Space News Update

— July 25, 2017 —

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1. NASA might privatize one of its great observatories

Management of NASA's Spitzer Space Telescope could be turned over to an academic institution or private operator in 2019 once the space agency's funding for the observatory runs out, a senior NASA manager said this week.

Launched in August 2003 on a planned five-year mission, the infrared observatory is getting farther from Earth as it circles the sun, complicating communications with the telescope. But the mission continues to make observations, yielding discoveries about worlds around other stars, faraway galaxies that populated the early universe, and planets and asteroids within our own solar system.

NASA last year agreed to continue funding the Spitzer mission through early 2019, keeping the observatory active through the commissioning of the James Webb Space Telescope, a $10 billion flagship project that will represent perhaps the biggest leap in space astronomy since the launch of the Hubble Space Telescope in 1990.

Spitzer, which covers much of the same infrared wavelengths as JWST, could identify targets for follow-up observations by Webb. Parallel imaging of the same targets by Spitzer and JWST could also aid in calibration of the new telescope.

While Spitzer operations will be more challenging as the telescope flies greater distances from Earth, the spacecraft and instruments could remain functional after NASA's mission-end date in 2019.

Operated by NASA's Jet Propulsion Laboratory with engineering support from spacecraft-builder Lockheed Martin, Spitzer could be turned over to a private institution after NASA's support for the mission ends in 2019, according to Paul Hertz, director of the agency's astrophysics division.

"We are certainly open to a partnership proposal from any U.S. institution that would like to operate Spitzer on non-NASA funding beyond the NASA-funded mission, and I've heard there are people discussing this," Hertz said Wednesday in a meeting of NASA's Astrophysics Advisory Committee. "I just want to make sure everyone knows that we would welcome such an inquiry, proposal, or discussion."

If an outside funding source is found and approved, Spitzer would be loaned to a private operator, but NASA would retain ownership and responsibility for liability, Hertz said.

The model closely follows the way NASA turned over control of the GALEX astronomy satellite in Earth orbit to Caltech, which used private funds to continue operating the mission once NASA's commitment ended. That agreement was the first of its type for a government-owned science probe.

"We loan (it), and then they have to pay all the money it takes to operate it, and then at the end of the funded mission, we take it back and do safe disposal of the spacecraft," Hertz said.

A review of Spitzer's scientific potential last year by a panel of independent researchers recommended NASA continue the mission into early 2019. But the reviewers concluded NASA should divert Spitzer's funding to more worthwhile projects shortly after JWST's launch.

Faced with a limited federal budget, NASA must balance the need to develop future, more capable missions with keeping older spacecraft operational. A similar "senior review" of NASA's operating astrophysics missions in 2014 recommended NASA end its support of Spitzer that year, but top NASA officials overruled the panel after Spitzer found ways to operate the mission for less money.

"There's certainly good science to be done (with Spitzer) that can't fit into our funding plan," Hertz said Wednesday.

NASA's budget request for Spitzer operations in fiscal year 2018, which begins Oct. 1, is for $11 million.

Spitzer was the last of four telescopes to launch in NASA's Great Observatories program, joining Hubble, the Compton Gamma-Ray Observatory, and the Chandra X-ray Observatory.

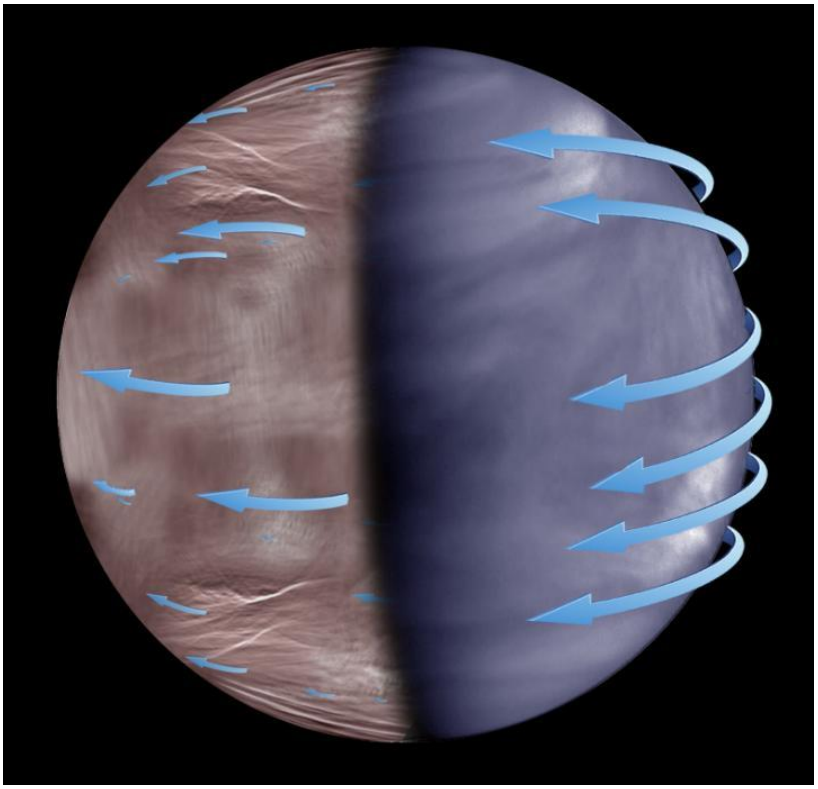
A Delta 2 rocket launched Spitzer from Cape Canaveral into an Earth-trailing orbit around the sun. The telescope circles the sun slightly slower than Earth, so Spitzer gets a little farther away each day. As of Saturday, the telescope was approximately 146 million miles (235 million kilometers) from Earth.

