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Space Sciences NEWS

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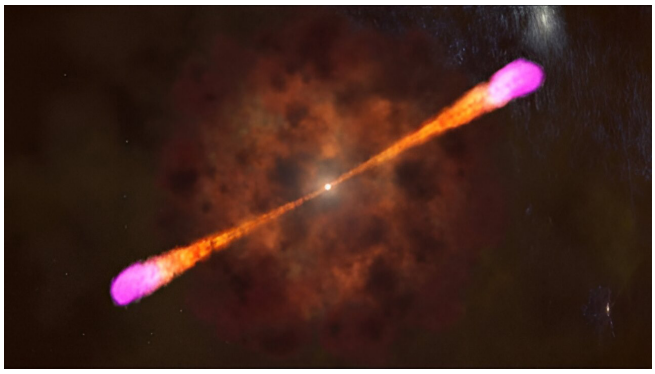
Astrophysics research advances understanding of how gamma-ray bursts produce light



Artist concept of a jet of particles piercing a star as it collapses into a black hole during a typical gamma-ray burst (GRB). GRBs are the most energetic and luminous electromagnetic events since the Big Bang. Credit: NASA

Gamma-ray bursts (GRBs) are intense bursts of gamma radiation, typically generating more energy in a few seconds than the sun will produce over its ten-billion-year lifetime. These transient phenomena present one of the most challenging puzzles in astrophysics, dating back to their accidental discovery in 1967 by a nuclear surveillance satellite.

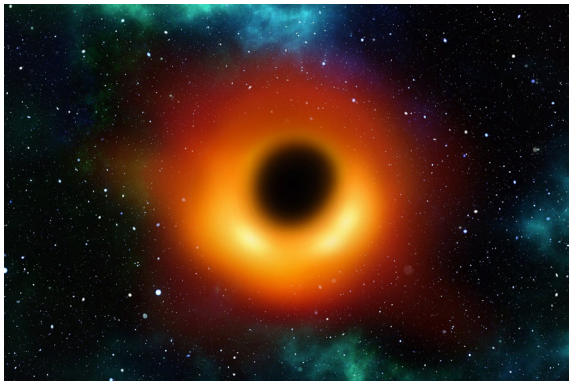
Dr. Jon Hakkila, a researcher from The University of Alabama in Huntsville (UAH), a part of the University of Alabama System, is lead author on a paper in The Astrophysical Journal that promises to shed light on the behavior of these mysterious cosmic powerhouses by focusing on the motion of the jets where these forces originate. The paper is co-authored by UAH alumnus Dr. Timothy Giblin, Dr. Robert Preece and Dr. Geoffrey Pendleton of deciBel Research, Inc.

“Despite being studied for over fifty years, the mechanisms by which GRBs produce light are still unknown, a great mystery of modern astrophysics,” Hakkila explains. “Understanding GRBs helps us understand some of the most rapid and powerful light-producing mechanisms that Nature employs. GRBs are so bright, they can be seen over the breadth of the universe, and—because light travels at a finite velocity—they allow us to see back to the earliest times that stars existed.”

One reason for the mystery is the inability of theoretical models to provide consistent explanations of GRB characteristics for their light-curve behaviors. In astronomy, a light curve is a graph of the light intensity of a celestial object as a function of time. Studying light curves can yield significant information about the physical processes that produce them, as well as help define the theories about them. No two GRB light curves are identical, and the duration of emission can vary from milliseconds to tens of minutes as a series of energetic pulses.

“Pulses are the basic units of GRB emission,” Hakkila says. “They indicate times when a GRB brightens and subsequently fades away. During the time a GRB pulse emits, it undergoes brightness variations that can sometimes occur on very short timescales. The strange thing about these variations is that they are reversible in the same way words like ‘rotator’ or ‘kayak’ (palindromes) are reversible. ...Read More...

AI and physics combine to reveal the 3D structure of a flare erupting around a black hole



Credit: CC0 Public Domain

Scientists believe the environment immediately surrounding a black hole is tumultuous, featuring hot magnetized gas that spirals in a disk at tremendous speeds and temperatures. Astronomical observations show that within such a disk, mysterious flares occur up to several times a day, temporarily brightening and then fading away.

Now a team led by Caltech scientists has used telescope data and an artificial intelligence (AI) computer-vision technique to recover the first three-dimensional video showing what such flares could look like around Sagittarius A* (Sgr A*) the supermassive black hole at the heart of our own Milky Way galaxy.

The 3D flare structure features two bright, compact features located about 75 million kilometers (or half the distance between Earth and the sun) from the center of the black hole. It is based on data collected by the Atacama Large Millimeter Array (ALMA) in Chile over a period of 100 minutes directly after an eruption seen in X-ray data on April 11, 2017.

“This is the first three-dimensional reconstruction of gas rotating close to a black hole,” says Katie Bouman, assistant professor of computing and mathematical sciences, electrical engineering and astronomy at Caltech, whose group led the effort described in a paper in Nature Astronomy titled “Orbital Polarimetric Tomography of a Flare Near the Sagittarius A* Supermassive Black Hole.”

Aviad Levis, a postdoctoral scholar in Bouman’s group and lead author of the paper, emphasizes that while the video is not a simulation, it is also not a direct recording of events as they took place. “It is a reconstruction based on our models of black hole physics. There is still a lot of uncertainty associated with it because it relies on these models being accurate,” he says.

To reconstruct the 3D image, the team had to develop new computational imaging tools that could, for example, account for the bending of light due to the curvature of space-time around objects of enormous gravity, such as a black hole.

The multidisciplinary team first considered if it would be possible to create a 3D video of flares around a black hole in June 2021. The Event Horizon Telescope (EHT) Collaboration, of which Bouman and Levis are members, had ..Read More...

