Space News Update

— August 3, 2018 —

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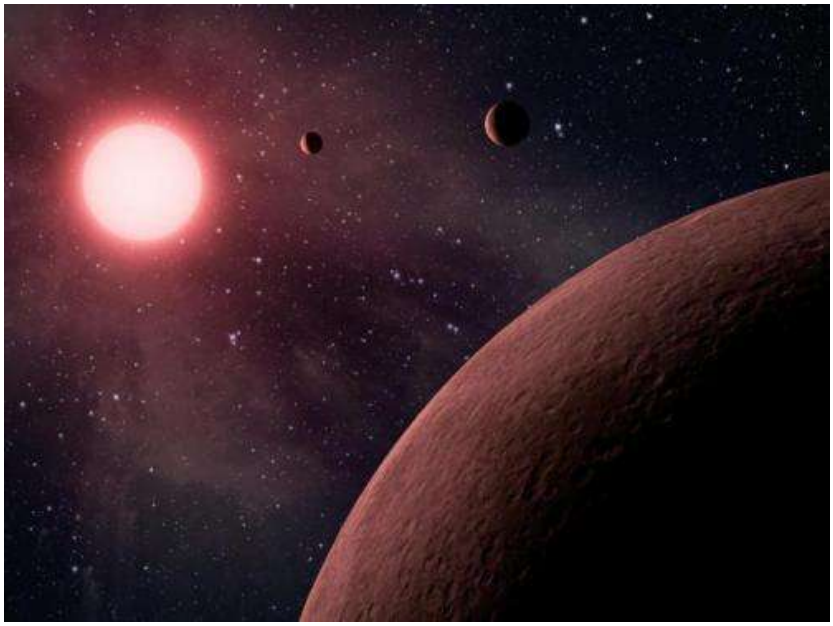
1. Scientists Identify Exoplanets Where Life Could Develop as it Did on Earth



Scientists have identified a group of planets outside our solar system where the same chemical conditions that may have led to life on Earth exist.

The researchers, from the University of Cambridge and the Medical Research Council Laboratory of Molecular Biology (MRC LMB), found that the chances for life to develop on the surface of a rocky planet like Earth are connected to the type and strength of light given off by its host star.

Their study, published in the journal *Science Advances*, proposes that stars which give off sufficient ultraviolet (UV) light could kick-start life on their orbiting planets in the same way it likely developed on Earth, where the UV light powers a series of chemical reactions that produce the building blocks of life.

The researchers have identified a range of planets where the UV light from their host star is sufficient to allow these chemical reactions to take place, and that lie within the habitable range where liquid water can exist on the planet's surface.

"This work allows us to narrow down the best places to search for life," said Dr. Paul Rimmer, a postdoctoral researcher with a joint affiliation at Cambridge's Cavendish Laboratory and the MRC LMB, and the paper's first author. "It brings us just a little bit closer to addressing the question of whether we are alone in the universe."

The new paper is the result of an ongoing collaboration between the Cavendish Laboratory and the MRC LMB, bringing together organic chemistry and exoplanet research. It builds on the work of Professor John Sutherland, a co-author on the current paper, who studies the chemical origin of life on Earth.

In a paper published in 2015, Professor Sutherland's group at the MRC LMB proposed that cyanide, although a deadly poison, was in fact a key ingredient in the primordial soup from which all life on Earth originated.

In this hypothesis, carbon from meteorites that slammed into the young Earth interacted with nitrogen in the atmosphere to form hydrogen cyanide. The hydrogen cyanide rained to the surface, where it interacted with other elements in various ways, powered by the UV light from the sun. The chemicals produced from these interactions generated the building blocks of RNA, the close relative of DNA which most biologists believe was the first molecule of life to carry information.

In the laboratory, Sutherland's group recreated these chemical reactions under UV lamps, and generated the precursors to lipids, amino acids and nucleotides, all of which are essential components of living cells.

"I came across these earlier experiments, and as an astronomer, my first question is always what kind of light are you using, which as chemists they hadn't really thought about," said Rimmer. "I started out measuring the number of photons emitted by their lamps, and then realised that comparing this light to the light of different stars was a straightforward next step."

The two groups performed a series of laboratory experiments to measure how quickly the building blocks of life can be formed from hydrogen cyanide and hydrogen sulphite ions in water when exposed to UV light. They then performed the same experiment in the absence of light.

"There is chemistry that happens in the dark: it's slower than the chemistry that happens in the light, but it's there," said senior author Professor Didier Queloz, also from the Cavendish Laboratory. "We wanted to see how much light it would take for the light chemistry to win out over the dark chemistry."

The same experiment run in the dark with the hydrogen cyanide and the hydrogen sulphite resulted in an inert compound which could not be used to form the building blocks of life, while the experiment performed under the lights did result in the necessary building blocks.

The researchers then compared the light chemistry to the dark chemistry against the UV light of different stars. They plotted the amount of UV light available to planets in orbit around these stars to determine where the chemistry could be activated.

They found that stars around the same temperature as our sun emitted enough light for the building blocks of life to have formed on the surfaces of their planets. Cool stars, on the other hand, do not produce enough light for these building blocks to be formed, except if they have frequent powerful solar flares to jolt the chemistry forward step by step. Planets that both receive enough light to activate the chemistry and could have liquid water on their surfaces reside in what the researchers have called the abiogenesis zone.