The range to Spitzer, and its closer proximity to the sun as viewed from Earth, makes communications with the observatory more difficult over time. Spitzer is also exposed to hotter temperatures as it gets farther from Earth because it must point its antenna at higher angles toward the sun to stay in contact with ground controllers.

One of Spitzer's most recent accomplishments was its role in the discovery of seven Earth-sized planets around a star 40 light-years, or about 235 trillion miles (378 trillion kilometers) from Earth. The TRAPPIST-1 system, announced in February, holds the record for the most potentially habitable planets around a single star outside our solar system, scientists said.

Source: Spaceflight Now Return to Contents

2. Venus's turbulent atmosphere



Venus is often referred to as Earth's twin because both planets share a similar size and surface composition. Also, they both have atmospheres with complex weather systems. But that is about where the similarities end: Venus is one the most hostile places in our solar system. Its atmosphere consists of 96.5 percent carbon dioxide, with surface temperatures of constantly about 500 degrees Celsius. Venus is a slowly rotating planet -- it needs about 243 terrestrial days to complete one rotation. We would expect its atmosphere to rotate with the same rhythm, but in fact it takes only four days. This phenomenon is called super-rotation, and it causes substantial turbulences in the planet's atmosphere. The scientists do not yet fully understand its origin and motor, but are working on an answer to this puzzle. The many waves in the planet's atmosphere may play an important role.

The research results were generated by an international collaboration headed by the Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency (JAXA). Experts in space and astronautical science and astrophysics from universities and institutions in Ja-pan, Spain, Italy, and Germany are cooperating in the project. From Germany, the Rhenish Institute for Environmental Research at the University of Cologne and the Center for Astronomy and Astrophysics at Technische Universität Berlin are involved.

The research team analyzed data generated by the spacecraft Venus Express to investigate components of Venus's complex atmosphere, including thermal measurements with regard to horizontal and vertical wave patterns. The data also included first global measurements from the tracking of individual features in thermal emission images at 3.8 and 5.0 µm (micrometer) during 2006-2008 and 2015.

Vertical information in unison with horizontal data helps to understand the nature of the observed wave patterns. The vertical information from the VeRa instrument (an atmosphere experiment where radio waves sent by spacecraft Venus Express are being analyzed) could help to identify the observed waves as gravity waves. This, in turn, is crucial for the analysis of atmospheric processes.

Dr. Silvia Tellmann is Vice-Director of the Department of Planetary Research at the Rhenish Institute for Environmental Research at the University of Cologne. She is an expert on the structure, dynamics, and circulation of planetary atmospheres and a co-author of the study. 'We were able to relate the stationary gravity waves found at higher altitudes with the surface elevations of Venus', she says. 'Hence, the waves can be explained with wind currents caused by topographical obstacles. We assume that these stationary waves are substantial for the continuity of the super rotation in the atmosphere of Venus.'

