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Molecule is found

Long search for the universe's first type of molecule is over

By Kassandra Bell and Alison Hawkes
USRA and NASA Ames Public Affairs

The first type of molecule that ever formed in the universe has been detected in space for the first time, after decades of searching. Scientists discovered its signature in the Milky Way Galaxy using the world's largest airborne observatory, NASA's Stratospheric Observatory for Infrared Astronomy, or SOFIA, as the aircraft flew high above the Earth's surface and pointed its sensitive instruments out into the cosmos.

When the universe was still very young, only a few kinds of atoms existed. Scientists believe that around 100,000 years after the big bang, helium and hydrogen combined to make a molecule called helium hydride for the first time. Helium hydride should be present in some parts of the modern universe, but it has never been detected in space until now.

SOFIA found modern helium hydride in a planetary nebula, a remnant of what was once a sun-like star. Located 3,000 light-years away near the constellation Cygnus, this planetary nebula, called NGC 7027, has conditions that allow this mystery molecule to form. The discovery serves as proof that helium hydride can, in fact, exist in space. This confirms a key part of our basic understanding of the chemistry of the early universe and how it evolved over billions of years into the complex chemistry of today. The results are published in an April issue of *Nature*.

"This molecule was lurking out there, but we needed the right instruments making observations in the right position and SOFIA was able to do that perfectly," said Harold Yorke, director of the SOFIA Science Center, in California's Silicon Valley.

Today, the universe is filled with large, complex structures such as planets, stars and galaxies. But more than 13 billion years ago, following the big bang, the early universe was hot and all that existed were a few

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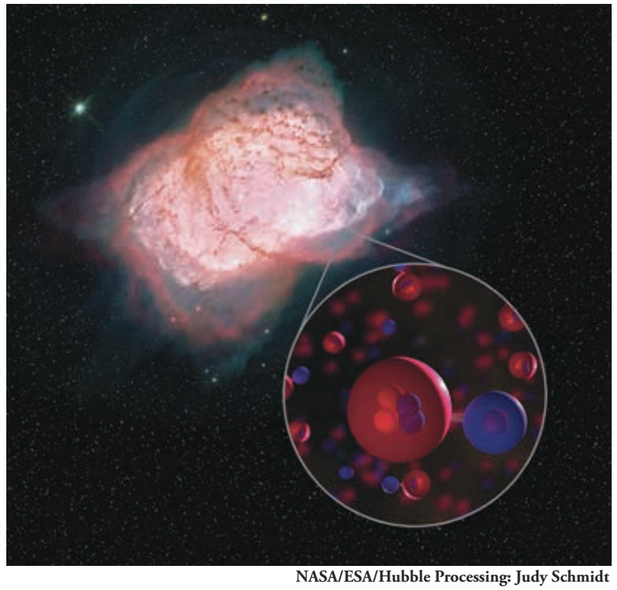

NASA/ESA/Hubble Processing: Judy Schmidt

This image of planetary nebula NGC 7027, with an illustration of helium hydride molecules, shows where SOFIA detected helium hydride, a combination of helium (red) and hydrogen (blue). It was the first type of molecule to ever form in the early universe. This is the first time helium hydride has been found in the modern universe.

NASA/SOFIA/ Wayne Williams

SOFIA takes off from Christchurch International Airport and heads for home following a successful observation campaign in 2018.

Space experiments

NASA, Blue Origin rocket launch inspires researchers

By Nicole Quenelle
Fuentek writer

"We are now on the verge of giving students and teachers the ability to build and fly affordable experiments in space," said Elizabeth Kennick, president of Teachers in Space. "When teachers are this excited about putting experiments in space, their students can't help but get excited about space too."

Kennick does not take the opportunity to fly an experiment to space for granted. The nonprofit organization has worked with educators and engineers to design and test standard equipment for classroom-developed experiments, including 3D-printed frames, customizable processors and power adaptors. The equipment first flew on high-altitude balloons and more recently on a stratospheric glider. Now, thanks to support from NASA's Flight Opportunities program, nine NASA-supported payloads flew higher than ever before: to space on Blue Origin's New Shepard rocket May 2.

"It's such a huge milestone," said Kennick. "This opens the door to flying more experiments for more schools and that means exposing more teachers and students to the promise of spaceflight."