Among the known exoplanets which reside in the abiogenesis zone are several planets detected by the Kepler telescope, including Kepler 452b, a planet that has been nicknamed Earth's 'cousin', although it is too far away to probe with current technology. Next-generation telescopes, such as NASA's TESS and James Webb Telescopes, will hopefully be able to identify and potentially characterise many more planets that lie within the abiogenesis zone.

Of course, it is also possible that if there is life on other planets, that it has or will develop in a totally different way than it did on Earth.

"I'm not sure how contingent life is, but given that we only have one example so far, it makes sense to look for places that are most like us," said Rimmer. "There's an important distinction between what is necessary and what is sufficient. The building blocks are necessary, but they may not be sufficient: it's possible you could mix them for billions of years and nothing happens. But you want to at least look at the places where the necessary things exist."

According to recent estimates, there are as many as 700 million trillion terrestrial planets in the observable universe. "Getting some idea of what fraction have been, or might be, primed for life fascinates me," said Sutherland. "Of course, being primed for life is not everything and we still don't know how likely the origin of life is, even given favourable circumstances—if it's really unlikely then we might be alone, but if not, we may have company."

Explore further: Researchers show role for cyanide in origins of life

More information: P.B. Rimmer el al., "The origin of RNA precursors on exoplanets," *Science Advances* (2018). DOI: 10.1126/sciadv.aar3302 , http://advances.sciencemag.org/content/4/8/eaar3302

Source: Phys.org

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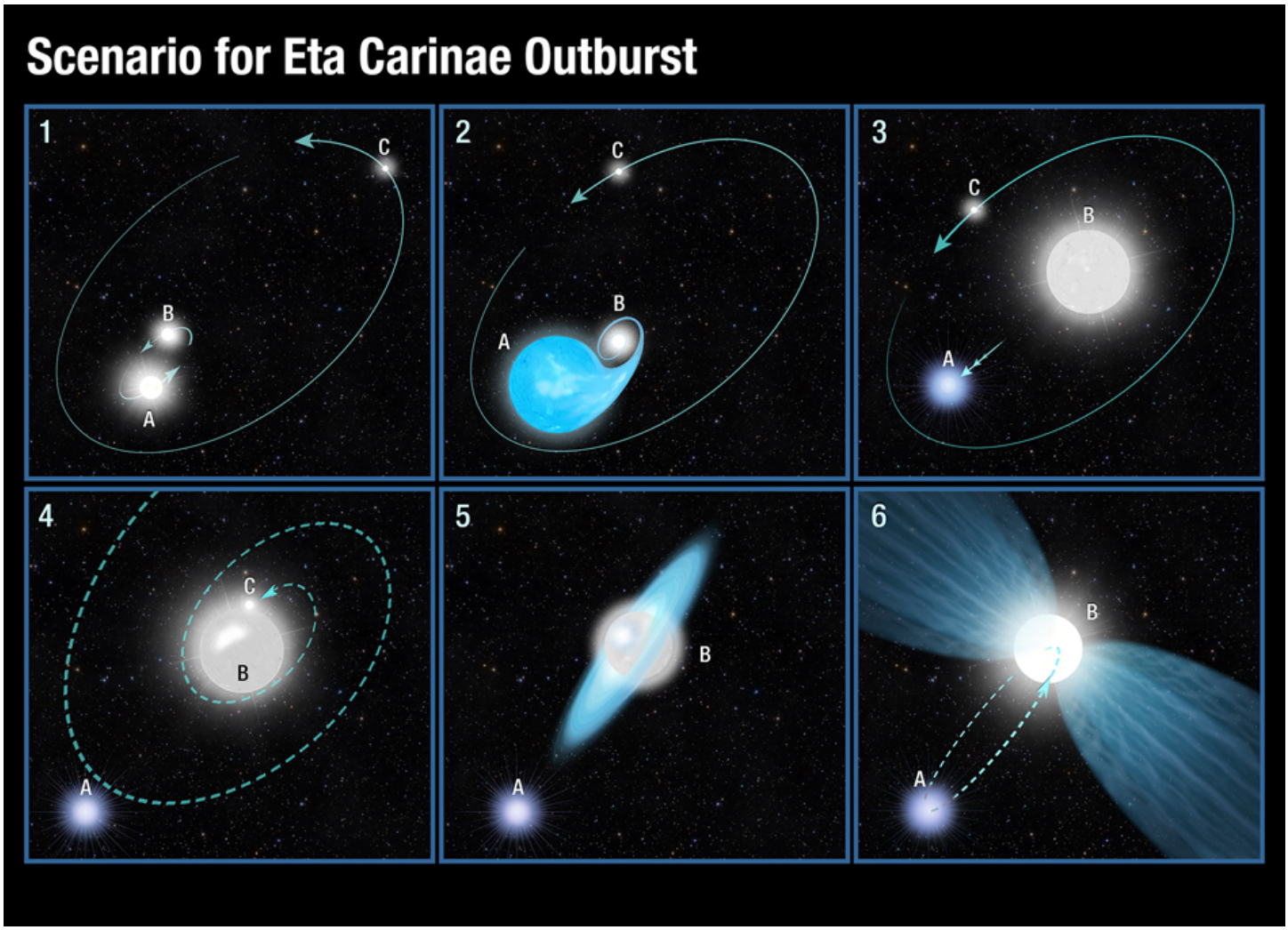
2. New Clues to Eta Carinae Outburst



What happens when a star behaves like it exploded, but it's still there?