Source: EurekAlert

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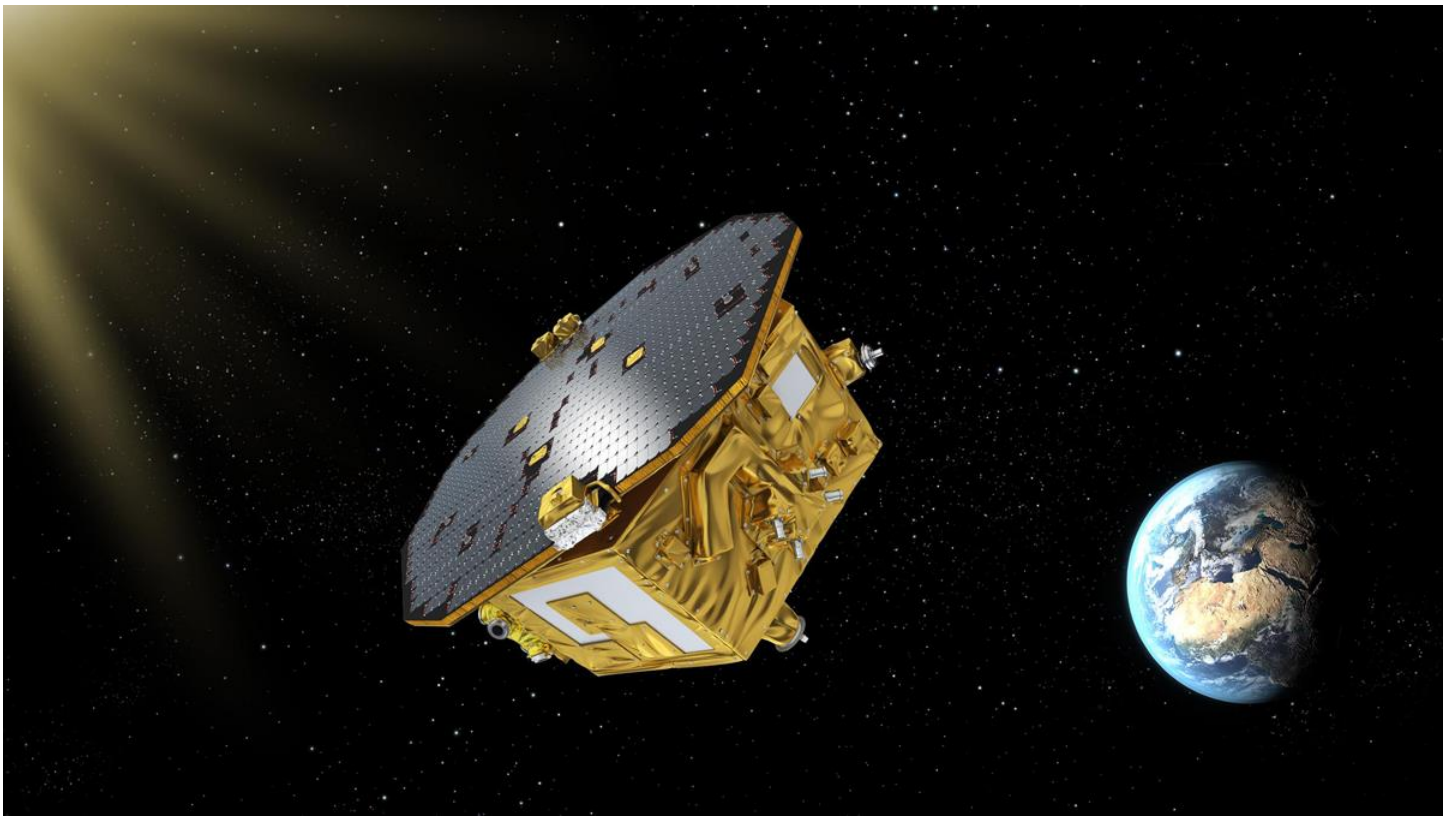
3. A Final Farewell to LISA Pathfinder



With the push of a button, final commands for the European Space Agency's LISA Pathfinder mission were beamed to space on July 18, a final goodbye before the spacecraft was powered down.

LISA Pathfinder had been directed into a parking orbit in April, keeping it out of Earth's way. The final action this week switches it off completely after a successful 16 months of science measurements.

While some spacecraft are flashy, never sitting still as they zip across the solar system, LISA Pathfinder was as steady as they come -- literally.

It housed a space-age motion detector so sensitive that it had to be protected against the force of photons from the Sun. That was made possible thanks to a system of thrusters that applied tiny reactive forces to the spacecraft, cancelling out the force of the Sun and allowing the spacecraft to stay within 10 nanometers of an ideal gravitational orbit.

These requirements for Pathfinder were so challenging and unique that LISA Pathfinder flew two independent systems based on different designs - one provided by NASA and one by ESA - and ran tests with both during its 16-month mission.

"We were trying to hold it as stable as the width of a DNA helix," said John Ziemer, systems lead for the U.S. thruster system at NASA's Jet Propulsion Laboratory in Pasadena, California. "And we went down from there to the width of part of a DNA helix."

JPL managed development of the thruster system, formally called the Space Technology 7 Disturbance Reduction System (ST7-DRS). The thrusters were developed by Busek Co., Inc., Natick, Massachusetts, with technical support from JPL. During the U.S. operations phase, Pathfinder was controlled using algorithms developed by ST7 team members at NASA's Goddard Space Flight Center in Greenbelt, Maryland. This control

system took inputs from the European sensors and sent commands to the thrusters to precisely guide the spacecraft along its path.

JPL finished primary mission experiments in the fall of 2016. In March and April of this year, they continued validating the algorithms used in stabilizing the spacecraft. They improved them through a number of tests.

"The main goal for us was to show we can fly the spacecraft drag-free," Ziemer said. "The main force on the spacecraft comes from the Sun, from photons with extremely tiny force that can subtly move the spacecraft."

So why build something this sensitive to begin with?

LISA Pathfinder was just a starting point. The mission was led by ESA as a stepping-stone of sorts, proving the technology needed for an even more ambitious plan, the Laser Interferometer Space Antenna (LISA): a trio of spacecraft proposed to launch in 2034. With each spacecraft holding as still as possible, they would be able to detect the ripples sent out across space by the merging of black holes.

