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1. Spinning black hole swallowing star explains superluminous event

An extraordinarily brilliant point of light seen in a distant galaxy, and dubbed ASASSN-15lh, was thought to be the brightest supernova ever seen. But new observations from several observatories, including the NASA/ESA Hubble Space Telescope, have now cast doubt on this classification. Instead, a group of astronomers propose that the source was an even more extreme and rare event — a rapidly spinning black hole ripping apart a passing star that came too close.

In 2015, the All Sky Automated Survey for SuperNovae (ASAS-SN) detected an event, named ASASSN-15lh, that was recorded as the brightest supernova ever — and categorised as a superluminous supernova, the explosion of an extremely massive star at the end of its life. It was twice as bright as the previous record holder, and at its peak was 20 times brighter than the total light output of the entire Milky Way.

An international team, led by Giorgos Leloudas at the Weizmann Institute of Science, Israel, and the Dark Cosmology Centre, Denmark, has now made additional observations of the distant galaxy, about 4 billion light-years from Earth, where the explosion took place and they have proposed a new explanation for this extraordinary event.

“We observed the source for 10 months following the event and have concluded that the explanation is unlikely to lie with an extraordinary bright supernova. Our results indicate that the event was probably caused by a rapidly spinning supermassive black hole as it destroyed a low-mass star,” explains Leloudas.

In this scenario, the extreme gravitational forces of a supermassive black hole, located in the centre of the host galaxy, ripped apart a Sun-like star that wandered too close — a so-called tidal disruption event, something so far only observed about 10 times. In the process, the star was “spaghettified” and shocks in the colliding debris as well as heat generated in accretion led to a burst of light. This gave the event the appearance of a very bright
supernova explosion, even though the star would not have become a supernova on its own as it did not have enough mass.

The team based their new conclusions on observations from a selection of telescopes, both on the ground and in space. Among them was the NASA/ESA Hubble Space Telescope, the Very Large Telescope at ESO’s Paranal Observatory and the New Technology Telescope at ESO’s La Silla Observatory [1].

“There are several independent aspects to the observations that suggest that this event was indeed a tidal disruption and not a superluminous supernova,” explains coauthor Morgan Fraser from the University of Cambridge, UK (now at University College Dublin, Ireland).

In particular, the data revealed that the event went through three distinct phases over the 10 months of follow-up observations. These data overall more closely resemble what is expected for a tidal disruption than a superluminous supernova. An observed re-brightening in ultraviolet light as well as a temperature increase further reduce the likelihood of a supernova event. Furthermore, the location of the event — a red, massive and passive galaxy — is not the usual home for a superluminous supernova explosion, which normally occur in blue, star-forming dwarf galaxies.

Although the team say a supernova source is therefore very unlikely, they accept that a classical tidal disruption event would not be an adequate explanation for the event either. Team member Nicholas Stone from Columbia University, USA, elaborates: “The tidal disruption event we propose cannot be explained with a non-spinning supermassive black hole. We argue that ASASSN-15lh was a tidal disruption event arising from a very particular kind of black hole.”

The mass of the host galaxy implies that the supermassive black hole at its centre has a mass of at least 100 million times that of the Sun. A black hole of this mass would normally be unable to disrupt stars outside of its event horizon — the boundary within which nothing is able to escape its gravitational pull. However, if the black hole is a particular kind that happens to be rapidly spinning — a so-called Kerr black hole — the situation changes and this limit no longer applies.

“Even with all the collected data we cannot say with 100% certainty that the ASASSN-15lh event was a tidal disruption event,” concludes Leloudas. “But it is by far the most likely explanation.”

Source: ESA  

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2. Earth's Magnetic Fields Could Track Ocean Heat

As Earth warms, much of the extra heat is stored in the planet's ocean -- but monitoring the magnitude of that heat content is a difficult task.

A surprising feature of the tides could help, however. Scientists at NASA's Goddard Space Flight Center in Greenbelt, Maryland, are developing a new way to use satellite observations of magnetic fields to measure heat stored in the ocean.

"If you're concerned about understanding global warming, or Earth's energy balance, a big unknown is what's going into the ocean," said Robert Tyler, a research scientist at Goddard. "We know the surfaces of the oceans are heating up, but we don't have a good handle on how much heat is being stored deep in the ocean."

