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Astronomy & Physics Weekly News

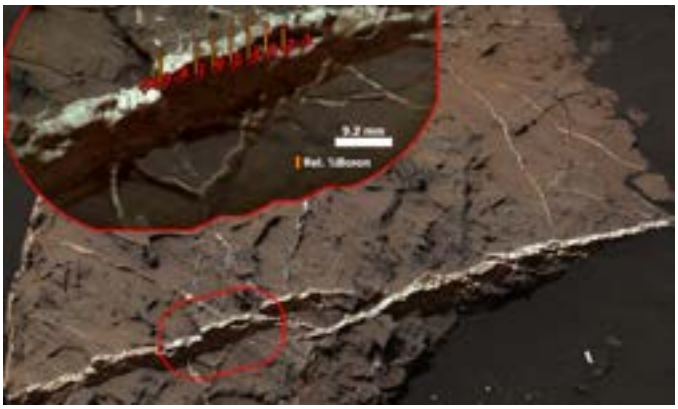
Dept. of Applied Physics & Astronomy - University of Sharjah
Compiled by Dr. Ilias Fernini

Top News

IT Support Issam Jami

Designed by Mohamed Bakir

First detection of boron on the surface of Mars



ChemCam target Catabola is a raised resistant calcium sulfate vein with the highest abundance of boron observed so far. The red outline shows the location of the ChemCam target remote micro images (inset). The remote micro images show the location of each individual ChemCam laser point (red crosshairs) and the B chemistry associated with each point (colored bars). The scale bar is 9.2 mm or about 0.36 inches. Image courtesy JPL-Caltech/MSSS/LANL/CNES-IRAP/William Rapin

Boron has been identified for the first time on the surface of Mars, indicating the potential for long-term habitable groundwater in the ancient past. This finding and others from NASA's Curiosity rover science team will be discussed in a press conference in San Francisco during the American Geophysical Union conference.

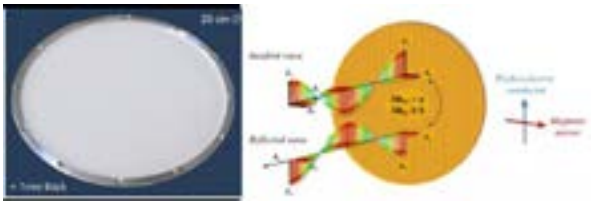
"No prior mission to Mars has found boron," said Patrick Gasda, a postdoctoral researcher at Los Alamos National Laboratory. "If the boron that we found in calcium sulfate mineral veins on Mars is similar to what we see on Earth, it would indicate that the groundwater of ancient Mars that formed these veins would have been 0-60 degrees Celsius [32-140 degrees Fahrenheit] and neutral-to-alkaline pH." The temperature, pH, and dissolved mineral content of the groundwater could make it habitable. (Watch video here.)

The boron was identified by the rover's laser-shooting Chemistry and Camera (ChemCam) instrument, which was developed at Los Alamos National Laboratory in conjunction with the French space agency. Los Alamos' work on discovery-driven instruments like ChemCam stems from the Laboratory's experience building and operating more than 500 spacecraft instruments for national defense.

Boron is famously associated with arid sites where much water has evaporated away--think of the borax that mule teams once hauled from Death Valley. However, environmental implications of the boron found by Curiosity are still open to debate.

Scientists are considering at least two possibilities for the source of boron that groundwater left in the veins: It could be that the drying out of part of Gale lake resulted in a boron-containing deposit in an overlying layer, not yet reached by Curiosity. ...Read More...

Magnetic mirror could shed new light on gravitational waves



Researchers have created a new metamaterial half-wave plate operating at millimeter wavelengths that is less than 1-millimeter thick. When light reflects off the device, the polarization parallel to the wire-grid is reversed in its orientation, whereas the polarization perpendicular to it stays in the same direction. The overall effect is to create a differential phase-shift between orthogonal polarizations equal to 180 degrees. The rotation of the plate causes modulation of the polarization. Image courtesy Giampaolo Pisano, Cardiff University.