That promise is bolstered by Flight Opportunities, which lets researchers test technologies in a relevant environment, particularly innovations that will help NASA return to the Moon and send crewed missions to Mars.

The payloads experienced the rigors of a rocket launch and the challenges of a zero-gravity environment. These conditions gave researchers valuable insights into how their technologies would hold up on exploration missions.

Photo Courtesy of Blue Origin

The Flight Opportunities Program and Blue Origin are making it possible to inspire students while testing new generation technology that could assist the mission to the Moon and Mars.

A 3D printing experiment from the University of Kentucky and University of Louisville could further advances in space manufacturing – a critical capability for long-term stays on the lunar surface. While there are 3D printers on the International Space Station, the university's experiment could provide the capability to manufacture metal components in space.

Future explorers will need protection from potentially negative effects of deep space travel. With a new suborbital centrifuge from NanoRacks, researchers may be able to collect biological and physical data on suborbital rocket flights. A space-based centrifuge can simulate the gravity environment on the Moon or Mars. The capability could make it faster and cheaper to gather critical data.

Missions to the Moon and Mars will also require advanced fuel gauging systems, giving accurate measurements of the amount of propellant onboard vehicles operating in deep space without the need for complex procedures. A propellant gauging experiment from Purdue University aimed to do just that.

The other Flight Opportunities supported payloads aboard the rocket included:

Evolved Medical Microgravity Suction Device
Orbital Medicine Inc., Richmond, Virginia
This medical device could assist in treating space-based emergencies, such as a collapsed lung. It would collect blood in microgravity, allow lungs to continuously inflate and store blood for transfusion.

Suborbital Flight Experiment Monitor-2
NASA's Johnson Space Center, Houston
This instrumentation package is designed to characterize the flight environment (acceleration, acoustics, temperature, pressure and humidity) of suborbital vehicles that are candidates for testing new space technologies.

Flow Boiling in Microgap Coolers
NASA's Goddard Space Flight Center, Greenbelt, Maryland
This thermal management technique addresses the limitations of current cooling methods for miniaturized devices and electronics needed for technology payloads on space-bound missions.

BioChip SubOrbitalLab
HNu Photonics, LLC, Kahului, Hawaii

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AFRC2018-0127-34 NASA/Ken Ulbrich

***Above**, the No Chase Certificate of Waiver Authorization team at NASA Armstrong poses for a group photo with the unmanned aircraft system, the Ikhana. **Below**, the Ikhana takes off for its award-winning flight.*

Ikhana wins a Laureate

Elvia Valenzuela
Armstrong Public Affairs

Aviation Week & Space Technology selected Ikhana as a winner of one of its 62nd Annual Laureate Awards, in the category of Commercial Aviation, Unmanned Systems. The award presentation was March 14.

The Ikhana was recognized for its historic achievement as the first remotely piloted aircraft to fly without a safety chase plane in the national airspace June 12, 2018.

The team that accomplished the task was a collaboration among NASA Armstrong, General Atomics, Honeywell and the Federal Aviation Administration

AFRC2018-0127-12 NASA/Ken Ulbrich

"For more than six decades, Aviation Week editors have annually awarded Laureates to great achievers in aerospace and aviation," said Joe Anselmo, Aviation Week network editorial director. "This year's winners exemplify the spirit and innovations that are transforming our industry to meet the challenges of tomorrow."

The Laureate Awards honor extraordinary achievements in the global aerospace arena in the categories of Business Aviation, Commercial Aviation, Defense and Space.

Ikhana is the first aircraft to achieve a No Chase Certificate of Waiver Authorization (COA) flight without the need of a chase plane or visual observers as it operated in various classes of airspace. The teamwork among the organizations made the Ikhana a success and demonstrated the opportunity for Unmanned Aircraft Systems to be integrated into the National Airspace System.

"The Ikhana represents an extraordinary collaboration among innovative individuals dedicated to bringing Unmanned Aircraft Systems one step closer into our reality," said Jaiwon Shin, NASA's associate administrator for aeronautics. "We are very grateful to be recognized by this prestigious award. It's an honor and a privilege to be selected as a recipient."

News at NASA

Undersea crew preps for Moon

NASA will join an international crew on the floor of the Atlantic Ocean this summer to prepare for future deep space missions during the 10-day NASA Extreme Environment Mission Operations (NEEMO) 23 expedition slated to begin June 10.

