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Astronomy & Physics Weekly News

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Top News

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Mars rover Curiosity's new findings hailed as 'breakthroughs in astrobiology'

This self-portrait of the Mars Curiosity rover reveals a rock stuck to the left middle wheel.NASA Jet Propulsion Laboratory

New discoveries by NASA's Mars rover Curiosity add to a growing body of evidence supporting the idea that microscopic organisms might once have lived on the red planet — and have some scientists considering the possibility that microbial life might live there still.

As described in a pair of scientific papers published Thursday in the journal Science, Curiosity detected a range of carbon-containing compounds in ancient sediments on Mars and shifting levels of the organic molecule methane in the Martian atmosphere.

"Both these discoveries are breakthroughs in astrobiology," Inge Loes ten Kate, an astrobiologist at the Utrecht University in the Netherlands, said in a written commentary published along with the papers. She said "the question of whether life might have originated or existed on Mars is a lot more opportune now that we know that organic molecules were present on its surface" in the distant past.

Years ago, the Curiosity rover found evidence that liquid water and the chemical ingredients for microbial life once existed on Mars. But in one of the new discoveries, the car-size rover found that levels of methane in the Martian atmosphere vary widely from season to season, with levels peaking at the end of summer in the planet's northern hemisphere.

In the paper about the new finding, Christopher Webster, a senior research scientist at NASA's Jet Propulsion Laboratory in Pasadena, California, and his co-authors conclude that "the amplitude of the seasonal cycle indicates that there remain unknown atmospheric or surface processes occurring in present-day Mars."

But the scientists hypothesize that seasonal temperature shifts cause methane buried under the planet's surface to seep into the atmosphere through cracks and fissures in the surface (see diagram below).

Methane can be produced by simple nonbiological processes, but on Earth it's created mostly by microorganisms — a fact that led some scientists to consider the full range of possible sources of the Martian methane. ..Read More...

NIST atomic clock comparison confirms key assumptions of 'Einstein's elevator'

Einstein's elevator: As the Earth falls like an elevator in the sun's gravity, atomic clocks based on hydrogen and cesium maintain the same synchronicity in their ticking properties. NIST physicists just measured this phenomenon better than ever before. Credit: K. Rechin/NIST

By comparing different types of remote atomic clocks, physicists at the National Institute of Standards and Technology (NIST) have performed the most accurate test ever of a key principle underlying Albert Einstein's famous theory of general relativity, which describes how gravity relates to space and time.

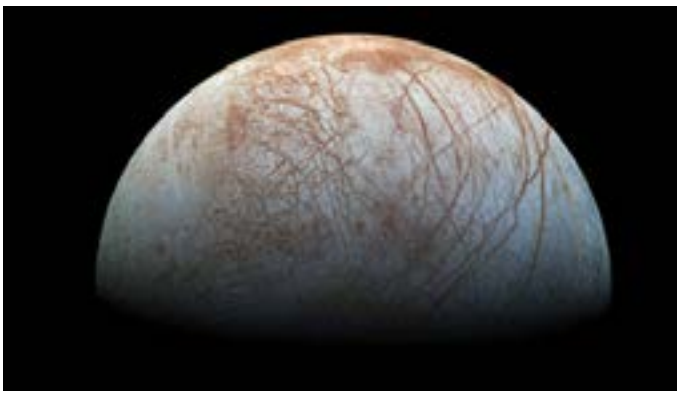
The NIST result, made possible by continual improvements in the world's most accurate atomic clocks, yields a record-low, exceedingly small value for a quantity that Einstein predicted to be zero.

As described in a Nature Physics paper posted online June 4, NIST researchers used the solar system as a laboratory for testing Einstein's thought experiment involving Earth as a freefalling elevator. Einstein theorized that all objects located in such an elevator would accelerate at the same rate, as if they were in a uniform gravitational field—or no gravity at all. Moreover,he predicted, these objects' properties relative to each other would remain constant during the elevator's free-fall.

In their experiment, the NIST team regarded Earth as an elevator falling through the Sun's gravitational field. They compared recorded data on the "ticks" of two types of atomic clocks located around the world to show they remained in sync over 14 years, even as the gravitational pull on the elevator varied during the Earth's slightly off-kilter orbit around the sun.Researchers compared data from 1999 to 2014for a total of 12 clocks—four hydrogen masers(microwave lasers) in the NIST time scale with eight of the most accurate cesium fountain atomic clocks operated by metrology laboratories in the United States, the United Kingdom, France, Germany and Italy.