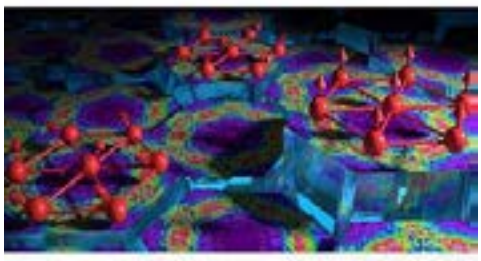
Researchers have created a new magnetic mirror-based device that could one day help cosmologists discover new details about ripples in space-time known as gravitational waves, particularly those emitted when the universe was extremely young.

The new work is part of a multi-institutional collaboration funded by the European Space Agency's (ESA) Technology Research Program to develop technologies necessary for future experiments such as the proposed Cosmic Origins Explorer satellite mission program. This space mission aims to acquire high precision, full-sky maps of the cosmic microwave background - the relic emission that survived since the Big Bang.

Cosmic microwave background has been the subject of intense investigation since its discovery about 50 years ago. Recent years have seen an increased focus on the polarized components of this microwave background - in particular a component called B-mode, which is thought to hold the key to information about primordial gravitational waves and the physical processes that occurred very early in the history of the universe.

In The Optical Society (OSA) journal Applied Optics, the researchers demonstrated a new type of polarization modulator based on a magnetic mirror. The new device could overcome a major challenge to detecting the B-mode polarization - the ability to modulate microwave polarization across a broad frequency range. Broadband operation is necessary to spectrally discriminate the extremely faint B-mode polarization from the foreground radiation of other astrophysical sources. "We, like others, have been working for over two decades on the development of technologies that would enable the detection of the B-mode polarization," said Giampaolo ...Read More...

Neutrons identify key ingredients of the quantum spin liquid recipe



Red arrows represent electron spin orientations in a portion of the YbMgGaO4 crystal structure, where antiferromagnetic interactions between groups of magnetic moments cause neighboring spins to align anti-parallel to one another. This mechanism is partially responsible for the quantum spin liquid behavior observed in the neutron scattering data, illustrated on the hexagonal tiles. Image courtesy ORNL/Jill Hemman.

Neutron scattering studies of a rare earth metal oxide have identified fundamental pieces to the quantum spin liquid puzzle, revealing a better understanding of how and why the magnetic moments within these materials exhibit exotic behaviors such as failing to freeze into an ordered arrangement even near absolute zero temperatures.

In a paper published in Nature Physics, a team of researchers from the Georgia Institute of Technology, the University of Tennessee and the Department of Energy's Oak Ridge National Laboratory used neutrons to examine the origins of unusual magnetic behavior in a rare earth-based metal oxide, ytterbium-magnesium-gallium-tetraoxide (YbMgGaO4). The material, discovered in 2015, is known to have strange magnetic properties, putting it in a unique category of materials classified as quantum spin liquids.

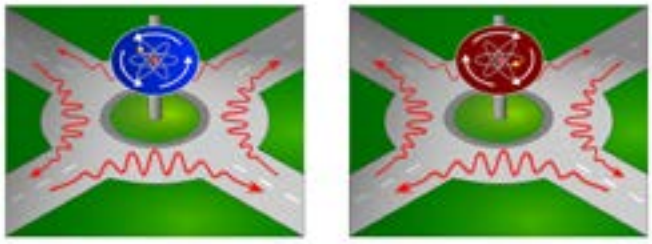
"A quantum spin liquid is an exotic state of matter characterized by the entanglement of particles over long distances across the atomic scale," said lead investigator Martin Mourigal, an assistant physics professor at the Georgia Institute of Technology.

Think of Schrodinger's cat, the thought experiment, he said: Many particles participate in a quantum superposition, where multiple quantum states combine to form a new quantum state, and cannot be characterized by the behavior of individual particles.

By definition, he said, "it's something we can't explain with classical physics." In a series of experiments at ORNL's Spallation Neutron Source, the researchers revealed three key features underpinning the material's exotic properties:

antiferromagnetic interactions, where groups of electron spins have an antiparallel alignment with their respective neighbors; spin space anisotropy, meaning that individual magnetic moments strongly prefer aligning themselves alongside specific directions in the material; and chemical disorder between the material's magnetic ...Read More...