NEEMO 23 will focus on exploration spacewalks and objectives related to space missions such as the International Space Station and future deep space missions to the Moon and Mars. As an analogue for future planetary science concepts and strategies, marine science also will be performed under the guidance of Florida International University's marine science department.

ESA astronaut Samantha Cristoforetti will command the NEEMO 23 mission aboard the Aquarius laboratory, 62 feet below the ocean surface near Key Largo Florida. Cristoforetti was part of space station Expeditions 42 and 43 from Nov. 2014 to June 2015, where she spent 200 days living and working in the extreme environment of space, currently the longest spaceflight of a European.

Objectives for the crew include evaluating scenarios for using science instruments and tools on the lunar surface, such as tools and hardware for getting science core samples; using augmented reality to guide an untrained operator from module to module by autonomously recognizing where it is; and studies of body composition and sleep.

AFRC2019-0088-08 NASA/Ken Ulbrich

At left, *Navmar Applied Sciences Corporation's Steve Hamilton, lead TigerShark pilot, and Brad Petty, mission commander and pilot, unload the crate containing the TigerShark.*

At right*, NASC's Daryl Ferguson, mission commander and pilot, Steve Hamilton and Brad Petty unload the TigerShark.*

AFRC2019-0088-13 NASA/Ken Ulbrich

AFRC2019-0088-30 NASA/Ken Ulbrich

At left, *Daryl Ferguson attaches the TigerShark's tail.*

At right*, Brad Petty attaches a winglet to the TigerShark.*

AFRC2019-0088-36 NASA/Ken Ulbrich

TigerShark

It's not often people see sharks in the desert, but there will be sightings at NASA Armstrong this summer.

This shark doesn't swim, it flies. With a wingspan of 21.9 feet and weighing 515 pounds, the TigerShark XP unmanned aircraft system (UAS) can carry payloads of up to 95 pounds and for up to 12 hours.

Navmar Applied Science Corporation (NASC) personnel delivered the TigerShark to Armstrong in a large crate May 6. Wings, a fuselage, a tail and other parts were unloaded and the aircraft was assembled. NASC is the aircraft's manufacturer and its Teros Mobile Operations Center, which also was delivered the same day, includes a ground cockpit.

This "shark" will undergo modifications, payload integration and ground systems checks in early June. It is intended to support Flight Test 6, which is part of the UAS Integration into the National Airspace System (NAS) Project managed by NASA Armstrong.

Objectives of Flight Test 6 include collection of data to inform the development of minimum operational performance standards for detect and avoid (DAA) for alerting and guidance and for the small size, low weight and power radar. The TigerShark will be equipped with a Honeywell digital active phased array lite airborne radar to support this flight test.

AFRC2019-0088-20 NASA/Ken Ulbrich

At left, *Steve Hamilton, Brad Petty and Daryl Ferguson attach the TigerShark's wing.*

At right*, Steve Hamilton and Brad Petty adjust the TigerShark's wing.*

Ken Ulbrich's background image shows the assembled aircraft (AFRC2019-0088-40).

AFRC2019-0088-22 NASA/Ken Ulbrich

AFRC2019-0052-03 NASA/Jim Ross

This was the view from a NASA TG-14 and a NASA T-34 as the aircraft flew over the super bloom of wildflowers and poppies at the Antelope Valley Poppy Reserve; solar panels can be seen in the background.

Super bloom

By Leslie Williams
Armstrong News Chief

Due to a very rainy winter season for the Antelope Valley, the desert was covered with a canopy of yellow wildflowers and orange blooming California poppies, the state flower. The flowers were accessible to people who visited the Poppy Reserve in Lancaster.

Armstrong's Glenn Graham, director of Safety and Mission Assurance, and Rex Walheim, a former NASA astronaut and currently assistant director for operations for the Flight Operations Directorate, flew above the valley's super bloom in the center's T-34 mission support aircraft April 2. The T-34 is used by the center for pilot proficiency and as a chase plane for research flights.

Jim Ross photographed the T-34 and the super bloom from a NASA TG-14 aircraft piloted by Tim Williams.

AFRC20190063-06 NASA/Carla Thomas

NASA's T-34 aircraft flown from Armstrong approaches the Antelope Valley Poppy Reserve. The image was taken from a TG-14 aircraft that accompanied the T-34.

