will also be added to the VLT.

Between these upgrades and the deployment of next-generation space telescopes in the coming years (like the *James Webb Space Telescope*, which will be deploying in 2021), astronomers expect to bringing a great deal more of the Universe "into focus". And what they see is sure to help resolve some long-standing mysteries, and will probably create a whole lot more!

And be sure to enjoy these videos of the images obtained by the VLT of Neptune and NGC 6388, courtesy of the ESO: https://youtu.be/yDMV7kmrfWY

Source: Universe Today Return to Contents

Space Image of the Week



Clouds of Earth and Sky
Image Credit & Copyright: Angelo Perrone

Explanation: If you go high enough, you may find yourself on a picturesque perch between the water clouds of the Earth and the star clouds of the Milky Way. Such was the case last month for one adventurous alpinist astrophotographer. Captured here in the foreground above white clouds are mountain peaks in the Dolomite

range in northern Italy. This multi-exposure image was captured from Lagazuoi, one of the Dolomites. Hundreds of millions of years ago, the Dolomites were not mountains but islands an ancient sea that rose through colliding tectonic plates. The Dolomites divergent history accounts for its unusually contrasting features, which include jagged crests andancient marine fossils. High above even the Dolomites, and far in the distance, dark dust lanes streak out from the central plane of our Milky Way Galaxy. The stars and dust are dotted with bright red clouds of glowing hydrogen gas -- such as the Lagoon Nebula just above and to the left of center.

Source: APOD

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