Why is methane seeping on Mars? NASA scientists have new ideas

Filled with briny lakes, the Quisquiro salt flat in South America's Altiplano region represents the kind of landscape that scientists think may have existed in Gale Crater on Mars, which NASA's Curiosity Rover is exploring. Credit: Maksym Bocharov

The most surprising revelation from NASA's Curiosity Mars Rover—that methane is seeping from the surface of Gale Crater—has scientists scratching their heads.

Living creatures produce most of the methane on Earth. But scientists haven't found convincing signs of current or ancient life on Mars, and thus didn't expect to find methane there. Yet, the portable chemistry lab aboard Curiosity, known as SAM, or Sample Analysis at Mars, has continually sniffed out traces of the gas near the surface of Gale Crater, the only place on the surface of Mars where methane has been detected thus far. Its likely source, scientists assume, are geological mechanisms that involve water and rocks deep underground.

If that were the whole story, things would be easy. However, SAM has found that methane behaves in unexpected ways in Gale Crater. It appears at night and disappears during the day. It fluctuates seasonally, and sometimes spikes to levels 40 times higher than usual. Surprisingly, the methane also isn't accumulating in the atmosphere: ESA's (the European Space Agency) ExoMars Trace Gas Orbiter, sent to Mars specifically to study the gas in the atmosphere, has detected no methane.

Why do some science instruments detect methane on the Red Planet while others don't?

"It's a story with a lot of plot twists," said Ashwin Vasavada, Curiosity's project scientist at NASA's Jet Propulsion Laboratory in Southern California, which leads Curiosity's mission.

Methane keeps Mars scientists busy with lab work and computer modeling projects that aim to explain why the gas behaves strangely and is detected only in Gale Crater. A NASA research group recently shared an interesting proposal.

Reporting in a March paper in the Journal of Geophysical Research: Planets, the group suggested that methane—no matter how it's produced—could be sealed under solidified salt that might form in Martian regolith, which is "soil" made of broken rock and dust. When temperature rises during warmer seasons or times of day, weakening the seal, the methane could seep out.

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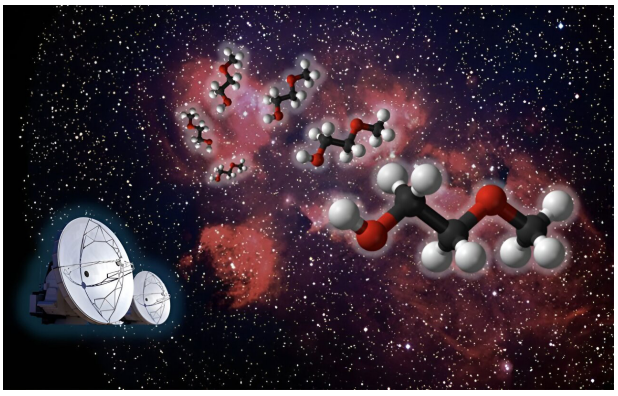
Researchers detect a new molecule in space



Scientists detected 2-Methoxyethanol in space for the first time using radio telescope observations of the star-forming region NGC 6334I. Credit: Massachusetts Institute of Technology

New research from the group of MIT Professor Brett McGuire has revealed the presence of a previously unknown molecule in space. The team's open-access paper, "Rotational Spectrum and First Interstellar Detection of 2-Methoxyethanol Using ALMA Observations of NGC 6334I," was published in the April 12 issue of The Astrophysical Journal Letters.

Zachary T.P. Fried, a graduate student in the McGuire group and the lead author of the publication, worked to assemble a puzzle comprised of pieces collected from across the globe, extending beyond MIT to France, Florida, Virginia, and Copenhagen, to achieve this exciting discovery.

"Our group tries to understand what molecules are present in regions of space where stars and solar systems will eventually take shape," explains Fried. "This allows us to piece together how chemistry evolves alongside the process of star and planet formation. We do this by looking at the rotational spectra of molecules, the unique patterns of light they give off as they tumble end-over-end in space.

"These patterns are fingerprints (barcodes) for molecules. To detect new molecules in space, we first must have an idea of what molecule we want to look for, then we can record its spectrum in the lab here on Earth, and then finally we look for that spectrum in space using telescopes."

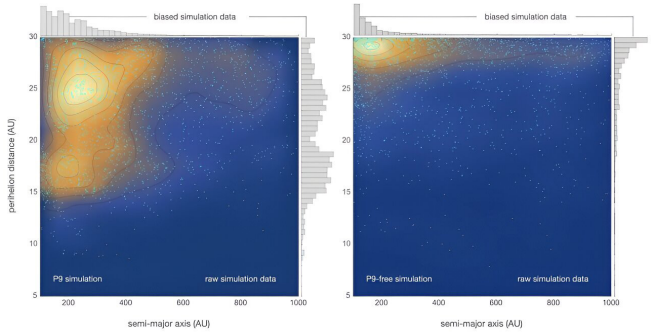
Searching for molecules in space

The McGuire Group has recently begun to utilize machine learning to suggest good target molecules to search for. In 2023, one of these machine learning models suggested the researchers target a molecule known as 2-methoxyethanol.

"There are a number of 'methoxy' molecules in space, like dimethyl ether, methoxymethanol, ethyl methyl ether, and methyl formate, but 2-methoxyethanol would be the largest and most complex ever seen," says Fried.

To detect this molecule using radio telescope observations, the group first needed to measure and analyze its rotational spectrum on Earth. The researchers combined experiments from the University of Lille (Lille, France), the New College of Florida (Sarasota, Florida), and the McGuire lab at MIT to measure this spectrum over a broadband region of ...Read More...