The experiment was designed to test a prediction of general relativity, the principle of local position invariance (LPI), which holds that in a falling elevator ...Read More...

Why Are the Galilean Moons So Massive?



The Jovian moon Europa, as captured by NASA's Galileo spacecraft. NASA / JPL / SETI Institute

Jupiter, with its 67 known moons, can be viewed as a miniature solar system revolving around the Sun. Four of these moons are large enough to be visible with even a small telescope. These so-called Galilean satellites — Io, Europe, Ganymede, and Callisto — are of nearly planetary size.

But scientists haven't been able to explain how these moons became so big. Now, scientists have conducted a study to suggest that Saturn might be to blame.

During the solar system's earliest years, a huge rotating disk of gas and dust surrounded the Sun. The dust quickly glommed together into pebble-sized chunks, out of which the planets and most moons formed. As Jupiter came together, it acquired its own disk by sweeping clean a gap in the gaseous disk around the Sun. It's likely that the Galilean moons began forming within Jupiter's circumplanetary disk.But even as the giant collected gas from the circumsolar disk, it was carving the gap that would cut off its disk from material that would have helped build its moons.

René Heller (University of Göttingen, Germany), who was not involved in the new study, notes that astronomers have long been lacking a mechanism to deliver solid material to Jupiter's circumplanetary disk. "This aspect has often been overlooked or simplified in previous models for the formation of the Galilean satellites; we assumed that the gas and dust was just there, out of nowhere," he says.

One of the astronomers who investigated this impasse is Thomas Ronnet (Astrophysical Laboratory of Marseille,-France). He realized that Jupiter's massive neighbor Saturn might be involved. When the planets were forming, their orbits were still migrating — resulting in a solar system that looked very different from the one we see now, Saturn in particular is thought to have been in an orbit much closer to that of Jupiter. So Saturn could have dispersed pebbles that were stuck in the midplane of the circumsolar disk, allowing Jupiter to capture them. ..Read More...

More Mystery Objects in the Galactic Center

The object G2 (red-yellow blob above center, with orbit shown in red) zoomed by the supermassive black hole in the Milky Way's core in 2013 and 2014. The stars orbiting the black hole are also shown along with blue lines marking their orbits. The stars and the cloud are shown in their actual positions in 2011.

Reporting June 6th at the summer American Astronomical Society meeting in Denver, Anna Ciurlo (University of California, Los Angeles) and Randy Campbell (W. M. Keck Observatory) and their colleagues have discovered three red, dusty objects whizzing near our galaxy's supermassive black hole, Sgr A*.

The objects are bright in wavelengths that catch emission from hydrogen, but they're not distended like stretched-out clouds. Instead, they're compact, ensconced in dust and gas.

This isn't the first time that astronomers have detected objects like these near the black hole. Two others, called G1 and G2, follow slingshot paths around Sgr A*. G2 in particular mobilized teams across the world after its discovery in 2012, as observers watched the cloud-like object plunge through its closest approach to the black hole in 2013 and 2014, waiting to see if it would shock-heat any gas in the vicinity. (It didn't, much to their dismay.) Although the black hole's gravity did disrupt G2's shroud as it sailed by, the object survived the pass, leading many astronomers to suspect there's actually a star hiding inside.

Now, as part of a reanalysis of 12 years of Keck data, Ciurlo, Campbell, and their colleagues have found three more G objects, which they're appropriately calling G3, G4, and G5.

The objects all look like their predecessors: They're compact, bright in hydrogen emission, and red and dusty. With surface temperatures of a few hundred kelvin, they're much cooler than any normal star (about 2000 kelvin and up). They're moving maybe a tenth as fast along our line of sight as G1 and G2 do, but they're actually brighter at the wavelengths the team studied.

Although many theories exist to explain what the G objects are, the team working out of UCLA's Galactic Center Orbits Initiative and their collaborators hope that the mysterious sources might be the key to understanding the stars nearest Sgr A*. In terms of stellar neighbors, our galaxy's central black hole lives in a dense ..Read More...