A nano-roundabout for light



Functional principle of a nano-roundabout is shown. Image courtesy TU Wien

Just like in normal road traffic, crossings are indispensable in optical signal processing. In order to avoid collisions, a clear traffic rule is required. A new method has now been developed at TU Wien to provide such a rule for light signals. For this purpose, the two glass fibers were coupled at their intersection point to an optical resonator, in which the light circulates and behaves as in a roundabout.

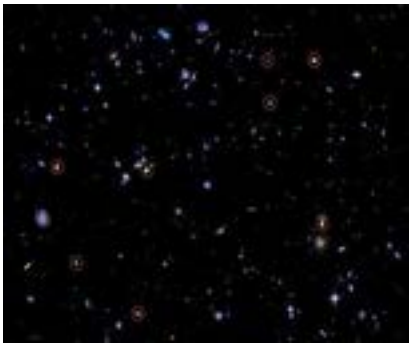
The direction of circulation is defined by a single atom coupled to the resonator. The atom also ensures that the light always leaves the roundabout at the next exit. This rule is still valid even if the light consists merely of individual photons. Such a roundabout will consequently be installed in integrated optical chips - an important step for optical signal processing.

Signal processing using light instead of electronics
The term "optical circulators" refers to elements at the intersection point of two mutually perpendicular optical fibers which direct light signals from one fiber to the other, so that the direction of the light always changes, for example, by 90 clockwise. "These components have long been used for freely propagating light beams," says Arno Rauschenbeutel from the Vienna Center for Quantum Science and Technology at the Institute of Atomic and Subatomic Physics of TU Wien.

"Such optical circulators are mostly based on the so-called Faraday effect: a strong magnetic field is applied to a transparent material, which is located between two polarization beam splitters which are rotated with respect to each other. The direction of the magnetic field breaks the symmetry and determines in which direction the light is redirected."

However, for technical reasons, components that make use of the Faraday effect cannot be realized on the small scales of nanotechnology. This is unfortunate as such components are important for future technological applications. "Today, we are trying to build optical integrated circuits with similar functions as they are known from electronics," says Rauschenbeutel. Other methods to break the symmetry of the light function only at very high light intensities or suffer from high optical losses. ...Read More...

Young, thin and hyperactive: That's what outlier galaxies look like



A new model explains the exceptions to the galaxy main sequence.

If we put the galaxies for which we have the relevant data into a graph relating the mass of stars in each galaxy with the star formation rate of that galaxy, most of them would appear as a compact cloud, which could be described by using a simple function.

This graph is known as the Galaxy Main Sequence (GMS), a fundamental observational relation for scientists who study galaxies. The picture that emerges is simple: the more massive the galaxy, the faster its star formation process tends to be.

But straightforward as it seems, there's a problem. There are some exceptions (abnormal or outlier cases) that do not seem to follow the rule. Certain galaxies, in fact, while not containing many stars have very intense rates of star formation.

The most accredited hypothesis to explain these abnormal cases invokes collision and merging between two galaxies: these outliers would therefore be nothing but galaxies captured during their collision, a phenomenon that would lead to a sudden, though transient, increase in their star formation rate.

Claudia Mancuso, SISSA researcher and first author of the study together with SISSA professors Andrea Lapi and Luigi Danese, suggested a fascinating alternative explanation: "According to the approach we developed at SISSA and published only a few months ago, collision and merging, while possible, are not so relevant as to be able to account for the formation and evolution of galaxies, including the outliers observed in GMS", says the scientist.

"Our approach offers an in situ explanation based solely on processes internal to the evolving galaxy".

The role of the central black hole
In particular, the explanation given by Mancuso and colleagues is based on the close relation that exists between star formation and the growth of the central black hole inside massive galaxies.

"These two events are simultaneous and inter-related. As the galaxy forms stars and increases its mass in a constant and substantial manner, its black hole grows as well, and does so at an even faster rate", explains Mancuso. "At a certain point the black hole becomes so big as to develop an 'energetic wind', which sweeps away gas and dust from its surrounding environment. Since these ...Read More...

Giving the Sun a brake

An image of the Sun taken with The Helioseismic and Magnetic Imager (HMI) on the Solar Dynamics Observatory spacecraft. HMI is an instrument designed to study oscillations and the magnetic field at the solar surface, or photosphere. HMI observes the full solar disk with a resolution of 1 arcsecond. Image courtesy NASA.