New evidence found for Planet 9



A comparison of the orbital distributions from P9-inclusive (left) and P9-free (right) N−body simulations. Both panels depict the perihelion distance against the semi-major axis of orbital footprints of simulated TNOs with i < 40 deg. The overlaying contour lines represent density distributions, with brighter colors indicating higher concentrations of objects. While the panels themselves show raw simulation data, the histograms along the axes show a biased frequency distribution for the perihelion distances (vertical) and semi-major axes (horizontal), assuming a limiting magnitude of Vlim = 24. Credit: arXiv (2024). DOI: 10.48550/arxiv.2404.11594

A small team of planetary scientists from the California Institute of Technology, Université Côte d'Azur and Southwest Research Institute reports possible new evidence of Planet 9. They have published their paper on the arXiv preprint server, and it has been accepted for publication in The Astrophysical Journal Letters.

In 2015, a pair of astronomers at Caltech found several objects bunched together beyond Neptune's orbit, near the edge of the solar system. The bunching, they theorized, was due to the pull of gravity from an unknown planet—one that later came to be called Planet 9. Since that time, researchers have found more evidence of the planet, all of it circumstantial. In this new paper, the research team reports what they describe as additional evidence supporting the existence of the planet.

The work involved tracking the movements of long-period objects that cross Neptune's orbit and exhibit irregular movements during their journey. They used these observations to create multiple computer simulations, each depicting different scenarios. In addition to factoring in the impact of Neptune's gravitational pull, the team also added data to take into account what has come to be known as the galactic tide, a combination of forces exerted by Milky Way objects beyond the solar system.

The research team found that the most plausible explanation for the behavior of the objects was interference from gravity exerted by a large distant planet. Unfortunately, the simulations were not of the type that would allow the research team to identify the location of the planet.

The team acknowledges that other forces could be at play that might explain the behavior that they simulated but suggest they are less likely. They also note that further evidence will become available as the Vera Rubin Observatory in Chile is set to begin operations sometime next year. It will be equipped, they note, to search in new ways for the planet in a rigorous assessment of its existence. ...Read More...

New JWST observations reveal black holes rapidly shut off star formation in massive galaxies

Credit: Unsplash/CC0 Public Domain

New research published in Nature showcases new observations from the James Webb Space Telescope (JWST) that suggest black holes rapidly shut off star-formation in massive galaxies by explosively removing large amounts of gas.

The international team found that more than 90% of the galactic wind is made of neutral gas, and therefore was virtually invisible in previous studies. This work is the first direct confirmation that supermassive black holes are capable of shutting down galaxies.

The difference between this new study and previous works is found in the type of gas observed: until now it was only possible to detect ionized gas, which is warm; while the JWST was able to also detect neutral gas, which is cold.

Dr. Rebecca Davies from Swinburne University of Technology's Center for Astrophysics and Supercomputing led the Australian team behind this discovery and helped to find the powerful black-hole driven outflow in a distant massive galaxy with a very low level of star formation.

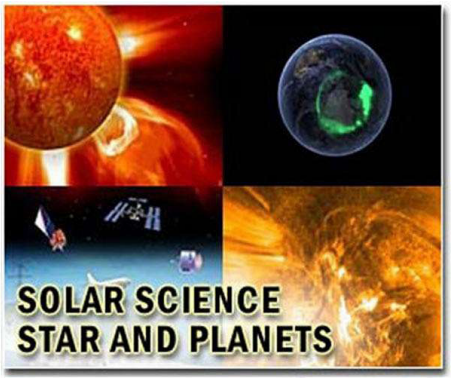
"The outflow is removing gas faster than gas is being converted into stars, indicating that the outflow is likely to have a very significant impact on the evolution of the galaxy. Our findings provide new evidence to indicate that black-hole driven outflows are able to rapidly shut off or 'quench' star formation in massive galaxies."

When star formation is quenched, it means that a galaxy has stopped forming stars. It represents the transformation between a galaxy that is actively forming stars, allowing it to grow and change, and a galaxy that is "dead" and static. Quenching is therefore a fundamental process in the life cycle of galaxies. However, astronomers still don't understand in detail what leads galaxies to stop forming stars.

Alongside internationally recognized researchers, particularly lead author Sirio Belli from the University of Bologna, Dr. Davies studied a galaxy that is located at an enormous distance from Earth whose light took more than 10 billion years to reach us.

Active galactic nuclei (AGN)—supermassive black holes consuming large amounts of gas—can drive ...Read More...

SwRI experiments during total eclipse reveal new aspects of the solar corona



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On April 8, 2024, a total solar eclipse cast a shadow from Texas to Maine, and the Southwest Research Institute led two major experiments to gather unique solar data from this event. The first, the Citizen Continental-America Telescopic Eclipse (CATE) 2024 experiment, involved over 200 participants who helped create a continuous 60-minute high-resolution movie of the eclipse. The second used specially equipped NASA WB-57F aircraft to collect data from the eclipse at altitudes unreachable by land-based methods.
Dr. Amir Caspi, principal investigator for both projects, noted, "Total solar eclipses provide rare opportunities to study the Sun's hot atmosphere above its visible surface. The CATE 2024 project not only advanced our scientific knowledge but also strengthened community bonds along the eclipse's path."

Total solar eclipses reveal the Sun's outer atmosphere's intricate dynamics, otherwise obscured by the Sun's brightness. The CATE 2024 project deployed 35 teams of "citizen scientists" who recorded the polarization of light in the solar corona, enhancing our understanding of this phenomenon.

"The telescopes used in CATE 2024 are equipped with polarizing filters that measure different angles of polarized light, which helps us gather detailed information about the corona," explained Caspi.