What it takes to discover small rocks in space

Richard Kowalski of the UA-operated Catalina Sky Survey holds a piece of 2008 TC3, the first-ever meteorite discovered while still cruising through space. (Credit: Full Moon Photography)

Once every month, on average, somewhere on Earth a fireball appears out of nowhere and for mere seconds, casts a blinding flash across the sky before it blows up in a thunderous explosion. It happened last Saturday over southern Africa, where a small space rock disintegrated in the night sky and - possibly - scattered debris on the ground, awaiting discovery by meteorite hunters.

Despite their relative frequency, of all the small space rocks that have impacted Earth, only three have been spotted by telescopes during the final hours of their collision course with our planet. All of them happened to be discovered by the Catalina Sky Survey, or CSS, and coincidentally by the same man: Richard Kowalski. Kowalski is one of the CSS's senior research specialists and a 13-year veteran of the University of Arizona's Lunar and Planetary Laboratory.

The CSS is the only asteroid search program capable of detecting imminent small impactors, says director Eric Christensen. On June 2, 2018 LA registered as a pixelated smudge on the camera sensor of the UA's 60-inch survey telescope on Mt. Lemmon when it was roughly the same distance from Earth as the Moon. Less than nine hours later, the 6-foot bolide exploded in a ball of fire in the night sky over southern Africa.

"A key part of this sensitivity is processing the data immediately as it's acquired, and having skilled observers like Richard review the data, and report and follow up anything new and potentially interesting," Christensen says. "Though our primary directive from NASA is to detect and track larger near-Earth objects, our survey is sensitive to smaller but closer asteroids as well."

Over the last 20 years, the CSS has discovered about 8,500 near-Earth objects, or nearly half the known NEO population, plus more than 100,000 non-hazardous Main Belt asteroids and hundreds of comets.

Why does the vast majority of small asteroids like 2018 LA go undetected?

Kowalski: The sky and the solar system are very large, and the field of view with our telescopes is ...Read More...

Collisions Spray Heavy Elements Throughout Small Galaxies

The Sculptor Dwarf galaxy, pictured here, is one of the smallest galaxies included in the new Caltech study. Scientists have discovered that the majority of heavy elements in these small galaxies are created by neutron star mergers. This informs the origin of heavy elements throughout the universe.

Caltech scientists have found, for the first time, that merging pairs of neutron stars - the burnt-out cores of stars that have exploded - create the majority of heavy elements in small "dwarf" galaxies. Heavy elements, such as silver and gold, are key for planet formation and even life itself. By studying these dwarf galaxies, the researchers hope to learn more about the primary sources of heavy elements for the whole universe.

The origin of the majority of the heaviest elements of the periodic table, including 95 percent of all gold on Earth, has been debated for decades. It is now known that the heaviest elements are created when the nuclei of atoms in stars capture particles called neutrons. For most old stars, including those residing in the dwarf galaxies in this study, the process happens rapidly and is therefore called an "r-process," where the "r" stands for rapid.

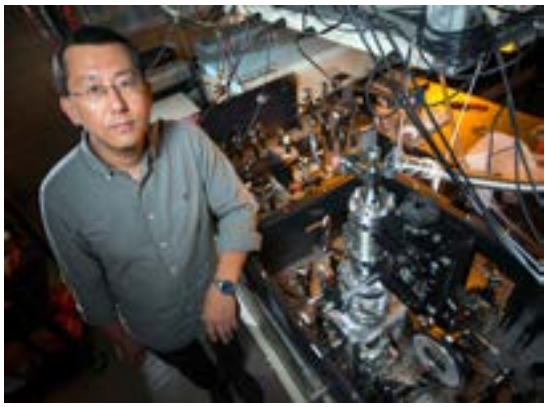
There are two favored sites where the r-process is theorized to occur. The first potential site is a rare type of a stellar explosion, or supernova, that produces large magnetic fields - a magnetorotational supernova. The second site is at the merger, or collision, of two neutron stars.

In August 2017, the National Science Foundation-funded Laser Interferometry Gravitational-wave Observatory (LIGO) and other ground-based telescopes detected one such neutron star collision in the act of creating the heaviest elements. But witnessing just one event doesn't tell astronomers where the majority of these materials are created in galaxies.