Astronomers from the University of Hawaii Institute for Astronomy (IfA), Brazil, and Stanford University may have solved a long-standing solar mystery. Two decades ago, scientists discovered that the outer five percent of the Sun spins more slowly than the rest of its interior. Now, in a new study, to be published in the journal Physical Review Letters, IfA Maui scientists Ian Cunnyngham, Jeff Kuhn, and Isabelle Scholl, together with Marcelo Emilio (Brazil) and Rock Bush (Stanford), describe the physical mechanism responsible for slowing the Sun's outer layers.

Team leader Jeff Kuhn said, "The Sun won't stop spinning anytime soon, but we've discovered that the same solar radiation that heats the Earth is 'braking' the Sun because of Einstein's special relativity, causing it to gradually slow down, starting from its surface." The Sun rotates on its axis at an average rate of about once per month, but that rotation isn't like, for example, the solid Earth or a spinning disk because the rate varies with solar latitude and distance from the center of the Sun.

The team used several years of data from NASA's Solar Dynamics Observatory and the Helioseismic and Magnetic Imager instrument to measure a sharp down-turn in the Sun's rotation rate in its very outer 150 km. Kuhn said, "This is a gentle torque that is slowing it down, but over the Sun's 5 billion year lifetime it has had a very noticeable influence on its outer 35,000 km." Their paper describes how this photon-braking effect should be at work in most stars.

This change in rotation at the Sun's surface affects the large-scale solar magnetic field, and researchers are now trying to understand how the solar magnetism that extends out into the corona and finally into the Earth's environment will be affected by this braking. ...Read More...

A new light on stellar death

An artist's depiction of a rapidly spinning supermassive black hole surrounded the rotating leftovers of a star that was ripped apart by the tidal forces of the black hole. Image courtesy ESO, ESA/Hubble, M. Kornmesser.

Back in 2015 when astronomers discovered an intense flare in a distant galaxy, they considered it the brightest supernova ever observed. Now, UC Santa Barbara astrophysicists and a group of international colleagues offer an entirely different interpretation based on new astronomical observation data from the Las Cumbres Observatory (LCO), a global robotic telescope network, and the Hubble Space Telescope.

The new information indicates that the event, called ASASSN-15lh, is actually a tidal disruption event (TDE) - the destruction of a star by a supermassive black hole. The findings appear in the inaugural issue of the journal Nature Astronomy. "Years ago we just wouldn't have been able to follow an event like this," said co-author Andy Howell, leader of the supernova group at the Goleta, California-based LCO and an adjunct professor in UCSB's Department of Physics.

"This study shows that large-area surveys, a global robotic telescope network and a NASA satellite can come together to reveal dramatic new discoveries that wouldn't be possible without each piece of that puzzle."

Using images from the Hubble Space Telescope that were not available when ASASSN-15lh was discovered, the scientists found that the event occurred at the center of the galaxy where the supermassive black hole resides. The black hole inferred to lie in this galaxy is more than 100 million times the mass of the sun.

For a star to be tidally disrupted by such a massive black hole - rather than swallowed whole - the black hole must be spinning very rapidly. This discovery marks the first time that a TDE has been used to probe the spin of a black hole, a property that is very difficult to measure and is used to infer the existence of so-called Kerr black holes.

ASASSN-15lh occurred when the star strayed too close to the supermassive black hole and was torn apart by the tides generated by the extreme gravity. The stellar material orbited around the black hole, collided with itself at high velocity and started falling into the ...Read More...

The quantum computers of the future will work equally well with encrypted and un-encrypted inputs

Credit: CCO Public Domain

When future users of quantum computers need to analyze their data or run quantum algorithms, they will often have to send encrypted information to the computer.

Because of this requirement, researchers from DTU Physics and the University of Toronto have investigated whether a quantum computer can work equally well with encrypted and unencrypted signals. The results indicate that the efficiency remains almost unchanged.

The development of a universal quantum computer is generally considered the ultimate goal within the area of physics called quantum information theory. If this goal is achieved it will enable huge progress within a long list of research fields where quantum effects are important. This could for example by in designing new medicine or new types of materials for construction or electronics.