Despite the significance of ocean heat to Earth's climate, it remains a variable that has substantial uncertainty when scientists measure it globally. Current measurements are made mainly by Argo floats, but these do not provide complete coverage in time or space. If it is successful, this new method could be the first to provide global ocean heat measurements, integrated over all depths, using satellite observations.

Tyler's method depends on several geophysical features of the ocean. Seawater is a good electrical conductor, so as saltwater sloshes around the ocean basins it causes slight fluctuations in Earth's magnetic field lines. The ocean flow attempts to drag the field lines around, Tyler said. The resulting magnetic fluctuations are relatively small, but have been detected from an increasing number of events including swells, eddies, tsunamis and tides.

"The recent launch of the European Space Agency's Swarm satellites, and their magnetic survey, are providing unprecedented observational data of the magnetic fluctuations," Tyler said. "With this comes new opportunities."

Researchers know where and when the tides are moving ocean water, and with the high-resolution data from the Swarm satellites, they can pick out the magnetic fluctuations due to these regular ocean movements.
That's where another geophysical feature comes in. The magnetic fluctuations of the tides depend on the electrical conductivity of the water -- and the electrical conductivity of the water depends on its temperature.

For Tyler, the question then is: "By monitoring these magnetic fluctuations, can we monitor the ocean temperature?"

At the American Geophysical Union meeting in San Francisco this week, Tyler and collaborator Terence Sabaka, also at Goddard, presented the first results. They provide a key proof-of-concept of the method by demonstrating that global ocean heat content can be recovered from "noise-free" ocean tidal magnetic signals generated by a computer model. When they try to do this with the "noisy" observed signals, it doesn't yet provide the accuracy needed to monitor changes in the heat content.

But, Tyler said, there is much room for improvement in how the data are processed and modeled, and the Swarm satellites continue to collect magnetic data. This is a first attempt at using satellite magnetic data to monitor ocean heat, he said, and there is still much more to be done before the technique could successfully resolve this key variable. For example, by identifying fluctuations caused by other ocean movements, like eddies or other tidal components, scientists can extract even more information and get more refined measurements of ocean heat content and how it's changing.

More than 90 percent of the excess heat in the Earth system goes into the ocean, said Tim Boyer, a scientist with the National Oceanic and Atmospheric Administration's National Centers for Environmental Information. Scientists currently monitor ocean heat with shipboard measurements and Argo floats. While these measurements and others have seen a steady increase in heat since 1955, researchers still need more complete information, he said. "Even with the massive effort with the Argo floats, we still don't have as much coverage of the ocean as we would really like in order to lower the uncertainties," Boyer said. "If you're able to measure global ocean heat content directly and completely from satellites, that would be fantastic."

Changing ocean temperatures have impacts that stretch across the globe. In Antarctica, floating sections of the ice sheet are retreating in ways that can't be explained only by changes in atmospheric temperatures, said Catherine Walker, an ice scientist at NASA's Jet Propulsion Laboratory in Pasadena, California.

She and her colleagues studied glaciers in Antarctica that lose an average of 6.5 to 13 feet (2 to 4 meters) of elevation per year. They looked at different options to explain the variability in melting -- surrounding sea ice, winds, salinity, air temperatures -- and what correlated most was influxes of warmer ocean water. "These big influxes of warm water come onto the continental shelf in some years and affect the rate at which ice melts," Walker said. She and her colleagues are presenting the research at the AGU meeting.

Walker's team has identified an area on the Antarctic Peninsula where warmer waters may have infiltrated inland, under the ice shelf -- which could have impacts on sea level rise.

Float and ship measurements around Antarctica are scarce, but deep water temperature measurements can be achieved using tagged seals. That has its drawbacks, however: "It's random, and we can't control where they go," Walker said. Satellite measurements of ocean heat content and temperatures would be very useful for the Southern Ocean, she added.

Ocean temperatures also impact life in the ocean -- from microscopic phytoplankton on up the food chain. Different phytoplankton thrive at different temperatures and need different nutrients. "Increased stratification in the ocean due to increased heating is going to lead to winners and losers within the phytoplankton communities," said Stephanie Schollaert Uz, a scientist at Goddard.
In research presented this week at AGU, she took a look 50 years back. Using temperature, sea level and other physical properties of the ocean, she generated a history of phytoplankton extent in the tropical Pacific Ocean, between 1958 and 2008. Looking over those five decades, she found that phytoplankton extent varied between years and decades. Most notably, during El Niño years, water currents and temperatures prevented phytoplankton communities from reaching as far west in the Pacific as they typically do.