About 170 years ago, astronomers witnessed a major outburst by Eta Carinae, one of the brightest known stars in the Milky Way galaxy. The blast unleashed almost as much energy as a standard supernova explosion.

Yet Eta Carinae survived.

An explanation for the eruption has eluded astrophysicists. They can't take a time machine back to the mid-1800s to observe the outburst with modern technology.

However, astronomers can use nature's own "time machine," courtesy of the fact that light travels at a finite speed through space. Rather than heading straight toward Earth, some of the light from the outburst rebounded or "echoed" off of interstellar dust, and is just now arriving at Earth. This effect is called a light echo. The light is behaving like a postcard that got lost in the mail and is only arriving 170 years later.

By performing modern astronomical forensics of the delayed light with ground-based telescopes, astronomers uncovered a surprise. The new measurements of the 19th-century eruption reveal material expanding with record-breaking speeds up to 20 times faster than astronomers expected. The observed velocities are more like the fastest material ejected by the blast wave in a supernova explosion, rather than the relatively slow and gentle winds expected from massive stars before they die.

Based on this data, researchers suggest that the 1840s eruption may have been triggered by a prolonged stellar brawl among three rowdy sibling stars, which destroyed one star and left the other two in a binary system. This tussle may have culminated with a violent explosion when Eta Carinae devoured one of its two companions, rocketing more than 10 times the mass of our Sun into space. The ejected mass created gigantic bipolar lobes resembling the dumbbell shape seen in present-day images.

The results are reported in a pair of papers by a team led by Nathan Smith of the University of Arizona in Tucson, Arizona, and Armin Rest of the Space Telescope Science Institute in Baltimore, Maryland.

The light echoes were detected in visible-light images obtained since 2003 with moderate-sized telescopes at the Cerro Tololo Inter-American Observatory in Chile. Using larger telescopes at the Magellan Observatory and the Gemini South Observatory, both also located in Chile, the team then used spectroscopy to dissect the light, allowing them to measure the ejecta's expansion speeds. They clocked material zipping along at more than 20 million miles per hour (fast enough to travel from Earth to Pluto in a few days).

The observations offer new clues to the mystery surrounding the titanic convulsion that, at the time, made Eta Carinae the second-brightest nighttime star seen in the sky from Earth between 1837 and 1858. The data hint at how it may have come to be the most luminous and massive star in the Milky Way galaxy.

"We see these really high velocities in a star that seems to have had a powerful explosion, but somehow the star survived," Smith explained. "The easiest way to do this is with a shock wave that exits the star and accelerates material to very high speeds."

Massive stars normally meet their final demise in shock-driven events when their cores collapse to make a neutron star or black hole. Astronomers see this phenomenon in supernova explosions where the star is obliterated. So how do you have a star explode with a shock-driven event, but it isn't enough to completely blow itself apart? Some violent event must have dumped just the right amount of energy onto the star, causing it to eject its outer layers. But the energy wasn't enough to completely annihilate the star.

One possibility for just such an event is a merger between two stars, but it has been hard to find a scenario that could work and match all the data on Eta Carinae.

The researchers suggest that the most straightforward way to explain a wide range of observed facts surrounding the eruption is with an interaction of three stars, where the objects exchange mass.

If that's the case, then the present-day remnant binary system must have started out as a triple system. "The reason why we suggest that members of a crazy triple system interact with each other is because this is the best explanation for how the present-day companion quickly lost its outer layers before its more massive sibling," Smith said.

In the team's proposed scenario, two hefty stars are orbiting closely and a third companion is orbiting farther away. When the most massive of the close binary stars nears the end of its life, it begins to expand and dumps most of its material onto its slightly smaller sibling.

The sibling has now bulked up to about 100 times the mass of our Sun and is extremely bright. The donor star, now only about 30 solar masses, has been stripped of its hydrogen layers, exposing its hot helium core.

Hot helium core stars are known to represent an advanced stage of evolution in the lives of massive stars. "From stellar evolution, there's a pretty firm understanding that more massive stars live their lives more quickly and less massive stars have longer lifetimes," Rest explained. "So the hot companion star seems to be further along in its evolution, even though it is now a much less massive star than the one it is orbiting. That doesn't make sense without a transfer of mass."

The mass transfer alters the gravitational balance of the system, and the helium-core star moves farther away from its monster sibling. The star travels so far away that it gravitationally interacts with the outermost third star, kicking it inward. After making a few close passes, the star merges with its heavyweight partner, producing an outflow of material.