These ripples, known as gravitational waves, have been a source of intense scientific interest in recent years. The ground-based Laser Interferometry Gravitational Wave Observatory detected gravitational waves for the first time in 2015.

But there's a bigger role for thrusters like the ones on LISA Pathfinder. Ziemer said the operation of super-steady thrusters could serve as an alternative to reaction wheels, the current standard for rotating and pointing spacecraft.

"This kind of technology could be essential for space telescopes," Ziemer said. "They could potentially hold them still enough to image exoplanets, or allow for formation flying of a series of spacecraft."

The thrusters are an enabling technology, opening up a magnitude of precision that simply wasn't available before.

The Pathfinder spacecraft was built by Airbus Defence and Space, Ltd., United Kingdom. Airbus Defence and Space, GmbH, Germany, is the payload architect for the LISA Technology Package.

Source: JPL Return to Contents

The Night Sky

Tuesday, July 25

• Now, in the west in twilight, a thicker, higher crescent moon shines upper left of Mercury and Regulus. The planet and star are in conjunction this evening, with Mercury to Regulus's lower right. (Their orientation in the scene here is for yesterday evening.)

Wednesday, July 26

• If you have a dark enough sky, the Milky Way forms a magnificent arch very high across the whole eastern sky after nightfall is complete. It runs all the way from below Cassiopeia in the north-northeast, up and across Cygnus and the Summer Triangle high in the east under bright Vega, and down past the spout of the Sagittarius Teapot in the south.

Thursday, July 27

• The first "star" you're likely to see coming out after sunset is Jupiter in the southwest. It's about a fist at arm's length left of the Moon this evening, as shown here.

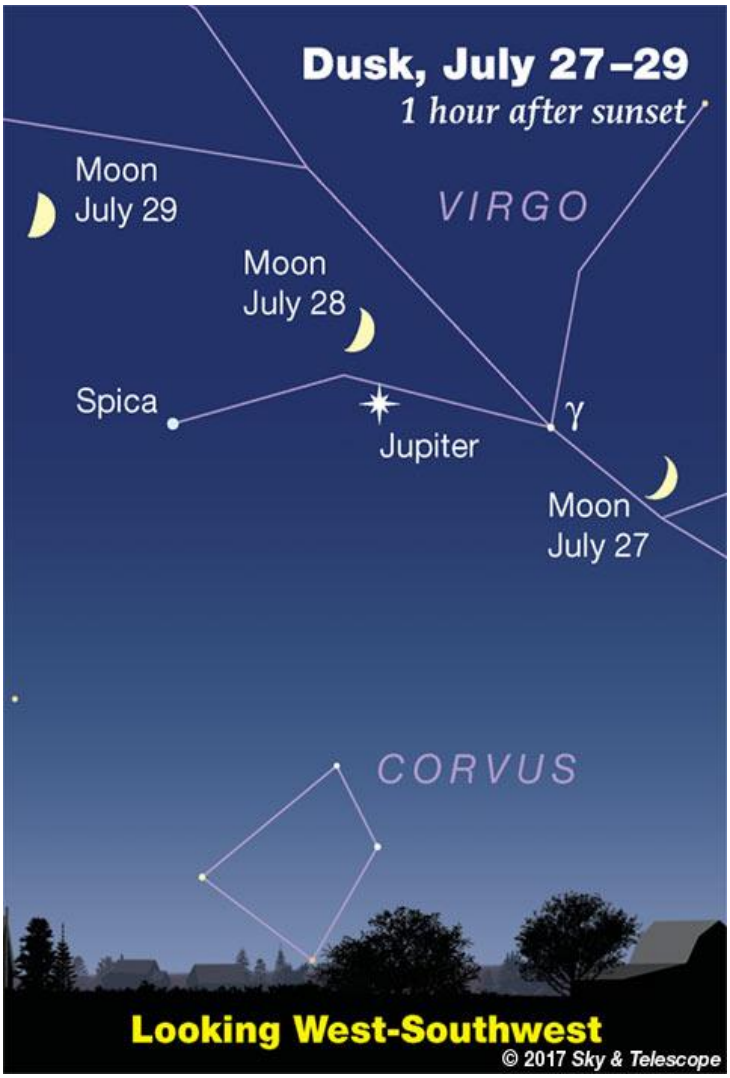
Once you find Jupiter, examine the sky about three fists above it for Arcturus, two magnitudes fainter.

As night deepens, you can see that the Moon forms the right-hand end of a gently curving arc with, to its left, faint Gamma Virginis, Jupiter, and Spica.

Friday, July 28

• Jupiter shines under the Moon this evening, more or less as drawn here (their exact placement will depend on your location).

• The Sagittarius Teapot is in the south after darkness is complete. It's about a fist at arm's length wide, and it's now tilting to pour from its spout on the right. The Teapot will tilt farther and farther, pouring out for the rest of the summer — or for much of the night if you stay out late.



Waxing further, the Moon passes the lineup of Spica, Jupiter, and Gamma (γ) Virginis.