Circuits, coding and robotics

Teachers gain STEM ideas from NASA Armstrong

Elvia Valenzuela
Armstrong Public Affairs

Teachers across the Antelope Valley gathered for a day at NASA Armstrong to learn about three concepts: circuits, coding and robotics.

About 25 teachers attended the Educational Technology Institute and saw firsthand the current research projects taking place at Armstrong and how they relate to the three concepts.

It is no secret that the journey of a NASA employee begins inside the classroom. The Office of STEM Engagement (OSTEM) at Armstrong is doing its part by providing NASA resources and materials to local teachers in the areas of STEM.

OSTEM holds a variety of NASA workshops and webinars for formal and informal teachers each year around the subjects of science, technology, engineering and math. The Educational Technology Institute marked the first time OSTEM decided to invite teachers to Armstrong's main campus for an all-day event since the days of the Apollo 40th anniversary.

AFRC2019-0058-20 NASA/Lauren Hughes

Tom Grindle, NASA Armstrong chief of maintenance, gives a hangar tour to a group of teachers.

A portion of the day was dedicated to NASA's first all-electric X-plane, the X-57 Maxwell based at Armstrong. Claudia Herrera, mod 4 deputy chief engineer of the X-57, shared with the group the mechanisms of the plane and the testing behind its power distribution system and its circuits.

The X-57 conversation connected with the course on circuit training.

"The circuit training is hands-on, and we can go through this step-by-step with the kids really easily. I am going to need to do circuits especially since it is part of our testing," said Kristin Deckner, fifth grade teacher at Golden Poppy Elementary.

Barbara "Barbie" Buckner, Armstrong's educator professional development specialist, demonstrated how to easily create a paper circuit with simple tools teachers may purchase without breaking the bank for their classrooms. Teachers also participated in a group exercise to learn how our bodies are able to create a circuit. Participants held hands to form a human circuit to light up an electric ball. Since human bodies consist of nearly 60 percent water, participants were able to carry the electricity, an easy and fun task for students to engage in the classroom.

"I have done a lot of Barbie's seminars, and I brought a lot of things she has taught us and demonstrated to the classroom," continued Deckner.

Other discussions and activities included the Engineering Design Process, coding and programming, building a Styrofoam robotic arm, a demonstration of the Aeronautics Augmented Reality app, and a tour of Life Support and NASA Armstrong's F-15 Hangar.

NASA tech pinpoints potent greenhouse gases

Whether they're idyllic floating cotton balls on an otherwise blue sky or ominous grey swirls that block the sun, clouds all begin as an invisible dot of water vapor. This elusive gas has been tricky to measure and track – until now. Research scientists at NASA's Langley Research Center in Hampton, Virginia, have created a new airborne instrument that can directly measure water vapor and floating particles in the atmosphere. The new data will help check the accuracy of satellite measurements, and improve weather and climate forecasts.

The instrument is called the High Altitude Lidar Observatory (HALO). It uses light detection and ranging (lidar), which works by shooting a pencil-thin laser beam through the atmosphere. Light from the pulsed laser bounces off molecules and particles suspended in the atmosphere, revealing what the human eye cannot see. The intensity of the signal reflected back to the lidar instrument gives the team the information they need to directly measure water vapor, as well as aerosol and cloud profiles.

Water vapor is the most abundant and potent greenhouse gas in the atmosphere. It warms the air by trapping heat emitted from Earth, but also cools by forming bright clouds that reflect heat radiated by the Sun. HALO's data will help scientists as they research the extent of each of these processes.

HALO is a minifridge-sized modular instrument that allows scientists to more easily measure either water vapor or methane. This kind of technology is new at NASA, said Amin Nehrir, a research scientist and HALO's principal investigator.

HALO joined another NASA-funded instrument, the Doppler Aerosol Wind Lidar (DAWN), which measures wind speed and direction. Both HALO and DAWN are helping validate data collected by the Atmospheric Dynamics Mission Aeolus (ADM-Aeolus) lidar instrument, an ESA (European Space Agency) satellite that measures wind speeds, aerosols and cloud profiles across the globe.

HALO began its mission over the Pacific Ocean on April 15 aboard a DC-8 Airborne Science Laboratory based at NASA Armstrong. Validation flights are scheduled to continue as the ADM-Aeolus makes passes over the eastern Pacific.