In the merger's initial stages, the ejecta is dense and expanding relatively slowly as the two stars spiral closer and closer. Later, an explosive event occurs when the two inner stars finally join together, blasting off material moving 100 times faster. This material eventually catches up with the slow ejecta and rams into it like a snowplow, heating the material and making it glow. This glowing material is the light source of the main historical eruption seen by astronomers a century and a half ago.

Meanwhile, the smaller helium-core star settles into an elliptical orbit, passing through the giant star's outer layers every 5.5 years. This interaction generates X-ray emitting shock waves.

A better understanding of the physics of Eta Carinae's eruption may help to shed light on the complicated interactions of binary and multiple stars, which are critical for understanding the evolution and death of massive stars.

The Eta Carinae system resides 7,500 light-years away inside the Carina nebula, a vast star-forming region seen in the southern sky.

The team published its findings in two papers, which appear online Aug. 2 in The Monthly Notices of the Royal Astronomical Society [https://academic.oup.com/mnras].

Source: Spaceref.com Return to Contents

3. NASA Assigns Crews to First Test Flights, Missions on Commercial Spacecraft

NASA introduced to the world on Aug. 3, 2018, the first U.S. astronauts who will fly on American-made, commercial spacecraft to and from the International Space Station – an endeavor that will return astronaut launches to U.S. soil for the first time since the space shuttle's retirement in 2011. The agency assigned nine astronauts to crew the first test flight and mission of both Boeing's CST-100 Starliner and SpaceX's Crew Dragon. The astronauts are, from left to right: Sunita Williams, Josh Cassada, Eric Boe, Nicole Mann, Christopher Ferguson, Douglas Hurley, Robert Behnken, Michael Hopkins and Victor Glover.

NASA introduced to the world on Friday the first U.S. astronauts who will fly on American-made, commercial spacecraft to and from the International Space Station – an endeavor that will return astronaut launches to U.S. soil for the first time since the space shuttle's retirement in 2011.

"Today, our country's dreams of greater achievements in space are within our grasp," said NASA Administrator Jim Bridenstine. "This accomplished group of American astronauts, flying on new spacecraft developed by our commercial partners Boeing and SpaceX, will launch a new era of human spaceflight. Today's announcement advances our great American vision and strengthens the nation's leadership in space."

The agency assigned nine astronauts to crew the first test flight and mission of both Boeing's CST-100 Starliner and SpaceX's Crew Dragon. NASA has worked closely with the companies throughout design, development and testing to ensure the systems meet NASA's safety and performance requirements.

"The men and women we assign to these first flights are at the forefront of this exciting new time for human spaceflight," said Mark Geyer, director of NASA's Johnson Space Center in Houston. "It will be thrilling to see our astronauts lift off from American soil, and we can't wait to see them aboard the International Space Station."

Starliner Test Flight Astronauts

Eric Boe was born in Miami and grew up in Atlanta. He came to NASA from the Air Force, where he was a fighter pilot and test pilot and rose to the rank of colonel. He was selected as an astronaut in 2000 and piloted space shuttle Endeavour for the STS-126 mission and Discovery on its final flight, STS-133.

Christopher Ferguson is a native of Philadelphia. He is a retired Navy captain, who piloted space shuttle Atlantis for STS-115, and commanded shuttle Endeavour on STS-126 and Atlantis for the final flight of the Space Shuttle Program, STS-135. He retired from NASA in 2011 and has been an integral part of Boeing's CST-100 Starliner program.

Nicole Aunapu Mann is a California native and a lieutenant colonel in the Marine Corps. She is an F/A-18 test pilot with more than 2,500 flight hours in more than 25 aircraft. Mann was selected as an astronaut in 2013. This will be her first trip to space.

Boeing's Starliner will launch aboard a United Launch Alliance (ULA) Atlas V rocket from Space Launch Complex 41 at Cape Canaveral Air Force Station in Florida.

Crew Dragon Test Flight Astronauts

Robert Behnken is from St. Ann, Missouri. He has a doctorate in engineering and is a flight test engineer and colonel in the Air Force. He joined the astronaut corps in 2000 and flew aboard space shuttle Endeavour twice, for the STS-123 and STS-130 missions, during which he performed six spacewalks totaling more than 37 hours.

Douglas Hurley calls Apalachin, New York, his hometown. He was a test pilot and colonel in the Marine Corps before coming to NASA in 2000 to become an astronaut. He piloted space shuttle Endeavor for STS-127 and Atlantis for STS-135, the final space shuttle mission.

SpaceX's Crew Dragon will launch aboard a SpaceX Falcon 9 rocket from Launch Complex 39A at Kennedy Space Center in Florida.

After each company successfully completes its crewed test flight, NASA will begin the final process of certifying that spacecraft and systems for regular crew missions to the space station. The agency has contracted six missions, with as many as four astronauts per mission, for each company.

Starliner First Mission Astronauts

Josh Cassada grew up in White Bear Lake, Minnesota. He is a Navy commander and test pilot with more than 3,500 flight hours in more than 40 aircraft. He was selected as an astronaut in 2013. This will be his first spaceflight.

Sunita Williams was born in Euclid, Ohio, but considers Needham, Massachusetts, her hometown. Williams came to NASA from the Navy, where she was a test pilot and rose to the rank of captain before retiring. Since her selection as an astronaut in 1998, she has spent 322 days aboard the International Space Station for Expeditions 14/15 and Expeditions 32/33, commanded the space station and performed seven spacewalks.