Source: Sky & Telescope

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ISS Sighting Opportunities

For Denver:

Date	Visible	Max Height	Appears	Disappears
Tue Jul 25, 9:20 PM	6 min	56°	10° above WSW	10° above NE
Tue Jul 25, 11:01 PM	1 min	13°	13° above N	10° above NNE
Wed Jul 26, 00:39 AM	< 1 min	10°	10° above NNE	10° above NNE
Wed Jul 26, 10:08 PM	2 min	18°	18° above NNW	10° above NNE
Wed Jul 26, 11:46 PM	< 1 min	10°	10° above N	10° above N
Thu Jul 27, 9:16 PM	3 min	27°	27° above NNW	10° above NNE
Thu Jul 27, 10:53 PM	< 1 min	11°	11° above N	10° above N
Fri Jul 28, 10:01 PM	1 min	13°	13° above N	10° above NNE
Fri Jul 28, 11:37 PM	1 min	10°	10° above N	10° above NNE

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

NASA-TV Highlights

(all times Eastern Daylight Time)

Tuesday, July 25

- 3 p.m. - Coverage of the RS-25 Rocket Engine Test Firing (all channels)
- 4 p.m. - Coverage of the RS-25 Rocket Engine Test Firing (all channels)
- 7 p.m. - Replay of the ISS Expedition 52 In-Flight Media Interviews with KOA Radio, Denver and KFI Radio, Los Angeles and NASA Flight Engineer Jack Fischer (all channels)
- 11 p.m. - Replay of the ISS Expedition 52 In-Flight Media Interviews with KOA Radio, Denver and KFI Radio, Los Angeles and NASA Flight Engineer Jack Fischer (NTV-1 (Public))

Wednesday, July 26

- 12 p.m. - Video File of the ISS Expedition 52-53/ Soyuz MS-05 Rollout to the Launch Pad and Pad Interviews at the Baikonur Cosmodrome in Kazakhstan (all channels)
- 2:30 p.m. - ISS Expedition 52 In-Flight Interview with the Guinness Book of World Records and NASA Flight Engineer Peggy Whitson (starts at 2:25 p.m.) (all channels)

Thursday, July 27

- 4 p.m., - Replay of the Russian State Commission Meeting and Final ISS Expedition 52-53 Pre-Launch Crew (Ryazanskiy, Bresnik, Nespoli) News Conference in Baikonur, Kazakhstan (all channels)

Friday, July 28

- 10:30 a.m. - ISS Expedition 52-53/Soyuz MS-05 Launch Coverage (Ryazanskiy, Bresnik, Nespoli; includes video B-roll of the crew's launch day pre-launch activities at 11 a.m. ET; launch scheduled at 11:41 a.m. ET) (starts at 10:45 a.m.) (all channels)

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

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Space Calendar

- Jul 25 - Cassini, Distant Flyby of Titan & Pan
- Jul 25 - Moon Occults Mercury
- Jul 25 - Comet 353P/McNaught) At Opposition (1.480 AU)
- Jul 25 - Aten Asteroid 2017 OM1 Near-Earth Flyby (0.006 AU)
- Jul 25 - Apollo Asteroid 2017 OE1 Near-Earth Flyby (0.022 AU)
- Jul 25 - Apollo Asteroid 2014 WW202 Near-Earth Flyby (0.052 AU)
- Jul 25 - Apollo Asteroid 480858 (2001 PT9) Near-Earth Flyby (0.069 AU)
- Jul 25 - Asteroid 128 Nemesis Closest Approach To Earth (1.642 AU)
- Jul 25 - Asteroid 48300 Kronk Closest Approach To Earth (1.935 AU)
- Jul 25-26 - Fred Lo Symposium, Charlottesville, Virginia
- Jul 25-29 - 15th International Conference on Topics in Astroparticle and Underground Physics (TAUP 2017), Sudbury, Canada
- Jul 25-Aug 03 - Summer School: Impacts and their Role in the Evolution of Life, Saaremaa, Estonia
- Jul 26 - Comet 259P/Garradd At Opposition (0.872 AU)
- Jul 26 - Asteroid 1332 Marconia Occults HIP 104204 (6.7 Magnitude Star)
- Jul 26 - Apollo Asteroid 4660 Nereus Closest Approach To Earth (0.996 AU)
- Jul 26 - Apollo Asteroid 2135 Aristaeus Closest Approach To Earth (1.771 AU)
- Jul 26 - Asteroid 5805 Glasgow Closest Approach To Earth (1.804 AU)
- Jul 26 - Asteroid 12820 Robinwilliams Closest Approach To Earth (1.868 AU)
- Jul 26 - Colloquium: MeerKATs with Big IDIAs - How Data-Intensive Astronomy is bringing the Research Cloud to Africa, Sydney, Australia
- Jul 26-27 - CHEOPS Open Time Workshop 2017, Schloss Seggau, Austria
- Jul 26-28 - NA61 Beyond 2020 Workshop: Future Physics Opportunities with the NA61/SHINE Spectrometer, Geneva, Switzerland
- Jul 27 - Cassini, Distant Flyby of Titan
- Jul 27 - Moon Occults Asteroid 16 Psyche
- Jul 27 - Comet 259P/Garradd Closest Approach To Earth (0.872 AU)
- Jul 27 - Asteroid 90125 Chrissquire Closest Approach To Earth (1.729 AU)
- Jul 27 - Asteroid 3125 Hay Closest Approach To Earth (2.106 AU)
- Jul 27 - Asteroid 1154 Astronomia Closest Approach To Earth (2.149 AU)
- Jul 27 - Wilhelm Brandes' 240th Birthday (1777)
- Jul 27-28 - 5th US-China Workshop on Radio Astronomy Science and Technology, Charlottesville, Virginia
- **Jul 28 - Soyuz MS-5 Soyuz-FG Launch (International Space Station 51S)**
- Jul 28 - Comet 198P/ODAS At Opposition (2.803 AU)
- Jul 28 - Comet 333P/LINEAR At Opposition (3.573 AU)
- Jul 28 - Asteroid 10101 Fourier Closest Approach To Earth (1.332 AU)
- Jul 28 - Asteroid 6111 Davemckay Closest Approach To Earth (1.487 AU)
- Jul 28 - Asteroid 5036 Tuttle Closest Approach To Earth (2.569 AU)
- Jul 28 - Charles Perrine's 150th Birthday (1867)
- Jul 28-29 - Butter Pot Star Party, Butter Pot Provincial Park, Canada
- Jul 28-30 - Nova East 2017 Star Party, Smileys Provincial Park, Nova Scotia, Canada
- Jul 28-30 - Camping & Observing Weekend (COW) Mactaquac Star Party, Mactaquac, Canada
- Jul 28-30 - RASCals Star Party, Metchosin, Canada