Inspired by the history of the development of the classical computer, the researchers expect that the first generation of quantum computers will be large, expensive and difficult to operate and maintain.

For these reasons it is also expected that these devices will, at least initially, only be available to large organizations and governments.

Can a blind quantum computer be useful?

This leads to the idea of delegated quantum computing, where a user obtains access to a centralized quantum computer through a network, often thought of as a quantum version of the internet. If the user wants the request forwarded to the quantum computer to be secret, even to the quantum computer itself, she is able to encrypt them. The question is then if a quantum computer that is working in the dark, because the input is encrypted, is as efficient as when it is working on the plain input. A universal quantum computer consists of a number of so-called gates. More generally, a gate is a logical operation. Both quantum and ordinary computers make use of gates ..Read More...

Researchers achieve meter-scale optical coherence tomography for first time

A new 3-D OCT technique allows imaging of large objects such as this life-size mannequin and chessboard. Credit: James G. Fujimoto, Massachusetts Institute of Technology

An industry-academic collaboration has achieved the first optical coherence tomography (OCT) images of cubic meter volumes. With OCT's ability to provide difficult-to-obtain information on material composition, subsurface structure, coatings, surface roughness and other properties, this advance could open up many new uses for OCT in industry, manufacturing and medicine. The achievement also represents important progress toward developing a high-speed, low-cost OCT system on a single integrated circuit chip.

"Our study demonstrates world-record results in cubic meter volume imaging, with at least an order of magnitude larger depth range and volume compared to previous demonstrations of three-dimensional OCT," said James G. Fujimoto of the Massachusetts Institute of Technology (MIT), Massachusetts. "These results provide a proof-of-principle demonstration for using OCT in this new regime."

OCT, first invented by Fujimoto's group and collaborators in the 1990s, is now the standard of care in ophthalmology and is increasingly used in cardiology and gastroenterology. Although OCT provides useful 3-D images with micron-scale resolution, it has been limited to imaging depths of just millimeters to a few centimeters.

In The Optical Society's journal for high impact research, Optica, the researchers report high speed, 3-D OCT imaging with 15-micron resolution over a 1.5-meter area. They demonstrated the new OCT approach by imaging a mannequin, a bicycle and models of a human brain and skull. They also conducted measurements of objects ranging in scale from meters to microns.

Multiple scales over long ranges

In addition to the advantages of high speeds and fine resolution, OCT enables imaging, profiling and distance measurement at multiple depths simultaneously ..Read More...

New diamond harder than a jeweller's diamond, cuts through ultra-solid materials

Diamond in the anvil the scientists used to make the nano-sized Lonsdaleite. Credit: Jamie Kidston, ANU

The Australian National University (ANU) has led an international project to make a diamond that's predicted to be harder than a jeweller's diamond and useful for cutting through ultra-solid materials on mining sites.

ANU Associate Professor Jodie Bradby said her team - including ANU PhD student Thomas Shiell and experts from RMIT, the University of Sydney and the United States - made nano-sized Lonsdaleite, which is a hexagonal diamond only found in nature at the site of meteorite impacts such as Canyon Diablo in the US.

"This new diamond is not going to be on any engagement rings. You'll more likely find it on a mining site - but I still think that diamonds are a scientist's best friend. Any time you need a super-hard material to cut something, this new diamond has the potential to do it more easily and more quickly," said Dr Bradby from the ANU Research School of Physics and Engineering.

Her research team made the Lonsdaleite in a diamond anvil at 400 degrees Celsius, halving the temperature at which it can be formed in a laboratory.

"The hexagonal structure of this diamond's atoms makes it much harder than regular diamonds, which have a cubic structure. We've been able to make it at the nanoscale and this is exciting because often with these materials 'smaller is stronger'."

Lonsdaleite is named after the famous British pioneering female crystallographer Dame Kathleen Lonsdale, who was the first woman elected as a Fellow to the Royal Society.

The research is published in Scientific Reports.

Co-researcher Professor Dougal McCulloch from RMIT said the collaboration of world-leading experts in the field was essential to the project's success. "The discovery of the nano-crystalline hexagonal diamond was only made possible by close collaborative ties between leading ...Read More...