Meanwhile, the high-altitude observations from the WB-57 aircraft provided data free from atmospheric interference and weather risks. This effort was supported by NASA's Langley Research Center's SCIFLI team, which developed a new suite of imagers for these observations.

These comprehensive studies aim to unravel the reasons behind the corona's extreme heat and its role in geomagnetic storms that affect Earth. "These storms can disrupt satellites, power grids, and communications, making our research critical for understanding and mitigating these impacts," added Dr. Dan Seaton, SwRI co-investigator and science lead.

Caspi expressed his excitement about the collaborative nature of the experiments: "It was inspiring to see such dedicated teams working together to capture this data. We are eager to analyze the findings."

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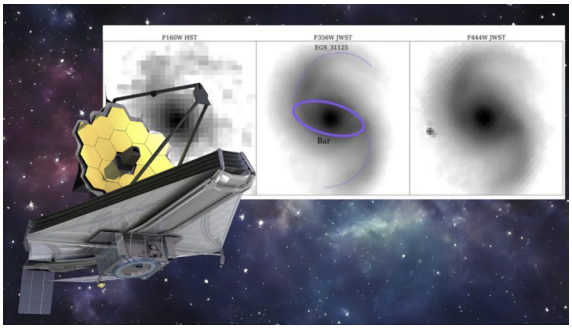
James Webb Space Telescope discovers some early universe galaxies grew up surprisingly fast



From left to right: Hubble Space Telescope WFC3 F160W and James Webb Space Telescope NIRCam F356W and F444W (Image credit: Zoe Le Conte)

"This means we will have to adjust our views on early galaxy evolution."

Using the James Webb Space Telescope, scientists have discovered that early universe galaxies must have grown up way faster than expected. Plus, the same team also found that, 10 billion years ago, the cosmos wasn't quite as disordered and chaotic as previously believed.

The international team, led by researchers from Durham University in the U.K., reached these conclusions by discovering evidence of structures called "star bars" forming in galaxies that existed just a few billion years after the Big Bang.

Star bars are elongated regions of increased star density found at the hearts of spiral galaxies like the Milky Way and other disk galaxies. As they form, star bars push gas toward the hearts of their respective galaxies, thereby regulating star birth. The presence of these central bar structures thus indicate that a galaxy has entered a more settled and "mature phase."

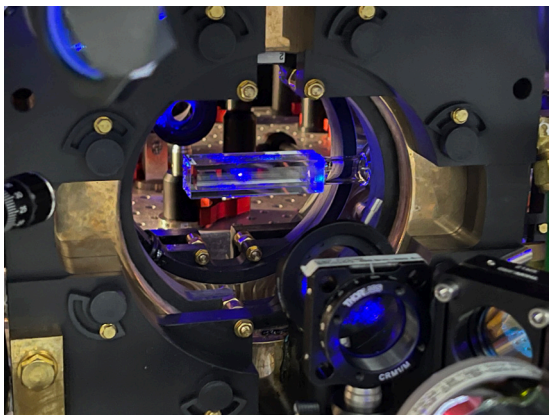
"Galaxies in the early universe are maturing much faster than we thought," Zoe Le Conte, team leader and a researcher at Durham University, said in a statement. "This is a real surprise because you would expect the universe at that stage to be very turbulent, with lots of collisions between galaxies and a lot of gas that hasn't yet transformed into stars.

"However, thanks to the JWST, we are seeing a lot of these bars much earlier in the life of the universe, which means that galaxies were at a more settled stage in their evolution than previously thought. This means we will have to adjust our views on early galaxy evolution."

Bar-hopping for the James Webb Space Telescope
This isn't the first time scientists have gone bar-hopping in the early history of the 13.8 billion-year history of the universe.

The Hubble space telescope witnessed these features as well, but that orbiting eye on the universe could only go as far back as 8 billion to 9 billion years. The increased sensitivity and wavelength range of the JWST, however, has stretched such observations back at least another 1 billion years. This has revealed bar formation in galaxies that are seen as they were between 8 billion and 11.5 billion years ago. In fact, of 368 disk...Read More...

Announcing the birth of QUIONE, a unique analog quantum processor



Picture of the glass cell with the strontium gas cloud in the middle. Credit: ICFO

Quantum physics requires high-precision sensing techniques to delve deeper into the microscopic properties of materials. From the analog quantum processors that have emerged recently, quantum-gas microscopes have proven to be powerful tools for understanding quantum systems at the atomic level. These devices produce images of quantum gases with very high resolution: They allow individual atoms to be detected.

Now, ICFO researchers (Barcelona, Spain) Sandra Buob, Jonatan Höschele, Dr. Vasiliy Makhalov, and Dr. Antonio Rubio-Abadal, led by ICREA Professor at ICFO Leticia Tarruell, explain how they built their own quantum-gas microscope, named QUIONE after the Greek goddess of snow. The group's quantum-gas microscope is the only one in the world imaging individual atoms of strontium quantum gases, as well as the first of its kind in Spain.

The team's research is published in the journal PRX Quantum.

Beyond the impactful images in which individual atoms can be distinguished, the goal of QUIONE is quantum simulation. As Prof. Tarruell explains, "Quantum simulation can be used to boil down very complicated systems into simpler models to understand the open questions that current computers cannot answer, such as why some materials conduct electricity without any losses even at relatively high temperatures."