Crew Dragon First Mission Astronauts

Victor Glover is from Pomona, California. He is a Navy commander, aviator and test pilot with almost 3,000 hours flying more than 40 different aircraft. He made 400 carrier landings and flew 24 combat missions. He was selected as part of the 2013 astronaut candidate class, and this will be his first spaceflight.

Michael Hopkins was born in Lebanon, Missouri, and grew up on a farm near Richland, Missouri. He is a colonel in the Air Force, where he was a flight test engineer before being selected as a NASA astronaut in 2009. He has spent 166 days on the International Space Station for Expeditions 37/38, and conducted two spacewalks.

Additional crew members will be assigned by NASA's international partners at a later date.

NASA's continuous presence on the space station for almost 18 years has enabled technology demonstrations and research in biology and biotechnology, Earth and space science, human health, physical sciences. This research has led to dramatic improvements in technology, infrastructure and medicine, and thousands of spinoff technologies that have improved quality of life here on Earth.

The new spaceflight capability provided by Boeing and SpaceX will allow NASA to maintain a crew of seven astronauts on the space station, thereby maximizing scientific research that leads to breakthroughs and also aids in understanding and mitigating the challenges of long-duration spaceflight.

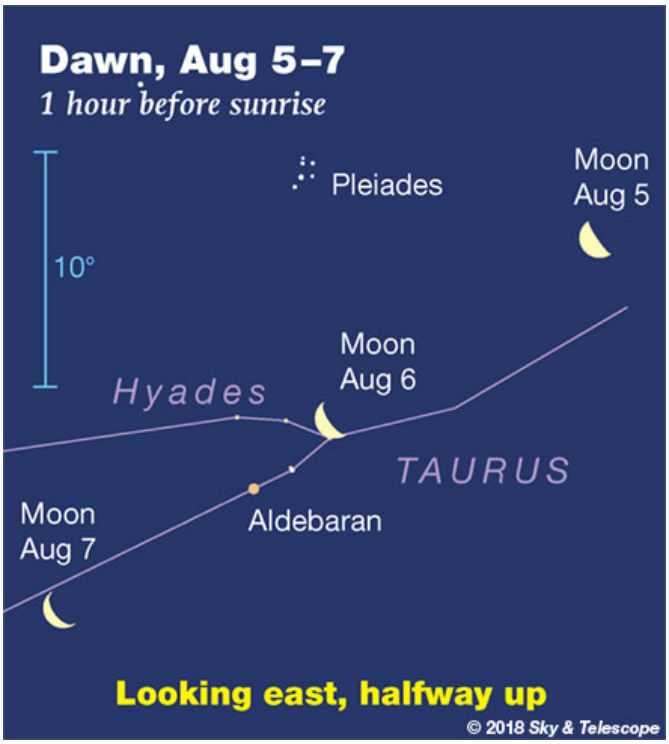
NASA's Commercial Crew Program is facilitating the development of a U.S. commercial crew space transportation capability with the goal of achieving safe, reliable and cost-effective access to and from the International Space Station and low-Earth orbit. The public-private partnerships fostered by the program will stimulate growth in a robust commercial space industry and spark life-changing innovations for future generations.

Learn more about NASA's Commercial Crew Program at https://www.nasa.gov/commercialcrew

Source: NASA Return to Contents

The Night Sky

Friday, August 3



• This week four bright planets shine at once during twilight, if you have low horizons in the right places. From right to left, they're Venus low in the west, Jupiter higher in the southwest, Saturn at about the same height in the south-southeast, and brilliant Mars low in the southeast. Best view: about 45 to 60 minutes after sunset.

• Action in Sagittarius. Less than 3° to the lower right of Saturn this week lies M8, the Lagoon Nebula and its associated star cluster. The Lagoon is the brightest emission nebula of the summer skies. In a dark sky it's obvious to the naked eye as a small Milky Way patch if you know where to look: above the spout of the Sagittarius Teapot.

Above M8 by 1.4°, and a bit to the right, is fainter M20, the Trifid Nebula and its adjacent cluster M21. This nebula generally needs a telescope.

But there's more! Matt Wedel, in his Binocular Highlight column in the August *Sky & Telescope*(page 43), calls attention to two other binocular clusters in the same field. They're sparse and subtle but easy to recognize once you know them. Collinder 367 is located 1.3° east-northeast of the Lagoon. ASCC 93 is the same distance east-northeast of the Trifid. Saturn is currently almost stepping on them.

"I can't help but see four objects in a parallelogram now," Wedel writes about the binocular view. "In the northwest corner, M20, M21, and a group of bright stars between them all merge together onto a bright glow that rivals M8, which occupies the southwest corner. To the east, Cr 367 and ASCC 93 seem like smaller, fainter echoes of their nebular neighbors." The things you didn't know!

Saturday, August 4

• Last-quarter Moon (exact at 2:18 p.m. Eastern Daylight Time). The Moon rises as late as 2 a.m. tonight, depending on your location. Once it's well up, spot the Pleiades to its left and Aldebaran below the Pleiades. As the very first light of dawn hints at the coming day, you'll find Orion clearing the eastern horizon far below Aldebaran (for mid-northern skywatchers).