To look at heavy element production in galaxies as a whole, the Caltech researchers studied several nearby dwarf galaxies using the W. M. Keck Observatory on Maunakea in Hawaii.

While our Milky Way is considered about average in size as far as galaxies go, these dwarf galaxies, which orbit around the Milky Way, have about 100,000 times less mass in stars than the Milky Way. ...Read More...

Physicists use terahertz flashes to uncover state of matter hidden by superconductivity



Jigang Wang of Iowa State and the Ames Laboratory led experiments that switched on a hidden state of matter in a superconductive alloy. Credit: Christopher Gannon/Iowa State University

Using the physics equivalent of the strobe photography that captures every twitch of a cheetah in full sprint, researchers have used ultrafast spectroscopy to visualize electrons interacting as a hidden state of matter in a superconductive alloy.

It takes intense, single-cycle pulses of photons—flashes—hitting the cooled alloy at terahertz speed—trillions of cycles per second—to switch on this hidden state of matter by modifying quantum interactions down at the atomic and subatomic levels.

And then it takes a second terahertz light to trigger an ultrafast camera to take images of the state of matter that, when fully understood and tuned, could one day have implications for faster, heat-free, quantum computing, information storage and communication.

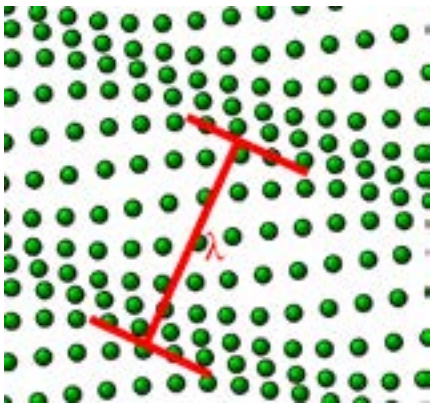
The discovery of this new switching scheme and hidden quantum phase was full of conceptual and technical challenges.

To find new, emergent electron states of matter beyond solids, liquids and gases, today's condensed matter physicists can no longer fully rely on traditional, slow, thermodynamic tuning methods such as changing temperatures, pressures, chemical compositions or magnetic fields, said Jigang Wang, an Iowa State University professor of physics and astronomy and a faculty scientist at the U.S. Department of Energy's Ames Laboratory.

"The grand, open question of what state is hidden underneath superconductivity is universal, but poorly understood," Wang said. "Some hidden states appear to be inaccessible with any thermodynamic tuning methods."

The new quantum switching scheme developed by the researchers (they call it terahertz light-quantum-tuning) uses short pulses of trillionths of a second at terahertz frequency to selectively bombard, without heating, superconducting niobium-tin, which at ...Read More...

Detecting the birth and death of a phonon



Phonon propagating through a square lattice (atom displacements greatly exaggerated). Credit: Wikipedia

Phonons are discrete units of vibrational energy predicted by quantum mechanics that correspond to collective oscillations of atoms inside a molecule or a crystal. When such vibrations are produced by light interacting with a material, the vibrational energy can be transferred back and forth between individual phonons and individual packets of light energy, the photons. This process is called the Raman effect.

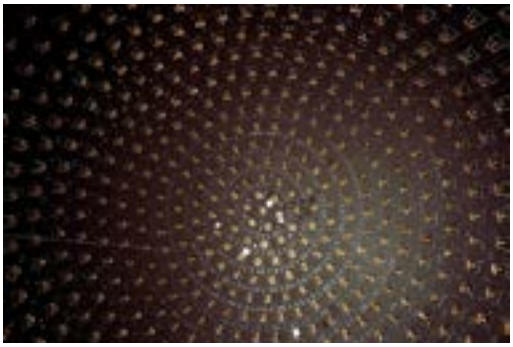
In a new study, the lab of Christophe Galland at EPFL's Institute of Physics has developed a technique for measuring, in real time and at room-temperature, the creation and destruction of individual phonons, opening up exciting possibilities in various fields such as spectroscopy and quantum technologies.

The technique uses ultra-short laser pulses, which are bursts of light that last less than 10-13 seconds (a fraction of a trillionth of a second). First, one such pulse is shot onto a diamond crystal to excite a single phonon inside it. When this happens, a partner photon is created at a new wavelength through the Raman effect and is observed with a specialized detector, heralding the success of the preparation step.