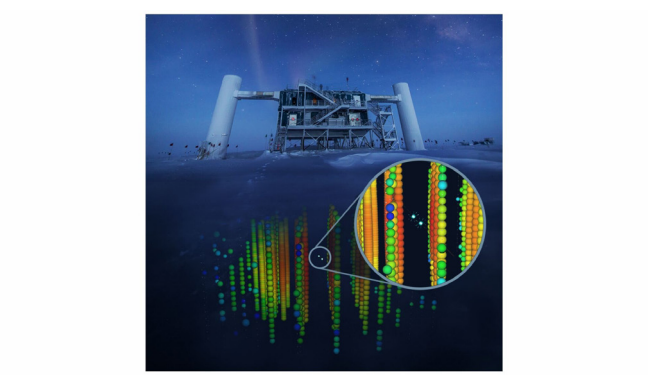
The singularity of this experiment lies in the fact that the team has managed to bring the strontium gas to the quantum regime, place it in an optical lattice where the atoms could interact by collisions, and then apply the single atom imaging techniques. These three ingredients altogether make ICFO's strontium quantum-gas microscope unique.

Why strontium?

Until now, these microscope setups relied on alkaline atoms, like lithium and potassium, which have simpler properties in terms of their optical spectrum compared to alkaline-earth atoms such as strontium. This means that strontium offers more ingredients to play with in these experiments.

In fact, in recent years, the unique properties of strontium have made it a very popular element for applications in the fields of quantum computing and quantum simulation. For example, a cloud of strontium atoms can be used as an ...Read More...

Hunting for the elusive: IceCube observes seven potential tau neutrinos



IceCube building in Antarctica (top) and tau-neutrino signals detected by the IceCube Neutrino Observatory (bottom). The colors indicate the relative time at which each sensor detected light, following the colors of the rainbow, with red being earlier times and blue being later times. Credit: IceCube/NSF

Researchers at the IceCube Neutrino Observatory in Antarctica have found seven signals that could potentially indicate tau neutrinos—which are famously hard to detect—from astrophysical objects.

Neutrinos are some of the most elusive particles to detect due to their extremely low mass and weak interactions with matter. One of the reasons why scientists are interested in these particles is their ability to travel long distances, which means they can hold information about astrophysical processes and objects happening far away from us.

The IceCube collaboration aims to study these neutrinos by observing the trail they leave when interacting or traversing across the ice on the detectors.

The present study, published in Physical Review Letters, details how IceCube has observed signals from neutrinos, seven of which could be the tau neutrino.

The researchers used convolutional neural networks (CNNs) to sift through 9.7 years of data collected by the observatory at the South Pole. Their main challenge was distinguishing between the three "flavors" of neutrinos, all of which leave behind similar signals.

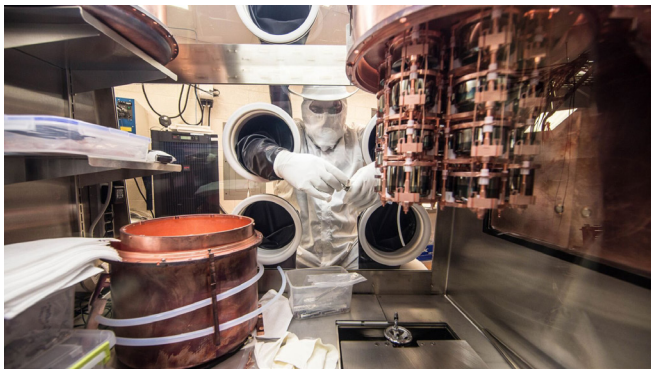
Muon, electron and tau neutrinos

The neutrino comes in three variants, or flavors, as they are known in the scientific community: the electron neutrino, the muon neutrino, and the tau neutrino. They are the most abundant particles with mass in the universe, as 100 trillion of them pass through your body every second!

However, as mentioned earlier, they are notoriously difficult to detect, and it is even harder to distinguish between the flavors.

"Compared to other particles, isolating neutrinos is particularly challenging due to their weak interactions with matter. Tau neutrinos can readily mimic electron or muon neutrinos, the other two known flavors of neutrino, so isolating them is even more challenging still," explained Prof. Doug ...Read More...

Scientists at the MAJORANA Collaboration look for rule-violating electrons



Scientists working at the MAJORANA DEMONSTRATOR at the Sanford Underground Laboratory in Lead, South Dakota. Credit: Matthew Kapust, Sanford Underground Research Facility

In a new study published inNature Physics, scientists at the MAJORANA Collaboration have tested the stringency of charge conservation and Pauli's exclusion principles using underground detectors. Alessio Porcelli has published a News & Views piece on the research in the same journal.

Today, the Standard Model of particle physics is one of two pillars on which modern physics rests. It successfully explains three out of the four fundamental forces and how subatomic particles behave.

Pauli's exclusion principle and the conservation of charge are two of the principles arising from the symmetries in the Standard Model. They have withstood many theoretical challenges and have repeatedly proven to the point where they are considered axiomatic.

Now, researchers believe that small violations of these principles could lead to physics beyond the Standard Model, such as exotic forms of matter.

The MAJORANA Collaboration is one such experiment. The project aims to explore neutrinoless double beta decay, a type of radioactive decay, hoping to establish if neutrinos are Majorana particles.

The research is an international collaboration of scientists, including Dr. Clint Wiseman from the University of Washington and Dr. Inwook Kim from Lawrence Livermore National Laboratory in California, who co-authored the Nature study.

Speaking to Phys.org, Dr. Wiseman shared his motivation behind this pursuit, "When I first learned quantum mechanics, I was taught to question things presented as unshakable principles. The principles of quantum mechanics—the bedrock of the Standard Model—are heavily ingrained in us because they have borne out to be true again and again.

"As we look for areas of new physics to explore in the 21st century, it can be worthwhile to go back to those principles and attempt to push the limits of their correctness."