Sunday, August 5

• The Big Dipper hangs diagonally in the northwest at nightfall. From its midpoint, look three fists at arm's length to the right to find Polaris (not very bright) glimmering due north as always.

Polaris is the handle-end of the Little Dipper. The only other parts of the Little Dipper that are even modestly bright are the two stars forming the outer end of its bowl: Kochab and Pherkad. On August evenings you'll find them to Polaris's upper left (by about a fist and a half at arm's length). They're called the Guardians of the Pole, since they circle endlessly around Polaris throughout the night and throughout the year.

Monday, August 6

• The tail of Scorpius, rich in binocular sights, is low in the south right after dark, well to the lower right of Saturn. *How* low it is depends on how far north or south you live: the farther south, the higher.

Look for the two stars especially close together in the tail. These are Lambda and fainter Upsilon Scorpii, known as the Cat's Eyes. They're canted at an angle; the cat is tilting his head and winking.

The Cat's Eyes point west (right) by nearly a fist-width toward Mu Scorpii, a much tighter pair known as the Little Cat's Eyes. They're oriented almost exactly the same way as the big Cat's Eyes. Can you resolve the Mu pair without using binoculars?

Source: Sky & Telescope Return to Contents

ISS Sighting Opportunities

For Denver:

Date	Visible	Max Height	Appears	Disappears
Fri Aug 3, 9:04 PM	4 min	17°	13° above NNW	10° above ENE
Fri Aug 3, 10:40 PM	< 1 min	36°	23° above NW	36° above NW
Sat Aug 4, 9:49 PM	2 min	46°	26° above NNW	40° above ENE
Sun Aug 5, 8:57 PM	4 min	28°	19° above NNW	10° above E
Sun Aug 5, 10:32 PM	1 min	23°	12° above WNW	23° above W
Mon Aug 6, 9:41 PM	2 min	70°	28° above WNW	45° above SSE

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

NASA-TV Highlights

(all times Eastern Daylight Time)

Friday, August 3

2 p.m., Replay of the Commercial Crew Program Crew Assignment Announcement Event for the first Boeing CST-100 Starliner and SpaceX Crew Dragon Missions (all channels)

4:30 p.m., Live Shot Interviews with the Crewmembers Assigned to the first Commercial Crew Program Boeing CST-100 Starliner and SpaceX Crew Dragon Missions (all channels)

7 p.m., Replay of the Commercial Crew Program Crew Assignment Announcement Event for the first Boeing CST-100 Starliner and SpaceX Crew Dragon Missions (all channels)

9 p.m., Replay of the Commercial Crew Program Crew Assignment Announcement Event for the first Boeing CST-100 Starliner and SpaceX Crew Dragon Missions (all channels)

Tuesday, August 7

12 p.m., ISS Expedition 56 Educational In-Flight Event with the Challenger Center in Washington, D.C. and NASA Flight Engineer Ricky Arnold (starts at 12:20 p.m.) (all channels)

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

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Space Calendar

- Aug 03 - Comet 349P/Lemmon At Opposition (2.113 AU)
- Aug 03 - Amor Asteroid 1580 Betulia Closest Approach To Earth (1.620 AU)
- Aug 03 - Asteroid 100007 Peters Closest Approach To Earth (2.135 AU)
- Aug 03 - Centaur Object 83982 Crantor At Opposition (17.832)
- Aug 04 - Moon Occults Asteroid 3 Juno
- Aug 04 - Asteroid 2672 Pisek Occults HIP 12387 (4.1 Magnitude Star)
- Aug 04 - Apollo Asteroid 428694 Saule Closest Approach To Earth (0.806 AU)
- Aug 04 - Asteroid 10050 Rayman Closest Approach To Earth (1.023 AU)
- Aug 04 - Asteroid 327 Columbia Closest Approach To Earth (1.600 AU)
- Aug 04 - Apollo Asteroid 4183 Cuno Closest Approach To Earth (1.743 AU)
- Aug 04 - Asteroid 2309 Mr. Spock Closest Approach To Earth (2.124 AU)
- Aug 04 - 20th Anniversary (1998), Zag Meteorite Fall in Morocco
- Aug 05 - Comet P/2013 R3 (Catalina-PANSTARRS) At Opposition (1.306 AU)
- Aug 05 - Comet P/2009 SK280 (Spacewatch-Hill) At Opposition (3.431 AU)
- Aug 05 - Aten Asteroid 398188 Agni Near-Earth Flyby (0.060 AU)
- Aug 05 - Amor Asteroid 6456 Golombek Closest Approach To Earth (0.341 AU)
- Aug 05 - Asteroid 9880 Stegosaurus Closest Approach To Earth (1.403 AU)
- Aug 05 - Asteroid 3808 Tempel Closest Approach To Earth (1.578 AU)
- Aug 05-26 - Workshop: SYK Models - From Interacting Quantum Matter to Black Holes, Aspen, Colorado
- Aug 06 - Moon Occults Aldebaran
- Aug 06 - Southern Iota Aquarids Meteor Shower Peak
- Aug 06 - Comet P/2010 U2 (Hill) At Opposition (2.603 AU)
- Aug 06 - Comet 200P/Larsen Closest Approach To Earth (2.811 AU)
- Aug 06 - Comet C/2017 M5 (TOTAS) Closest Approach To Earth (5.038 AU)
- Aug 06 - Apollo Asteroid 2018 OZ Near-Earth Flyby (0.018 AU)
- Aug 06 - Aten Asteroid 2011 FQ6 Near-Earth Flyby (0.094 AU)