Digging further into the data, she found that where the El Niño was centered has an impact on phytoplankton. When the warmer waters of El Niño are centered over the Eastern Pacific, it suppresses nutrients across the basin, and therefore depresses phytoplankton growth more so than a central Pacific El Niño.

"For the first time, we have a basin-wide view of the impact on biology of interannual and decadal forcing by many El Niño events over 50 years," Uz said.

As ocean temperatures impact processes across the Earth system, from climate to biodiversity, Tyler will continue to improve this novel magnetic remote sensing technique, to improve our future understanding of the planet.

NASA collects data from space, air, land and sea to increase our understanding of our home planet, improve lives and safeguard our future. NASA develops new ways to observe and study Earth's interconnected natural systems with long-term data records. The agency freely shares this unique knowledge and works with institutions around the world to gain new insights into how our planet is changing.

Source: JPL
3. Japanese cargo ship captured by space station crew

A Japanese cargo ship completed a four-day rendezvous with the International Space Station early Tuesday, bringing science gear, crew supplies and six powerful new batteries that will be installed in the lab’s solar power system in early January.

Expedition 50 commander Shane Kimbrough and European Space Agency astronaut Thomas Pesquet, operating the station’s robot arm, locked onto a grapple fixture on the side of the HTV-6 supply ship at 5:37 a.m. EST (GMT-5) as the two spacecraft sailed 250 miles above southern Chile.

“Houston, station, we see a good capture of the HTV,” Pesquet radioed after the arm locked on.

“Copy, we see the same, congrats,” replied astronaut Jessica Meir from mission control.

Flight controllers at the Johnson Space Center in Houston then took over arm operations and pulled the spacecraft in for berthing at the Earth-facing port of the station’s forward Harmony module. Once precisely aligned, 16 motorized bolts in the common berthing mechanism drove home to firmly lock the HTV in place. Berthing was completed at 8:57 a.m.

“It has about four-and-a-half tons of supplies for us, which we’re really excited about,” Kimbrough said after capture. “We were talking last night and thought it was really cool ... when you have a NASA astronaut and a European Space Agency astronaut using the Canadian robotic arm grabbing a Japanese vehicle and attaching it to the U.S. side of the space station. That’s pretty cool.”

The HTV, the sixth supplied by the Japan Aerospace Exploration Agency, or JAXA, features a pressurized compartment that the astronauts can access from inside the space station and an unpressurized cargo bay for exterior equipment that can be extracted by the robot arm.

HTV-6 is carrying 5,657 pounds of equipment and supplies in its pressurized cabin, including 2,786 pounds of food, water, clothing and other crew supplies, 1,461 pounds of station hardware, 925 pounds of science gear, 344 pounds of computer equipment, 77 pounds of spacesuit equipment and 62 pounds of Russian hardware.

Mounted on a pallet in the unpressurized cargo bay are six 550-pound lithium-ion batteries that will replace 12 aging nickel-hydrogen power packs in one of the station’s four sets of solar arrays. Three more sets of batteries that will be ferried up on future HTV flights.

The pallet carrying the first set will be pulled out of the HTV’s unpressurized cargo bay by the robot arm and moved to the right side of the station’s power truss later this month. Starting New Year’s Eve, the batteries will be robotically installed at the base of the inboard starboard 4, or S4, set of arrays, which feed two of the station’s eight power channels.

Two spacewalks will be required to complete the swap out. Kimbrough and astronaut Peggy Whitson will carry out the first EVA on Jan. 6 to service one of the two power channels while Kimbrough and Pesquet will service the second during a Jan. 13 spacewalk.

Nine of the 12 older batteries will be attached to the cargo pallet as the replacements are installed. When the work is complete, the pallet then will be moved back into the HTV-6 spacecraft. The retired batteries will burn up along
with the HTV when the cargo ship, loaded with station trash and other no-longer-needed equipment, plunges back into the atmosphere in late January.

The remaining three nickel-hydrogen batteries will be attached to “adapter plates” beside the new batteries at the base of the S4 arrays where they will remain in long-term storage. The adapter plates will be installed during the upcoming spacewalks.