The ADM-Aeolus launched on Aug. 22, 2018, from Europe's Spaceport in Kourou, French Guiana. It is the first satellite to profile wind speeds on a global scale from space, and it also collects aerosol data. HALO's aerosol measurements will be used to validate the satellite. Although HALO's water vapor measurements are not key to this particular mission, they will give scientists a more comprehensive picture of the atmosphere and help the team prepare for future airborne campaigns dedicated to atmospheric dynamic processes.

Molecule... from page 1

types of atoms, mostly helium and hydrogen. As atoms combined to form the first molecules, the universe was finally able to cool and began to take shape. Scientists have inferred that helium hydride was this first, primordial molecule.

Once cooling began, hydrogen atoms could interact with helium hydride, leading to the creation of molecular hydrogen – the molecule primarily responsible for the formation of the first stars. Stars went on to forge all the elements that make up our rich chemical cosmos of today. The problem is that scientists could not find helium hydride in space. This first step in the birth of chemistry was unproven until now.

"The lack of evidence of the very existence of helium hydride in interstellar space was a dilemma for astronomy for decades," said Rolf Guesten of the Max Planck Institute for Radio Astronomy in Bonn, Germany, and lead author of the paper.

Helium hydride is a finicky molecule. Helium itself is a noble gas making it very unlikely to combine with any other kind of atom. But in 1925, scientists were able to create the molecule in a laboratory by coaxing the helium to share one of its electrons with a hydrogen ion.

Then in the late 1970s, scientists studying the planetary nebula called NGC 7027 thought that this environment might be just right to form helium hydride. Ultraviolet radiation and heat from the aging star create conditions suitable for helium hydride to form. But their observations were inconclusive. Subsequent efforts hinted it could be there, but the mystery molecule continued to elude detection. The space telescopes used did not have the specific technology to pick out the signal of helium hydride from the medley of other molecules in the nebula.

In 2016 scientists turned to SOFIA for help. Flying up to 45,000 feet altitude, SOFIA makes observations above the interfering layers of Earth's atmosphere. It also has a benefit space telescopes don't – it returns after every flight.

"We're able to change instruments and install the latest technology," said Naseem Rangwala SOFIA deputy project scientist. "This flexibility allows us to improve observations and respond to the most pressing questions that scientists want answered."

A recent upgrade to one of SOFIA's instruments called the German Receiver at Terahertz Frequencies, or GREAT, added the specific channel for helium hydride that previous telescopes did not have. The instrument works like a radio receiver. Scientists tune to the frequency of the molecule they're searching for, similar to tuning an FM radio to the right station. When SOFIA took to the night skies, eager scientists were onboard reading the data from the instrument in real time. Helium hydride's signal finally came through loud and clear.

"It was so exciting to be there, seeing helium hydride for the first time in the data," said Guesten. "This brings a long search to a happy ending and eliminates doubts about our understanding of the underlying chemistry of the early universe.

SOFIA, the Stratospheric Observatory for Infrared Astronomy, is a Boeing 747SP jetliner modified to carry a 106-inch diameter telescope. It is a joint project of NASA and the German Aerospace Center, DLR. NASA's Ames Research Center in California's Silicon Valley manages the SOFIA program, science and mission operations in cooperation with the Universities Space Research Association headquartered in Columbia, Maryland, and the German SOFIA Institute (DSI) at the University of Stuttgart. The aircraft is maintained and operated from Armstrong's Building 703 in Palmdale.

Flight Opportunities... from page 2

This experiment aims to enable researchers to observe cell function in real time during a flight, in order to understand how microgravity and space exposure effects human physiology, critical insights for long-duration missions.

Strata-S1
University of Central Florida, Orlando
This payload addresses the need for detailed understanding of the behavior of space dust, regolith and other particles on the surfaces of small bodies in space, to inform robotic and human space exploration.

Flight Opportunities

The Flight Opportunities program is funded by NASA's Space Technology Mission Directorate at the agency's Headquarters in Washington, D.C., and managed at NASA Armstrong. NASA's Ames Research Center in California's Silicon Valley manages the solicitation and evaluation of technologies to be tested and demonstrated on commercial flight vehicles.

Blue Origin and other U.S. commercial spaceflight providers are contracted to provide flight services to NASA for flight testing and technology demonstration. Researchers from academia and industry with concepts for exploration, commercial space applications or other space utilization technologies of potential interest to NASA can receive grants from the Flight Opportunities program to purchase suborbital flights from these and other U.S. commercial spaceflight providers.

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