Source: JPL Space Calendar

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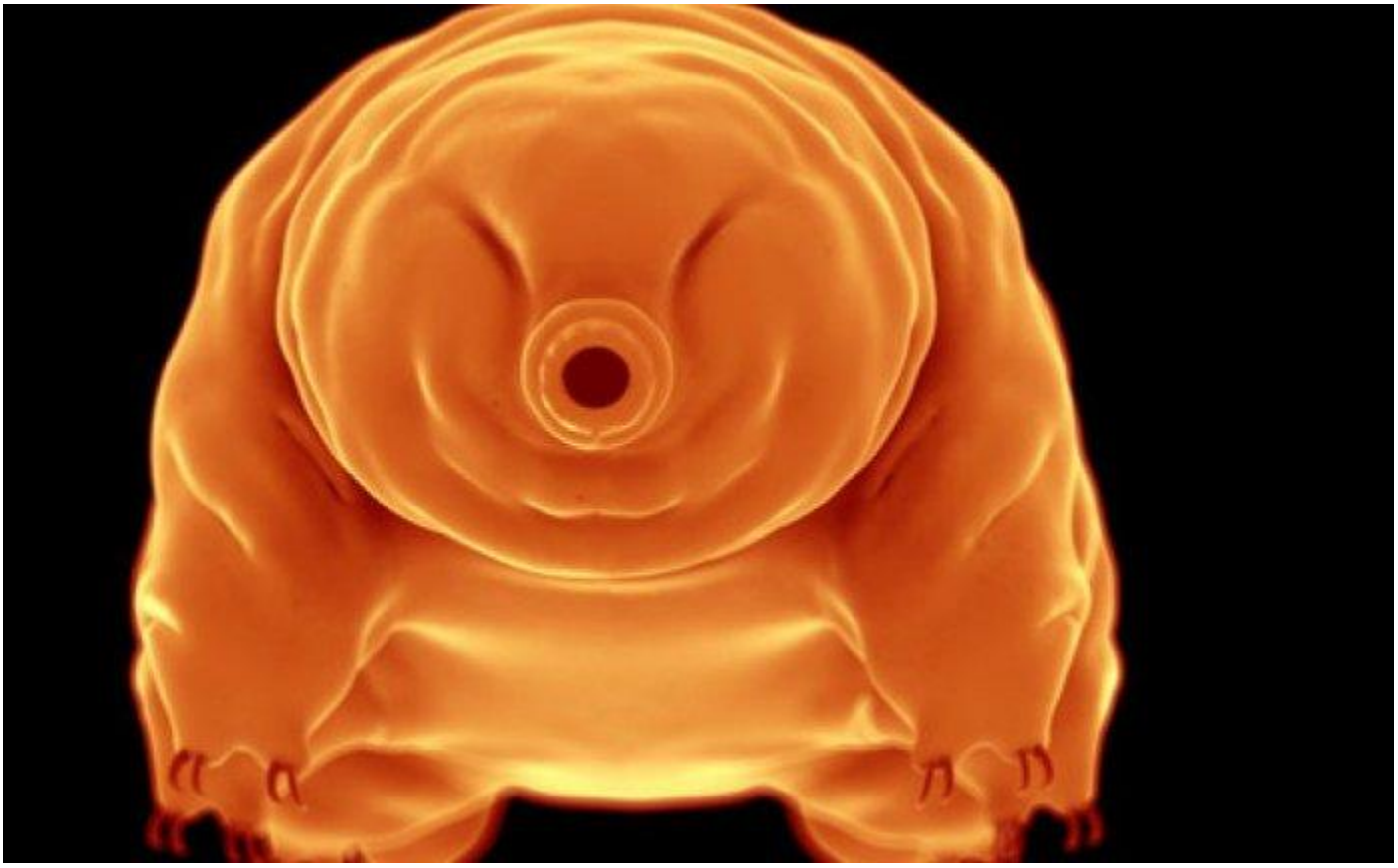
Food for Thought