“Based on a lot of the equipment that’s brought up, we’re going to see a lot of robotics and spacewalk activity coming up in the next few weeks, and it’s going to be really exciting,” Kimbrough said. “The vehicle has the new lithium-ion batteries that are going to get installed on the outside of the space station to improve our power system.”

“Again, congrats to our JAXA partners and other members of our international partnership on this really impressive achievement,” he said. “The vehicle is beautiful, and it performed flawlessly.”

Source: CBS News
The Night Sky

Tuesday, December 13

• Full supermoon (exactly full at 7:05 p.m. EST). The Moon, slightly larger and brighter than the average full Moon, shines between Orion, Taurus, and Gemini. Look for orange Aldebaran to its upper right and orange Betelgeuse to its lower right. As evening grows late, the triangle they make climbs higher, twists around, and slightly changes shape.

• The Geminid meteor shower should be at its strongest late tonight — but that extra-bright full Moon is in the same part of the sky as the shower's radiant! There will be no moonless period from dusk to dawn. Still, Geminid fireballs are not uncommon. You may see a dozen or more meteors per hour by 10 or 11 p.m. even through the moonlight, as the radiant climbs high in the east. Watch in a direction that keeps the glary Moon itself out of your vision.

The Geminid radiant passes overhead (for skywatchers at mid-northern latitudes) around 2 a.m. See Bob King's Supermoon and Geminids Duke It Out.

Wednesday, December 14

• Now the evening Moon shines between Betelgeuse to its right and Castor and Pollux to its left. As the evening grows late, look for Procyon coming up way down below.

Thursday, December 15

• The Moon rises after dark now. Look for Castor and Pollux to its upper left and, once the Moon is well up, Procyon rising to its lower right.

Friday, December 16

• Have you ever tried to see a Siriusrise? If you can find a spot with a good view down to the east-southeast horizon, watch for Sirius to come up about two fists at arm's length below Orion's Belt. It rises now sometime around 8 p.m. depending on your location. When a star is very low, it tends to twinkle quite slowly and often in vivid colors. Sirius is bright enough to show these effects well.

Source: Sky & Telescope
ISS Sighting Opportunities

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

NASA-TV Highlights
(all times Eastern Daylight Time)

- **TBD, Wednesday, December 14** - National Air and Space Museum’s “STEM in 30” – The Wright Stuff: Flying the Wright Flyer (NTV-1 (Public))
- **6 a.m., Wednesday, December 14** - NASA’s Cyclone Global Navigation Satellite System (CYGNSS) Spacecraft Prelaunch Program by NASA EDGE (all channels)
- **7 a.m., Wednesday, December 14** - NASA’s Cyclone Global Navigation Satellite System (CYGNSS) Spacecraft Launch Coverage and Commentary (all channels)
- **10:30 a.m., Thursday, December 15** - ISS Expedition 50 Educational In-Flight Event with the Nantucket New School, Nantucket, Massachusetts and ISS Commander Shane Kimbrough of NASA (Starts at 10:25 a.m.) (all channels)