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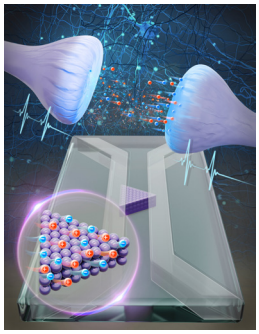
First experimental proof for brain-like computer with water and salt



Below shows a graphical representation of the synapse. The synapse consists of colloidal spheres with nano-channels between them. Credit: Utrecht University

Theoretical physicists at Utrecht University, together with experimental physicists at Sogang University in South Korea, have succeeded in building an artificial synapse. This synapse works with water and salt and provides the first evidence that a system using the same medium as our brains can process complex information.

The results appear in the journal Proceedings of the National Academy of Sciences.

In the pursuit of enhancing the energy efficiency of conventional computers, scientists have long turned to the human brain for inspiration. They aim to emulate its extraordinary capacity in various ways.

These efforts have led to the development of brain-like computers, which diverge from traditional binary processing to embrace analog methods akin to our brains. However, while our brains operate using water and dissolved salt particles called ions as their medium, most current brain-inspired computers rely on conventional solid materials.

This raises the question: Could we not achieve a more faithful replication of the brain's workings by adopting the same medium? This intriguing possibility lies at the heart of the burgeoning field of iontronic neuromorphic computing.
Artificial synapse

In the latest study published in PNAS, scientists have, for the very first time, demonstrated a system reliant on water and salt exhibiting the ability to process intricate information, mirroring the functionality of our brains. Central to this discovery is a minute device measuring 150 by 200 micrometers, which mimics the behavior of a synapse—an essential component in the brain responsible for transmitting signals between neurons.

Tim Kamsma, a Ph.D. candidate at the Institute for Theoretical Physics and the Mathematical Institute of Utrecht University, and the lead author of the study, expresses his excitement, stating, "While artificial synapses capable of processing complex information already exist based on solid materials, we now show for the first time that this feat can also be accomplished using water and salt. We are effectively replicating neuronal behavior using a system that employs the same medium as the brain."

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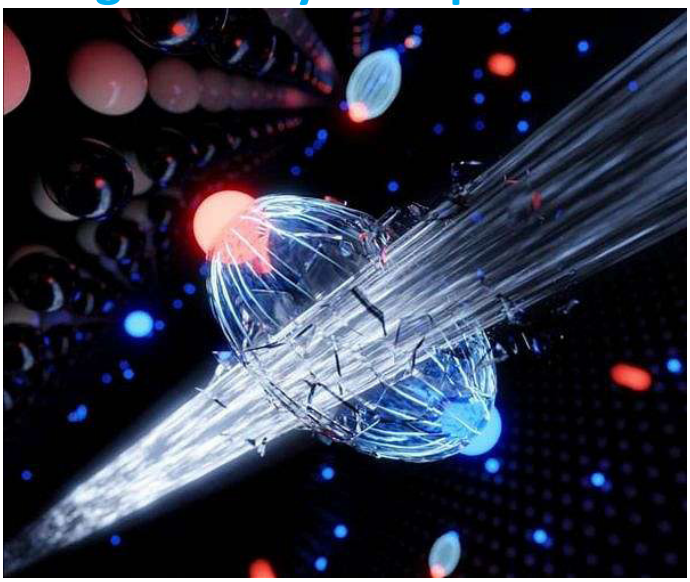
Special Read:

Exploring the ‘electron universe’: New paths in quantum geometry manipulation



For Illustration only

Researchers at Tohoku University and the Japan Atomic Energy Agency have made significant progress in understanding and manipulating the quantum metric-a geometric description of electronic states in magnetic materials under normal conditions.

The team has detected the quantum metric as an electric signal, separate from standard electrical conduction, showcasing a novel aspect of quantum physics. This discovery could lead to the creation of advanced spintronic devices that operate based on unconventional conduction methods introduced by the quantum metric.

Published in Nature Physics on April 22, 2024, the research investigates non-Ohmic electric conduction, a phenomenon where the current does not respond in direct proportion to voltage as described by Ohm’s law. By exploring quantum mechanics, specifically the quantum metric, researchers can design materials that exhibit non-Ohmic conduction, a critical step for next-generation electronic devices.

The quantum metric concept, influenced by the ‘metric’ in general relativity, describes how space-time geometry is altered by gravity. Similarly, understanding the quantum metric in materials helps in designing and manipulating electronic properties at the quantum level.

The study utilized a thin-film heterostructure made from Mn3Sn and Pt, which revealed unique magnetic interactions. When subjected to a magnetic field, the material demonstrated a controlled second-order Hall effect-a type of non-Ohmic conduction where the voltage changes in relation to the square of the applied current.

Lead author Jiahao Han explains, “Our experiments show that the second-order Hall effect stems from the interaction between the quantum metric and the specific magnetic texture of the Mn3Sn/Pt interface. This interaction can be tuned using spintronic techniques, allowing us to manipulate these properties effectively at room temperature.”

Yasufumi Araki, a key theorist in the team, emphasized the importance of the quantum metric in connecting experimental material properties with theoretical physics models. He expressed optimism that this experimental approach to the quantum metric would bolster theoretical research.

Shunsuke Fukami, the project’s principal investigator, noted the transformative implications of their findings: “Previously, the quantum metric was considered a fixed property, much like aspects of the universe. Our results challenge this view, opening possibilities for developing devices like rectifiers and detectors.”

..Read More...