Source: JPL Space Calendar

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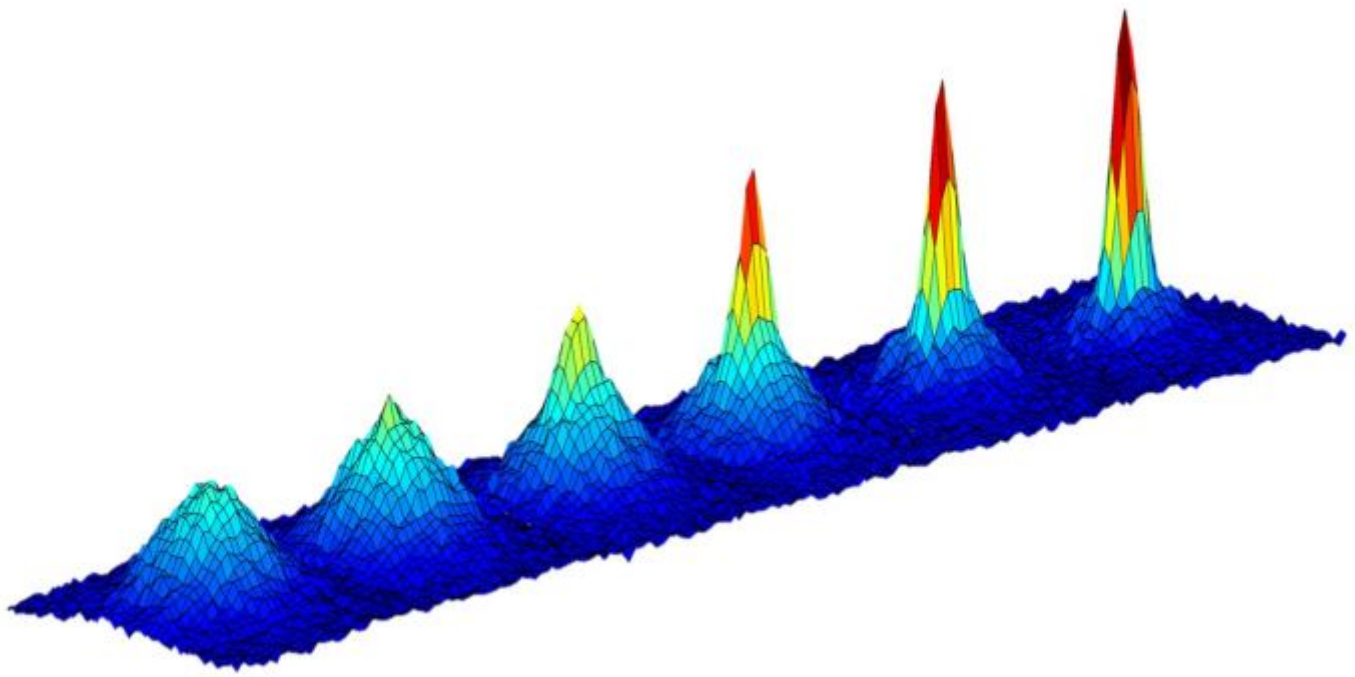
Food for Thought

The Coldest Place in Space Has Been Created. Next Challenge, Coldest Place in the Universe



Despite decades of ongoing research, scientists are trying to understand how the four fundamental forces of the Universe fit together. Whereas quantum mechanics can explain how three of these forces things work together on the smallest of scales (electromagnetism, weak and strong nuclear forces), General Relativity explains how things behaves on the largest of scales (i.e. gravity). In this respect, gravity remains the holdout.

To understand how gravity interacts with matter on the tiniest of scales, scientists have developed some truly cutting-edge experiments. One of these is NASA's Cold Atom Laboratory (CAL), located aboard the ISS, which recently achieved a milestone by creating clouds of atoms known as Bose-Einstein condensates (BECs). This was the first time that BECs have been created in orbit, and offers new opportunities to probe the laws of physics.

Originally predicted by Satyendra Nath Bose and Albert Einstein 71 years ago, BECs are essentially ultracold atoms that reach temperatures just above absolute zero, the point at which atoms should stop moving entirely (in theory). These particles are long-lived and precisely controlled, which makes them the ideal platform for studying quantum phenomena.

This is the purpose of the CAL facility, which is to study ultracold quantum gases in a microgravity environment. The laboratory was installed in the US Science Lab aboard the ISS in late May and is the first of its kind in space. It is designed to advance scientists' ability to make precision measurements of gravity and study how it interacts with matter at the smallest of scales.