Second, to interrogate the crystal and probe the newly created phonon, the scientists fire another laser pulse into the diamond. Thanks to another detector, they now record photons that have reabsorbed the energy of the vibration. These photons are witnesses that the phonon was still alive, meaning that the crystal was still vibrating with exactly the same energy.

This is in strong contradiction with our intuition: we are used to seeing vibrating objects progressively lose their energy over time, like a guitar string whose sound fades away. But in quantum mechanics this is "all or nothing": the crystal either vibrates with a specific energy or it is in its resting state; there is no state allowed in between. The decay of the phonon over time is therefore observed as a decrease of the probability of finding it in the excited state instead of having jumped down to ...Read More...

Blast from the past—First measurement of mono-energetic neutrinos



This interior view of the MiniBooNE detector tank shows the array of photodetectors used to pick up the light particles that are created when a neutrino interacts with a nucleus inside the tank. Credit: Fermilab / Reidar Hahn

By analyzing data collected over eight years ago, scientists at the U.S. Department of Energy's (DOE) Argonne National Laboratory and Fermi National Accelerator Laboratory have made a potentially groundbreaking discovery.

In 2002, scientists began the Booster Neutrino Experiment, known as MiniBooNE, at Fermilab to learn more about how neutrinos—very light, neutral fundamental particles—interact with matter. Scientists recently reexamined data from the experiment taken between 2009 and 2011, and they found the first direct evidence of mono-energetic neutrinos, or neutrinos with definite energy, that are energetic enough to produce a muon.

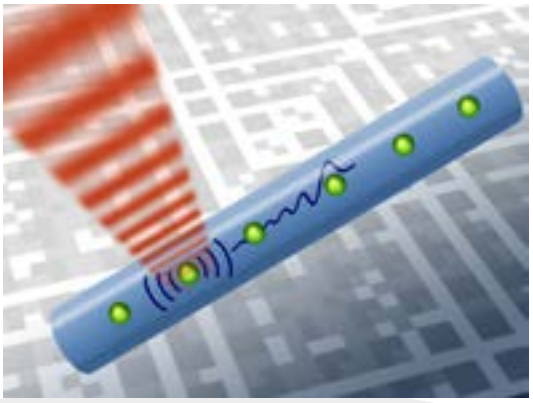
Neutrinos are extremely light and are only influenced by the weak subatomic force, so they rarely interact with matter. In fact, they could travel through light-years of lead before interacting with it. The particles are very difficult to detect, but not difficult to create. Because of the neutrino's elusiveness, scientists have to work with beams composed of large numbers of the particles. They shoot the beams at nuclei in a detector, hoping for neutrinos to collide with the target material.

"One complication of using these large beams is that the energies of the neutrinos are widely varied and somewhat unpredictable," said Argonne physicist Joe Grange, one of the scientists that helped discover mono-energetic neutrinos. "This makes it difficult to fully interpret the data."

The new discovery could help experimentalists solve this problem. The scientists realized that mono-energetic neutrinos were being released from a nearby neutrino beamline at Fermilab, and they decided to look at the MiniBooNE data to see if any of these neutrinos were detected during that experiment.

Sure enough, analysis of the MiniBooNE data showed evidence of thousands of neutrino-nucleus collisions where the neutrinos all started out with the same energy, 236 mega-electron-volts (MeV). During the MiniBooNE experiment, particles called kaons created in ...Read More...

Transferring quantum information using sound



Microwaves can influence the 'quantum switches' in a narrow diamond rod, which can be linked by vibrations. Credit: TU Wien

Quantum physics has led to new types of sensors, secure data transmission methods and researchers are working toward computers. However, the main obstacle is finding the right way to couple and precisely control a sufficient number of quantum systems (for example, individual atoms).

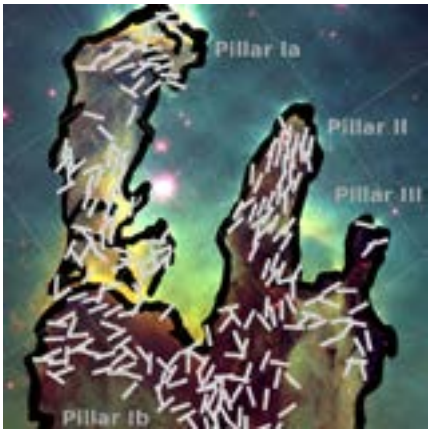
A team of researchers from TU Wien and Harvard University has found a new way to transfer quantum information. They propose using tiny mechanical vibrations. The atoms are coupled via phonons—the smallest quantum mechanical units of vibrations or sound waves.