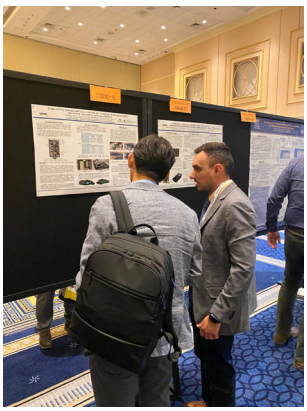
Special Read:

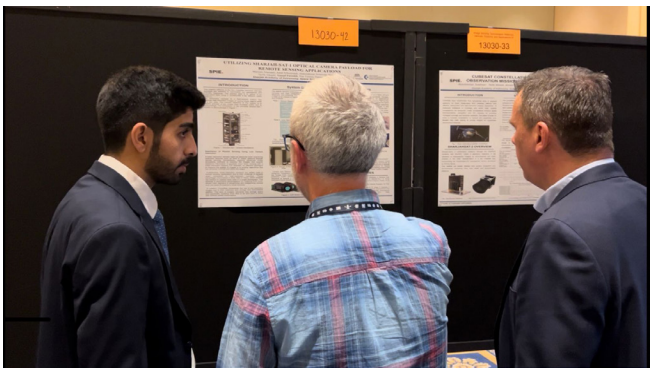
SPIE 2024 SAASST Participation

Engs. Yousuf Faroukh and Abdelrahmance Suleiman during the SPIE 2024 Conference in Washington, D.C.

Eng. Abdulrahman Sulaiman and Eng. Yousuf Faroukh from the SAASST CubeSat laboratory participated in the SPIE Defence and Commercial Sensing 2024 conference, representing the Sharjah Academy of Astronomy, Space sciences & Technology (SAASST) and University of Sharjah (UoS). The conference was held in Washington DC, United States, from 21st to 25th April 2024. UoS and SAASST participated with twelve research papers in the conference were both engineers presented several papers in the field of space science and technology and mechanical engineering.

As part of the conference, a large exhibition was held where the two engineers got a great chance to meet many leading companies in the optics and photonics industries.





AI and Satellite-Driven Urban Planning

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One might wonder about the view of their city from above: how do the residential neighborhoods appear, where are the parks nestled in between, and how far do the schools extend? Above all, who is the roads' architect and discerns the fertile lands fit for cultivation from those marred by decay?

An individual cannot take flight over cities and landscapes for such observations, yet we are fortunate to possess a technology designed for this purpose - Earth Observation (EO) Satellites. Their role lies in providing data that enriches strategic planning, including urban planning [1]. Thus, in pursuit of this endeavor, the United Arab Emirates (UAE) aims to establish robust infrastructure systems and efficiently utilize resources to develop sustainable cities that cater to the needs of their inhabitants.

Urban planning plays a pivotal role in shaping the quality of life for millions of people. It involves strategically organizing land use, infrastructure development, transportation networks, and environmental conservation within urban areas. Effective urban planning aims to make cities functional, sustainable, and responsive to the needs of their residents.

The power of EO satellite data becomes even more impactful when coupled with the capabilities of Artificial Intelligence (AI). AI is a computer science and technology field that focuses on developing computer systems and software programs capable of performing tasks that typically require human intelligence. Among its capabilities is image analysis, which is essential in the context of EO satellite imagery. This can be done through Deep Learning, a subfield of AI that utilizes Convolutional Neural Networks (CNNs).

Unlike human perception, which observes images holistically, CNNs perform pixel-level examinations. Pixels, similar to tiny dots, constitute the building blocks of ideas. These neural networks precisely scrutinize millions of these pixels, learning to recognize intricate patterns and distinct elements, such as buildings, road networks, parks, etc. Thus, using AI adds an added layer of analysis and interpretation to the vast troves of satellite data.

AI algorithms can analyze time-series satellite imagery to track urban expansion and growth patterns. Moreover, AI models like CNNs detect and map informal settlements in urban areas [2]. This helps urban planners monitor urban sprawl, identify areas of high population density and inadequate housing, and plan for infrastructure development accordingly.

Integrating AI and EO technology revolutionizes urban road infrastructure planning and management. Using object detection and tracking on satellite imagery optimizes traffic patterns, identifies congestion, and enhances transportation planning [3]. Real-time EO data monitoring provides actionable insights, improving road networks, traffic management, and public transport. This synergy empowers data-driven decisions, efficient infrastructure, and sustainable urban growth while ensuring safety and mobility for growing populations.

The application of AI on EO data can be used to detect urban heat islands, assess environmental impact, and guide sustainable practices, aiding informed decision-making [4]. This integration promotes sustainability by addressing deforestation, pollution, and green space health, advancing cities toward greener and more resilient futures.

In light of this, the Sharjah Academy for Astronomy, Space Sciences, and Technology (SAASST) is developing its second CubeSat Sharjah-Sat-2. It will feature a state-of-the-art spectral camera with a remarkable five-meter resolution, revolutionizing data collection from space [5]. This project aims to provide essential scientific data and imagery for urban planning, enabling the monitoring urban growth and changes while facilitating precise land mapping. The high-resolution camera promises to be a game-changer in urban development and strategic planning. Furthermore, AI will be used to process the imagery generated from the Sharjah-Sat-2 to fulfill the various areas of urban planning.

EO data and AI synergy empower decision-makers to manage urban growth, optimize transportation, and enhance sustainability. These technologies bolster the UAE's capabilities in space and sustainability commitment. Initiatives include monitoring lands for urban development, combating desertification, and tracking environmental changes. Hence, it becomes evident that EO satellites provide us with insights beyond our reach, as the ability to fly and explore the Earth's resources from above is a technological achievement of humanity.

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AI-Powered CubeSats: Innovating Earth Sustainability

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Thanks to the rapid evolution of artificial intelligence, our world is witnessing increasing innovations and modern technologies to enhance human learning. This quick progress is demonstrated by how artificial intelligence techniques are used to solve many global issues. As a result of this new science's major intervention, there is a shift in thinking about other factors connected to using creative methods to achieve greater environmental and societal gains, such as using space to support Earth."