Long After Humanity is Gone and the Sun Dies, the Water Bears Will Be There



Like all living creatures, stars have a natural lifespan. After going through their main sequence phase, they eventually exhaust their nuclear fuel and begin the slow process towards death. In our Sun's case, this will consist of it growing in size and entering the Red Giant phase of its evolution. When that happens, roughly 5.4 billion years from now, the Sun will encompass the orbits of Mercury, Venus, and maybe even Earth.

However, even before this happens, astronomers theorize that the Sun will dramatically heat up, which will render Earth uninhabitable to most species. But according to a new study by a team of researchers from Oxford and the University of Harvard, the species known as tardigrades (aka. the "water bear") will likely survive even after humanity and all other species have perished.

This study, which was recently published in the journal *Scientific Reports* under the title "The Resilience of Life to Astrophysical Events", was conducted by Dr. David Sloan, Dr. Rafael Alves Batista – from the Department of Astrophysics at Oxford University – and Dr. Abraham Loeb of the Harvard-Smithsonian Center for Astrophysics (CfA). As they indicate, previous studies into the effect Solar evolution will have on life have been rather lopsided.

Essentially, much attention has been dedicated to whether or not humanity will survive our Sun leaving its main sequence phase. Comparatively, very little research has been conducted on whether or not life itself (and which lifeforms) will be able to survive this change. As such, they considered the most statistically-likely events that would be capable of completely sterilizing an Earth-like planet, and sought to determine what lifeforms could endure them.

As Dr. Loeb told Universe Today via email, their team wanted to consider if there was an extinction-level event that could eliminate all life on Earth (not just humans):

"We wanted to find out how long life may survive on a planet once formed. Most previous studies focused on the survival of humans which are very sensitive to changes in the atmosphere or climate of the Earth and can be eliminated by the impact of an asteroid (nuclear winter) or bad politics."

What they found was that the species *Milnesium tardigradum* would survive all potential astrophysical catastrophes. What's more, they estimated that these creatures will be around for another 10 billion years at least – far longer than what is anticipated for the human race! As Loeb indicates, this was not an outcome that they were expecting.

"To our surprise, tardigrades are likely to survive all astrophysical catastrophes," he said. "Most likely, the DNA of tardigrades is able to repair itself quickly due to damage encountered by the environment. The process is not fully understood, and there is a group at Harvard University who studies the SNA of tardigrades with the hope of understanding it better."

To be fair, it has been known for some time that Tardigrades are the most resilient life form on Earth. Not only can they survive for up to 30 years without food or water (half their natural lifespan), they can also survive temperatures of up to 150 °C (302 °F) and as low as -200 °C (-328 °F). They have also shown themselves to be capable of enduring extremes in pressure, ranging from the 6000 atmospheres to the vacuum of open space.

Under these conditions, the research team concluded that they are likely to survive the Sun becoming a red giant and irradiating Earth, and will likely be alive even after the Sun has winked out of existence. On top of that, tardigrades can even be brought back to life, under the right circumstances. Much like all life on Earth, tradigrades need water to survive, even though they can survive in a dry state for extended periods of time – up to ten years, in fact.

But even after being deprived of water to the point of death, scientists have found that these organisms can be reanimated once water is reintroduced. This was demonstrated in 2007 when a batch of tardigrades was dehydrated before being launched to Low Earth Orbit (LEO). After being exposed to the hard vacuum of space and UV radiation for 10 days, they were returned to Earth and rehydrated – at which point, the majority were revived and able to produce viable embryos.

The team also concluded that other cataclysmic events – such as an asteroid strike, exploding stars (i.e. a supernovae) or gamma ray bursts – pose no existential threat to tardigrades. As Loeb explained:

"We have found that asteroid impacts are capable of boiling off all the oceans on Earth, but only if the asteroid is more massive than 10^{18} kg [10,000 trillion metric tons]. Such events are extremely rare and will not happen before the Sun will die; the probability of them happening earlier is less than one part in a million."

In fact, the last time an object large enough to boil the oceans (2×10^{18} kg) collided with Earth occurred roughly 4.51 billion years ago. On this occasion, Earth was struck by a Mars-sized object named Theia, which is believed to be what caused the formation of the Moon. Today, there are only a dozen known asteroids or dwarf planets in the Solar System that have this kind of mass, and none of them will intersect the Earth's orbit in the future.