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

- Dec 13 - **Geminids Meteor Shower** Peak
- Dec 13 - [Dec 12] **Apollo Asteroid 2016 XW20** Near-Earth Flyby (0.005 AU)
- Dec 13 - **Aton Asteroid 2015 XA169** Near-Earth Flyby (0.019 AU)
- Dec 13 - **Apollo Asteroid 2015 YA Near-Earth Flyby** (0.25 AU)
- Dec 13 - [Dec 12] **Apollo Asteroid 2016 XA21** Near-Earth Flyby (0.033 AU)
- Dec 13 - **Aton Asteroid 2014 XU6 Near-Earth Flyby** (0.095 AU)
- Dec 13 - **Asteroid 1777 Gehrels** Closest Approach To Earth (1.603 AU)
- Dec 13 - **Asteroid 25399 Vonnegut** Closest Approach To Earth (1.683 AU)
- Dec 13 - **Asteroid 45 Eugenia** (2 Moons) Closest Approach To Earth (1.950 AU)
- Dec 13 - **Asteroid 426 Hippo** Closest Approach To Earth (1.968 AU)
- Dec 13 - **Apollo Asteroid 6489 Golevka** Closest Approach To Earth (2.921 AU)
- Dec 13 - **Kuiper Belt Object 19521 Chaos At Opposition** (40.401 AU)
- Dec 14 - [Dec 08] **Asteroid 16260 Sputnik** Closest Approach To Earth (1.272 AU)
- Dec 14 - **Apollo Asteroid 3838 Epona** Closest Approach To Earth (1.565 AU)
- Dec 14 - **Asteroid 35334 Yarkovsky** Closest Approach To Earth (1.930 AU)
- Dec 14 - **Centaur Object 154783 (2004 PA44) At Opposition** (18.986 AU)
- Dec 14 - **Hans von Ohain's** 105th Birthday (1911)
- Dec 14 - **Tycho Brahe's** 470th Birthday (1546)
- Dec 15 - **Cassini**, Distant Flyby of Titan
- Dec 15 - **Comet 89P/Russell Perihelion** (2.220 AU)
- Dec 15 - **Comet 57P/du Toit-Neujmin-Delporte At Opposition** (3.174 AU)
- Dec 15 - **Comet 57P-A/du Toit-Neujmin-Delporte At Opposition** (3.174 AU)
- Dec 15 - **Comet 287P/Christensen At Opposition** (3.389 AU)
- Dec 15 - **Asteroid 12325 Bogota** Closest Approach To Earth (1.098 AU)
- Dec 15 - **Asteroid 16682 Donati** Closest Approach To Earth (1.149 AU)
- Dec 15 - **Asteroid 17024 Costello** Closest Approach To Earth (1.607 AU)
- Dec 15 - **Asteroid 3018 Godiva** Closest Approach To Earth (1.723 AU)
- Dec 15 - **Apollo Asteroid 2011 MD Closest Approach To Earth** (1.981 AU)
- Dec 15 - **Asteroid 11998 Fermilab** Closest Approach To Earth (2.111 AU)
- Dec 15 - 50th Anniversary (1966), **Audouin Dollfus'** Discovery of Saturn Moon Janus
- Dec 15 - **Roy Tucker's** 65th Birthday (1951)
- Dec 16 - [Dec 05] **Iridium NEXT 13-22 Falcon 9 Launch**
- Dec 16 - **Comet 205P-B/Giacobini Closest Approach To Earth** (2.954 AU)
- Dec 16 - **Asteroid 861 Aida Occults HIP 36411** (6.7 Magnitude Star)
- Dec 16 - **Apollo Asteroid 2016 WJ1 Near-Earth Flyby** (0.054 AU)
- Dec 16 - **Aton Asteroid 2001 YE4 Near-Earth Flyby** (0.081 AU)
- Dec 16 - **Asteroid 6701 Warhol** Closest Approach To Earth (1.634 AU)
- Dec 16 - **Giovanni Donati's** 190th Birthday (1826)
- Dec 16 - **Johann Ritter's** 240th Birthday (1776)

Source: **JPL Space Calendar**
Food for Thought

Finding the unknowns in the universe

What have pulsars, quasars, dark matter and dark energy got in common? Answer: each of them took the discoverer by surprise. While much of science advances carefully and methodically, the majority of truly spectacular discoveries in astronomy are unexpected.

Many of our telescopes are built to discover the known unknowns: the things we know we don't know, such as identifying the stuff that makes up dark matter.

But the real breakthroughs are the unknown unknowns. These are the things we don't even suspect are out there until we accidentally find them.

For example, of the ten greatest discoveries by the Hubble space telescope, only one featured in the proposal used to justify its construction and launch. That one, measuring the rate of expansion of the universe, is a known unknown.

In other words, we had a question about something that we knew about, and we thought Hubble could answer the question. Most of the other discoveries are unknown unknowns: we didn't know what they were until we stumbled across them.

They include the discovery of dark energy, the only Hubble discovery (so far) to win a Nobel prize, in 2011.

A chance discovery

Consider pulsars. They were discovered in the 1960s when a bright young PhD student in the UK, Jocelyn Bell Burnell, was studying the twinkling of radio waves by electrons in space (a known unknown).
She noticed odd bits of what she called "bits of scruff" on her chart recorder, and realised they were something much more startling than mere tractor interference, and thereby discovered pulsars – an unknown unknown – for which her supervisor Antony Hewish won the 1974 Nobel prize for physics.

So how did she make that discovery?

Apart from being a bright, persistent, open-minded student, Bell Burnell was also observing the universe in a way in which it had never been observed before. By looking at rapid changes in the radio waves, she was observing the universe using a parameter – in this case short timescale observations – that hadn't been used before.