"We are testing tiny diamonds with built-in silicon atoms—these quantum systems are particularly promising," says Professor Peter Rabl from TU Wien. "Normally, diamonds are made exclusively of carbon, but adding silicon atoms in certain places creates defects in the crystal lattice where quantum information can be stored." These microscopic flaws in the crystal lattice can be used like tiny switches that can be toggled between a state of higher energy and a state of lower energy using microwaves.

Together with a team from Harvard University, Peter Rabl's research group has developed a new idea to achieve the targeted coupling of these quanta within the diamond. One by one, they can be built into a tiny diamond rod measuring only a few micrometres in length, like individual pearls on a necklace. Just like a tuning fork, this rod can then be made to vibrate—however, these vibrations are so small that they can only be described using quantum theory. It is through these vibrations that the silicon atoms can form a quantum-mechanical link to each other.

"Light is made from photons, the quantum of light. In the same way, mechanical vibrations or sound waves can also be described in a quantum-mechanical manner. They are composed of phonons—the smallest possible units of mechanical vibration," explains Peter Rabl. As the research team has now been able to show using simulation calculations, any number of these quanta can be linked together in the diamond rod via phonons. ...Read More...

Magnetic fields could hold the key to star formation



Pillars of Creation. Credit: University of Central Lancashire

Astronomers have discovered new magnetic fields in space, which could shed light on how stars are formed and uncover the mysteries behind one of the most famous celestial images.

For the first time, extremely subtle magnetic fields in the Pillars of Creation – a structure made famous thanks to an iconic image taken by the Hubble Space Telescope – have been discovered and mapped.

The structure consists of cosmic dust and cold, dense gas that have nurseries of stars forming at their tips. This innovative research has shown that the magnetic fields that run along the lengths of the Pillars are at a different angle to the regions surrounding the Pillars, revealing the reason behind their unusual structure.

This ground-breaking discovery suggests that the Pillars have evolved due to the strength of the magnetic field and that the Pillars are held up thanks to magnetic support, suggesting that stars could be formed by the collapse of clumps of gas being slowed down by magnetic fields, and resulting in a pillar-like formation.

The discovery was made by a global team of researchers known as BISTRO and led by astronomers from the University of Central Lancashire (UCLan) who made measurements at the James Clerk Maxwell Telescope in Hawaii. Using an instrument on the telescope known as a polarimeter, the researchers showed that the light emitted from the Pillars is polarised, indicating the direction of the magnetic field.

Professor Derek Ward-Thompson, Head of the School of Physical Sciences and Computing at UCLan, said: "The technology employed to view the minutiae of the magnetic fields is truly remarkable, and the fact that we have been able to observe the incredibly weak magnetic field with this sensitive instrument will help us to solve the mystery of the formation of stars." ...Read More...

Juno solves 39-year old mystery of Jupiter lightning

This artist's concept of lightning distribution in Jupiter's northern hemisphere incorporates a JunoCam image with artistic embellishments. Data from NASA's Juno mission indicates that most of the lightning activity on Jupiter is near its poles. Credit: NASA/JPL-Caltech/SwRI/JunoCam

Ever since NASA's Voyager 1 spacecraft flew past Jupiter in March, 1979, scientists have wondered about the origin of Jupiter's lightning. That encounter confirmed the existence of Jovian lightning, which had been theorized for centuries. But when the venerable explorer hurtled by, the data showed that the lightning-associated radio signals didn't match the details of the radio signals produced by lightning here at Earth.

In a new paper published in Nature today, scientists from NASA's Juno mission describe the ways in which lightning on Jupiter is actually analogous to Earth's lightning. Although, in some ways, the two types of lightning are polar opposites.

"No matter what planet you're on, lightning bolts act like radio transmitters—sending out radio waves when they flash across a sky," said Shannon Brown of NASA's Jet Propulsion Laboratory in Pasadena, California, a Juno scientist and lead author of the paper. "But until Juno, all the lightning signals recorded by spacecraft [Voyagers 1 and 2, Galileo, Cassini] were limited to either visual detections or from the kilohertz range of the radio spectrum, despite a search for signals in the megahertz range. Many theories were offered up to explain it, but no one theory could ever get traction as the answer."