As for supernova, they indicated that an exploding star would need to be 0.14 light-years from Earth in order for it to boil the oceans from its surface. Since the closest star to our Sun (Proxima Centauri) is 4.25 light

years away, this scenario is not a foreseeable risk. As for gamma-ray bursts, which are even rarer than supernova, the team determined that they too are too far away from Earth to pose a threat.

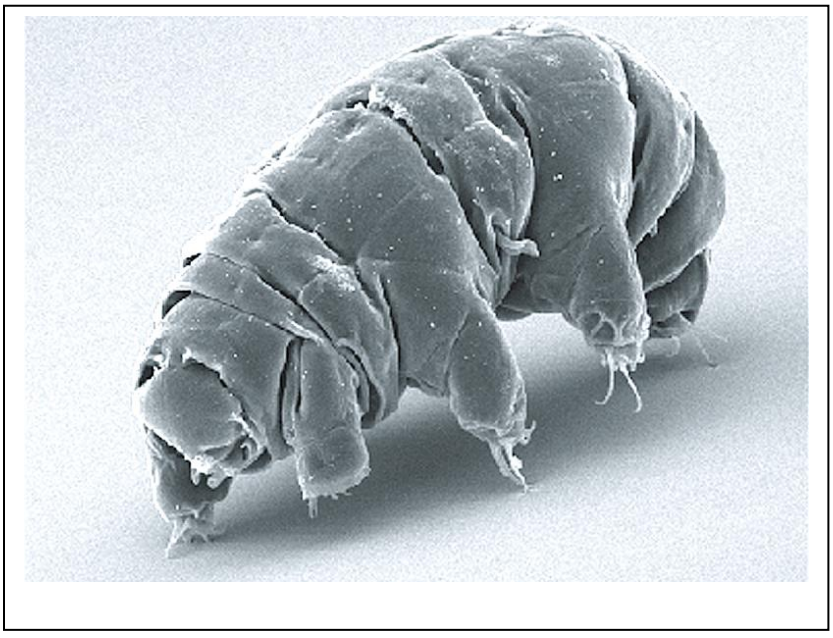
The implications of this study are quite fascinating. For one, it reminds us just how fragile human life is compared to basic, microscopic life forms. It also demonstrates that similarly hardy organisms could exist in a variety of locations that we may have once considered too hostile for life. As Dr Rafael Alves Batista, one of the co-authors on the study, said in a University of Oxford press release:

"Without our technology protecting us, humans are a very sensitive species. Subtle changes in our environment impact us dramatically. There are many more resilient species' on earth. Life on this planet can continue long after humans are gone. Tardigrades are as close to indestructible as it gets on Earth, but it is possible that there are other resilient species examples elsewhere in the Universe. In this context there is a real case for looking for life on Mars and in other areas of the Solar System in general. If Tardigrades are earth's most resilient species, who knows what else is out there?'"

And as Dr. Loeb explained, studies like this have potential benefits that go far beyond assessing our own survivability. Not only do they help us understand life's ability to endure catastrophic events – which is essential to understanding how and where life could emerge in the Universe – but they also offer possibilities on how we might better our own chances of survival.

"We get a better understanding of the conditions under which life will persist," he said. "In about a billion years, when the Sun will heat up life will cease, but until then it will continue in some form. Understanding the self-repair mechanism of the DNA on tardigrades could potentially help in combating disease for humans as well."

And all his time, we thought cockroaches were the toughest critters on the planet, what with their ability to withstand a nuclear holocaust. But these eight-legged creatures, which are arguably cuter than cockroaches too, clearly have the market on toughness cornered. We're just lucky they only get up to 0.5 mm (0.02 in) in size; otherwise we might have something to worry about!



Scanning Electron Microscope (SEM) image of Milnesium tardigradum in active state. Credit: Schokraie E/Warnken U/Hotz-Wagenblatt A/Grohme MA/Hengherr S, et al.

Source: Universe Today

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Space Image of the Week

IC 1396: Emission Nebula in Cepheus
Image Credit & Copyright: César Blanco González

Explanation: Stunning emission nebula IC 1396 mixes glowing cosmic gas and dark dust clouds in the high and far off constellation of Cepheus. Energized by the bright central star seen here, this star forming region sprawls across hundreds of light-years, spanning over three degrees on the sky while nearly 3,000 light-years from planet Earth. Among the intriguing dark shapes within IC 1396, the winding Elephant's Trunk nebula lies just below center. Stars could still be forming inside the dark shapes by gravitational collapse. But as the denser clouds are eroded away by powerful stellar winds and radiation, any forming stars will ultimately be cut off from the reservoir of star stuff. The gorgeous color view is a composition of image data from narrowband filters, mapping emission from the nebula's atomic oxygen, hydrogen, and sulfur into blue, green, and red hues.

Source: APOD

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