Other discoveries happen when people observe with a different parameter, such as faintness, or area of sky, that hasn't been observed before. Together, these parameters make up our parameter space.

Most major astronomical discoveries seem to happen when somebody observes a new part of parameter space; observing the universe in a way it hasn't been observed before.

This new way might consist of looking more deeply, or with better resolution, or on a larger scale, or maybe just seeing much more of the universe. Extending any of these parameters into their unexplored regions is likely to lead to an unexpected discovery.

Right now several next-generation telescopes are being built, boldly going where no telescope has gone before. They will significantly expand the volume of observational parameter space, and should in principle discover unexpected new phenomena and new types of object.

For example, CSIRO's A$165-million ASKAP telescope, now nearing completion, is exploring several areas of uncharted parameter space, with an excellent chance of stumbling across a major unexpected discovery that could shake the scientific world.

But will we recognise it when we see it? Probably not.

Bell Burnell discovered pulsars by laboriously sifting through all her data, and noticed a tiny anomaly that didn't fit her understanding of the telescope.

**How much data?**

If Bell Burnell were observing with ASKAP, she would have to sift through about 80 petabytes of data a year, from a machine that is so complex that nobody truly understands every bit of it. Sorry, not even Bell Burnell's brain is up to the task of sifting through that amount of data.

We cannot possibly examine all that data by eye. So the way we do our science is that we decide on the scientific question we are asking, and turn it into a data query.

We then mine the database looking for those bits of data that will answer our question.

This is a very efficient way of answering the known unknowns. Sadly, it is useless at finding the unknown unknowns. We only receive answers to the questions that we ask, and not to the questions that we didn't know we ought to ask.

Now remember the Hitchhiker's Guide to the Galaxy science fiction/fantasy series by author Douglas Adams? When a giant computer, Deep Thought, found the answer to "life, the universe, and everything" to be 42, another, even bigger, computer had to be built to find out what the actual question was.
So can we design a machine, or a piece of software, to replicate Bell Burnell's brain in detecting unknown unknowns but working comfortably with petabytes of data and unbelievably complex telescopes?

**WTF into the unknowns**

I think we can, and we've already started the project WTF, which stands for *Widefield ouTlier Finder*, with the progress so far published just last month. The WTF machine will sift through the petabytes of data, searching for something unexpected, without knowing exactly what it's looking for.

The trick is to use machine learning techniques, where we teach the software about all the things we know about, and then ask it to find things we don't know about.

For example, it might plot a graph of radio brightness against optical colour. On that graph, it would find a cluster of quasars grouped together, another cluster of galaxies like the Milky Way, and so on.

Maybe it will find another cluster of objects that we didn't expect and didn't know about. Our puny brains couldn't make more than a small dent into all the possible graphs that need to be plotted, but WTF will take these in its stride.

This process won't be easy. At first, WTF will probably turn up things we forgot to tell it, and it will also find radio interference and instrumental artefacts.

As we gradually teach it what these are, it will start to recognise truly new objects and phenomena. More significantly, it will start to learn new things from the data that are made invisible to our brains by their sheer multidimensional complexity, but will be grist to the mill for WTF.

We expect WTF to become smarter than us, able to find those rare discoveries buried in the data. Perhaps WTF may even win the first non-human Nobel prize.

Source: Phys.org
The Coolest Landscape on Mars (or Earth)

Many Martian landscapes contain features that are familiar to ones we find on Earth, like river valleys, cliffs, glaciers and volcanos.

However, Mars has an exotic side too, with landscapes that are alien to Earthlings. This image shows one of these exotic locales at the South Pole. The polar cap is made from carbon dioxide (dry ice), which does not occur naturally on the Earth. The circular pits are holes in this dry ice layer that expand by a few meters each Martian year.

New dry ice is constantly being added to this landscape by freezing directly out of the carbon dioxide atmosphere or falling as snow. Freezing out the atmosphere like this limits how cold the surface can get to the frost point at -130 degrees Celsius (-200 F). Nowhere on Mars can ever get any colder this, making this this coolest landscape on Earth and Mars combined.

This is a stereo pair with ESP_047237_0930.

Image credit: NASA/JPL-Caltech/ Univ. of Arizona

Source: JPL