Enter Juno, which has been orbiting Jupiter since July 4, 2016. Among its suite of highly sensitive instruments is the Microwave Radiometer Instrument (MWR), which records emissions from the gas giant across a wide spectrum of frequencies.

"In the data from our first eight flybys, Juno's MWR detected 377 lightning discharges," said Brown. "They were recorded in the megahertz as well as gigahertz range, which is what you can find with terrestrial lightning emissions. We think the reason we are the only ones who can see it is because Juno is flying closer to the lighting than ever before, and we are searching at a radio frequency that passes easily through ...Read More...

Special Read:

Asteroid 2018 LA Explodes Over Botswana Hours After Discovery

A frame grab from Barend Swanepoel's security video shows the fireball made by incoming asteroid 2018 LA on June 2. Barend Swanepoel

Richard Kowalski of the Catalina Sky Survey (CSS) has done it again! On June 2, 2018, he spotted an asteroid only hours before it came crashing down to Earth. The new object, designated 2018 LA, was first picked up by the Mt. Lemmon Survey (part of the CSS) at 09:32 UT, a little more than 7 hours before it entered the atmosphere near the border of South Africa and Botswana at 16:53 UT. Kowalski observed the object using a 60-inch reflecting telescope located atop Mt Lemmon in the Santa Catalina mountains outside Tucson, Arizona.

Traveling to the east at about 17 kilometers a second, the meteoroid grew into a spectacular fireball. Witnesses described it as equal to the Sun in brilliance and accompanied by thunderous explosions – good signs that fragments of the object may have survived and landed as meteorites. 2018 LA is an Earth-crossing asteroid (no kidding!) belonging to the Apollo group, with an estimated diameter between 2.1 and 4.6 meters.

Already, several meteorite hunters are en route to the region hoping to gather more eyewitness reports and other data that would help narrow the search for a possible strewnfield where pieces might be found. If you're reading this and live in the region or know someone who does, Mike Hankey of the American Meteor Society urges you to fill out this fireball report form as soon as possible. If pieces fell, hunters want to get the pristine material into the hands of researchers as quickly as possible to maximize the fall's scientific return. .

This is only the third time an asteroid has been discovered on an impact trajectory. And all three were nailed by the survey's senior research specialist Richard Kowalski. 2008 TC3 was the first, a 4.1-meter object discovered on October 7, 2008. Nineteen hours later it exploded over Sudan's Nubian Desert, dropping more than 600 meteorites with a total weight of 10.5 kilograms. The parent body proved to be a bizarre mishmash of different meteorite types, from rare ureilites to common, metal-rich chondrites.

On January 1, 2014, Kowalski hit a second home run with 2014 AA, another Apollo asteroid estimated at 2 to 4 meters across. It was observed for only 70 minutes before it plummeted into the Atlantic Ocean northeast of Brazil about 21 hours later. ...Read More...

This Week's Sky at a Glance
June 09-15, 2018

Jun 13	We	23:43	New Moon
Jun 15	Fr	03:55	Moon Perigee: 359500 km
		04:52	Moon North Dec.: 20.8° N

Shawwal 1439 AH Crescent Report

Shawwal 1439 AH

Basic Astronomical Information about the observations of the crescent of Shawwal 1439 AH:

	June 13, 2018	June 14, 2018
New Moon	23:43	--
Sunset (Azimuth)	19:09 (296º)	19:09 (296º)
Moonset (Azimuth)	18:44 (292º)	19:49 (293º)
Moon's Altitude	-5.6º	7.7º
Lag Time ((Minutes)	--	40
Age (Hrs, Min)	--	19h 26 m

Summary:

An impossible setting for the crescent to be observed on Jun. 13 with the naked eye since the Moon sets before sunset. We should expect the first day of Shawwal 1439 AH to be on Friday Jun. 15, 2018.

Special Shawwal 1439 AH Crescent Observation

Location: Sharjah Observatory (SCASS)

Date: Thursday, June 14, 2018

Time: 18:30 - 20:00

Open to All

(Light breakfast will be provided)