Scientific research from Stanford University has been made public, highlighting the importance of satellites in attaining environmental sustainability on Earth. With state-of-the-art artificial intelligence algorithms, these satellites are thought to be a rich and potent source of enormous volumes of vital data that can be utilized to arrive at space-based sustainability solutions. The institution is also working on research and construction initiatives to develop new artificial intelligence-assisted picture analysis methods. Because these satellite-produced photos include important data about Earth, such as air quality, sea level rise, land usage, and more, they qualify for use in accomplishing sustainability goals. This data can help propose answers for climate-related sustainable development concerns.

According to these studies, satellite photos present a viable remedy for the lack of consistency and scarcity of data. High-resolution images are being produced by satellites and made available much more quickly. Places that were shot numerous times a year are now photographed several times per week. Even at medium resolution, the quality of these photos reflects not just the health and sustainability of people and the earth on a larger scale but also very localized human activities, such as infrastructure and productivity increases.

In many fields, machines are starting to outperform humans. For instance, high-resolution images of a particular region of Earth can now be produced quickly using satellites rather than labor-intensive aircraft methods. Reducing carbon dioxide emissions is one advantage of using fewer aircraft since a single helicopter can produce tons of this gas when taking pictures over a 150-mile radius. On the other hand, satellites emit as little as 75 grams of gas for the same distance, providing superior images with much less environmental impact.

In developed and productive countries like the United Arab Emirates, satellites are crucial to resolving numerous issues that threaten the nation's ecology and economy. Being one of the top oil-producing nations, the United Arab Emirates has a sizable network of oil transportation routes. Oil spills in marine environments are a major problem brought on by oil ship activities, drilling, and discharges. Following this concern, The Sharjah Academy for Astronomy, Space Sciences, and Technology is currently developing and constructing the Sharjah CubeSat-2 (Sharjah-Sat 2), a satellite intended to monitor and observe various aspects of Earth, including aquatic and terrestrial environments and the atmosphere, to lessen this problem. The satellite will deliver hyperspectral imaging technology-captured high-resolution images, potentially reaching as far as 4.75 meters. As such, the generated images will be analyzed to extract pertinent information using remote sensing techniques and geographic information systems. Therefore, the role of AI comes through learning a model using novel techniques that can identify oil spill incidents by analyzing these photos.

Based on the evidence presented, satellites and artificial intelligence cannot only solve the problem of oil spills, but they can also solve various other issues. Now that science has developed and flourished in many areas, it is at a point where it is reaching out into space to benefit society. As a pioneering and forward-thinking country in science, the United Arab Emirates seeks to utilize space technology and scientific methods to create a bright future for both the planet and the nation.

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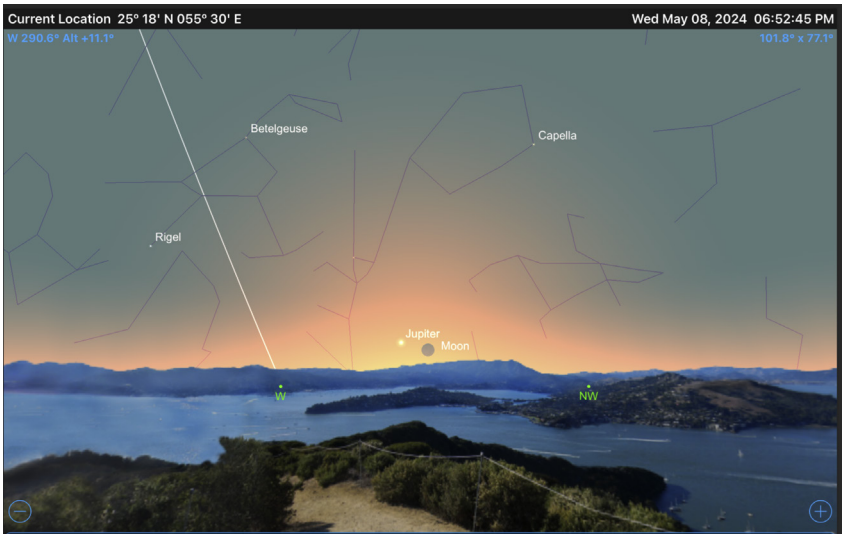
Observing Dhu'l Qiddah 1445 AH Crescent
May 08, 2024

Here is below som basic astronomical Information about the observations of the crescent of Dhu'l Qiddah 1445 AH:

	May 08, 2024	May 09, 2024
	Sun/Moon data	Sun/Moon Data
New Moon	7:21 am	--
Sunset (Azimuth)	6:52 pm (290^0)	6:53 pm (290^0)
Moonset (Azimuth)	7:22 pm (295^0)	8:30 pm (299^0)
Moon's Altitude	5.4^0	18.4^0
Moon's Illumination (%)	0.4+	3.06+
Lag Time (Minutes)	30	97
Age (Hrs, Min)	11h 31min	35h 32min



A very difficult setting for the crescent to be observed on 08 May with the naked eye because of its low elevation and young age. The simulation shows a very low location of the Moon at sunset time. We should expect the first day of Dhu'l Qiddah 1445 AH to be on Friday, May 10, 2024.

This Week's Sky at a Glance - Apr. 27 - May 03, 2024

Apr. 27	Sa	00:00	Moon-Antares: 0.3° S
Apr. 28	Su	18:28	Moon South Dec.: 28.5° S
May 01	We	15:27	Last Quarter

Note - Some astronomical events listed above do happen during daylight, so they are not observable.