As Robert Thompson, the CAL project scientist and a physicist at NASA's Jet Propulsion Laboratory, explained in a recent press release:

"Having a BEC experiment operating on the space station is a dream come true. It's been a long, hard road to get here, but completely worth the struggle, because there's so much we're going to be able to do with this facility."

About two weeks ago, CAL scientists confirmed that the facility had produced BECs from atoms of rubidium – a soft, silvery-white metallic element in the alkali group. According to their report, they had reached temperatures as low as 100 nanoKelvin, one-ten million of one Kelvin above absolute zero (-273 °C; -459 °F). This is roughly 3 K (-270 °C; -454 °F) colder than the average temperature of space.

Because of their unique behavior, BECs are characterized as a fifth state of matter, distinct from gases, liquids, solids and plasma. In BECs, atoms act more like waves than particles on the macroscopic scale, whereas this behavior is usually only observable on the microscopic scale. In addition, the atoms all assume their lowest energy state and take on the same wave identity, making them indistinguishable from one another.

In short, the atom clouds begin to behave like a single "super atom" rather than individual atoms, which makes them easier to study. The first BECs were produced in a lab in 1995 by a science team consisting of Eric Cornell, Carl Wieman and Wolfgang Ketterle, who shared the 2001 Nobel Prize in Physics for their accomplishment. Since that time, hundreds of BEC experiments have been conducted on Earth and some have even been sent into space aboard sounding rockets.

But the CAL facility is unique in that it is the first of its kind on the ISS, where scientists can conduct daily studies over long periods. The facility consists of two standardized containers, which consist of the larger "quad locker" and the smaller "single locker". The quad locker contains CAL's physics package, the compartment where CAL will produce clouds of ultra-cold atoms.

This is done by using magnetic fields or focused lasers to create frictionless containers known as "atom traps". As the atom cloud decompresses inside the atom trap, its temperature naturally drops, getting colder the longer it remains in the trap. On Earth, when these traps are turned off, gravity causes the atoms to begin moving again, which means they can only be studied for fractions of a second.

Aboard the ISS, which is a microgravity environment, BECs can decompress to colder temperatures than with any instrument on Earth and scientists are able to observe individual BECs for five to ten seconds at a time and repeat these measurements for up to six hours per day. And since the facility is controlled remotely from the Earth Orbiting Missions Operation Center at JPL, day-to-day operations require no intervention from astronauts aboard the station.

Robert Shotwell, the chief engineer of JPL's astronomy and physics directorate, has overseen the project since February 2017. As he indicated in a recent NASA press release:

"CAL is an extremely complicated instrument. Typically, BEC experiments involve enough equipment to fill a room and require near-constant monitoring by scientists, whereas CAL is about the size of a small refrigerator and can be operated remotely from Earth. It was a struggle and required significant effort to overcome all the hurdles necessary to produce the sophisticated facility that's operating on the space station today."

Looking ahead, the CAL scientists want to go even further and achieve temperatures that are lower than anything achieved on Earth. In addition to rubidium, the CAL team is also working towards making BECSs using two different isotopes of potassium atoms. At the moment, CAL is still in a commissioning phase, which consists of the operations team conducting a long series of tests see how the CAL facility will operate in microgravity.

However, once it is up and running, five science groups – including groups led by Cornell and Ketterle – will conduct experiments at the facility during its first year. The science phase is expected to begin in early September and will last three years. As Kamal Oudrhiri, JPL's mission manager for CAL, put it:

"There is a globe-spanning team of scientists ready and excited to use this facility. The diverse range of experiments they plan to perform means there are many techniques for manipulating and cooling the atoms that we need to adapt for microgravity, before we turn the instrument over to the principal investigators to begin science operations."

Given time, the Cold Atom Lab (CAL) may help scientists to understand how gravity works on the tiniest of scales. Combined with high-energy experiments conducted by CERN and other particle physics laboratories around the world, this could eventually lead to a Theory of Everything (ToE) and a complete understanding of how the Universe works.

And be sure to check out this cool video (no pun!) of the CAL facility as well, courtesy of NASA:

https://youtu.be/z85AA2tF9f8?list=PLTiv_XWHnOZoPT2VCxZJOF7Vg1VTNuGj4

Source: Universe Today Return to Contents

Space Image of the Week

Eclipse over the Gulf of Poets

Explanation The total phase of the July 27 lunar eclipse lasted for an impressive 103 minutes. That makes it the longest total lunar eclipse of the 21st century. The Moon passed through the center of Earth's shadow while the Moon was near apogee, the most distant point in its elliptical orbit. From start to finish, the entire duration of totality is covered in this composite view. A dreamlike scene, it includes a sequence of digital camera exposures made every three minutes. The exposures track the totally eclipsed lunar disk, accompanied on that night by bright planet Mars, as it climbs above the seaside village of Tellaro, Italy. In the foreground lies the calm mediteranean Gulf of La Spezia, known to some as the Gulf of Poets. In the 3rd century BCE, heliocentric astronomer Aristarchus also tracked the duration of lunar eclipses, though without the benefit of digital clocks and cameras. Using geometry he devised a way to calculate the Moon's distance from the eclipse duration, in terms of the radius of planet Earth.

Image Credit & Copyright: Paolo Lazzarotti

Source: APOD

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