Europe's own satnav, Galileo, due to go live

Joint ESA-Galileo Contro team.

Seventeen years and more than 10 billion euros ($11 billion) later, Europe's Galileo satnav system is set to go live Thursday, promising to outperform US and Russian rivals while boosting regional self-reliance.

Initial services, free to use worldwide, will be available only on smartphones and navigation boxes already fitted with Galileo-compatible microchips.

Some devices may only need a software update to start using the new technology, and European Commission spokeswoman Mirna Talko said several smartphone giants were already making chips compatible with it.

"It will be the first time that users around the world will be able to be guided by Galileo satellites," said Lucia Caudet of the Commission, which funds the project.

Somewhat fuzzy at first, the signal will be boosted with help from satellites in the US military-run GPS system, growing stronger over time as orbiters are added to the now 18-strong Galileo network circling 23,222 kilometres (14,430 miles) above Earth.

According to its proud parents, the Commission and European Space Agency (ESA), Galileo should be fully operational by 2020, providing time and positioning data of unprecedented accuracy.

"GPS allows a train to know which area it is in -- Galileo will allow it to identify the track it is on," according to Jean-Yves Le Gall, president of France's CNES space agency, one of ESA's 22 country members.

Such precision would also be invaluable for safer driverless cars and nuclear power plants, as well as better telecommunications.

- Setbacks - The civil-controlled service is also of great strategic importance for Europe, which relies on two military-run services -- GPS and Russia's GLONASS, which provide no guarantee of uninterrupted service. ...Read More...

NASA Tech - it's all around us

JPL research into imaging technology helped to revolutionize digital cameras in the 1990s, eventually paving the way for smaller devices like phone cameras and GoPros.

Next time you share an amazing GoPro video with a friend, consider that NASA made that technology possible. The image sensors that would later be used in GoPros - and in all modern digital cameras, including those in cell phones - were first developed in the early 1990s at NASA's Jet Propulsion Laboratory, Pasadena, California. Those rudimentary sensor arrays used less power and were easier to mass produce than the standard methods of the time, helping to kickstart an entire industry.

Complementary metal-oxide-semiconductor (CMOS) image sensor technology, which grew out of NASA's efforts during that time to create "faster, better, cheaper" spacecraft, is just one of many tech transfer examples in the 2017 issue of Spinoff. This annual publication highlights how space technology has been adopted by commercial industries, leading to benefits for people on Earth. This year's Spinoff includes several unique success stories from JPL and other NASA centers.

Digital imaging made wingsuit videos possible
In the 1980s, spacecraft imaging was done using charge coupled device (CCD) technology, which was integral to founding the digital camera industry. CCD acts as a kind of "bucket brigade," passing along a light-generated charge from pixel to pixel in a microchip's array. When the charge reaches the end of the array, it gets amplified and recorded.

A JPL engineer named Eric Fossum thought there was a better way. CMOS technology, which had changed microprocessors, allowed each pixel to also serve as a charge amplifier, using less energy and making each pixel more sensitive.

Major companies like Kodak and AT and T Bell Labs eventually licensed the technology. Fossum, along with several JPL colleagues, founded a company called Photobit to develop it further. By the end of the decade, CMOS sensors had become the standard in the digital camera industry. GoPro would later leverage the unique, low-power capabilities of CMOS to make cameras even smaller. That allowed video to be shot from the front of surfboards, the tops of helmets, and ...Read More...

This Week's Sky at a Glance - Dec. 10 - 16

Dec. 18	Regulus 1.0°N of Moon (22:13)
Dec. 19	Moon at Ascending Node (08:46)
Dec. 21	Last Quarter Moon (05:56)
Dec. 21	Winter Solstice (14:45)
Dec. 22	Ursid Meteor Shower
Dec. 22	Jupiter 2.4°S of Moon (20:37)

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Sharjah Center for Astronomy and Space Sciences
Sharjah - United Arab Emirates
Phone: 00-971-6-5166000
www.scass.ae / scass@scass.ae

College of Sciences - University of Sharjah
POB 27272 - Sharjah - United Arab Emirates
Phone: 00-971-6-5050351
www.sharjah.ac.ae /physics@sharjah.ac.ae