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Astronomy & Physics News

Department of Applied Physics— University of Sharjah
Weekly Scientific News Compiled by Dr. Ilias Fernini

Inside this issue:

Evidence for new state of hydrogen: Discovery gives glimpse of conditions found on other planets

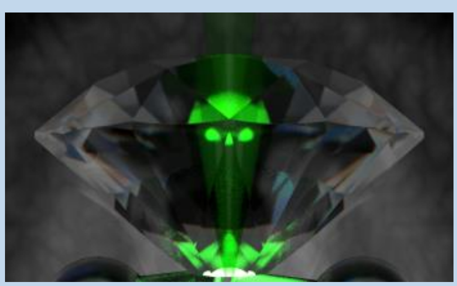
Scientists have recreated an elusive form of the material that makes up much of the giant planets in our solar system, and the sun.

Experiments have given a glimpse of a previously unseen form of hydrogen that exists only at extremely high pressures - more than 3 million times that of Earth's atmosphere.

Hydrogen - which is among the most abundant elements in the Universe - is thought to be found in this high-pressure form in the interiors of Jupiter and Saturn.

Researchers around the world have been trying for years to create this form of the element, known as the metallic state, which is considered to be the holy grail of this field of physics. It is believed that this form of hydrogen makes up most of the interiors of Jupiter and Saturn.

The metallic and atomic form of hydrogen, formed at elevated pressures, was first theorized to exist 80 years ago. Scientists have tried to confirm this in lab experiments ...Read More...



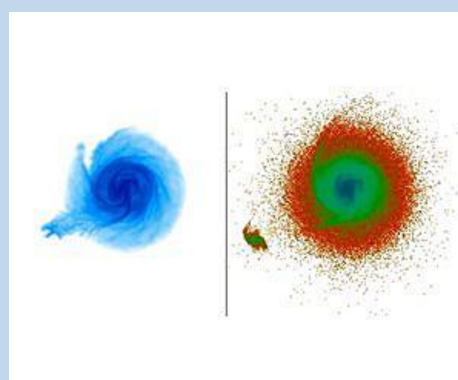
An artistic representation of a hydrogen molecule under compression using opposed diamond anvil devices. The experimental work using micro-focused Raman spectroscopy explores the possibility of breaking the hydrogen molecule through means of room-temperature compression in an attempt to reach the long proposed metallic state of hydrogen. Credit: Philip Dalladay-Simpson and Eugene Gregoryanz

Galaxy Quakes Could Improve Hunt for Dark Matter

A trio of brightly pulsating stars at the outskirts of the Milky Way is racing away from the galaxy and may confirm a method for detecting dwarf galaxies dominated by dark matter and explain ripples in the outer disk of the galaxy.

This new method to characterize dark matter marks the first real application of the field of galactoseismology. Just as seismologists analyze waves to infer properties about the Earth's interior, Sukanya Chakrabarti, assistant professor at Rochester Institute of Technology, uses waves in the galactic disk to map the interior structure and mass of galaxies.

Chakrabarti and her team used spectroscopic observations to calculate the speed of the three Cepheid variables - stars used as yardsticks to measure distance in galaxies - in the Norma constellation. Chakrabarti's 2015 study used Cepheid variables to mark the location of a dark-matter dominated dwarf galaxy approximately 300,000 light-years away. In contrast, the ...Read More...



These images of the Milky Way show the distribution of gas, at left, compared to the distribution of stars, at right, after the dwarf satellite disrupts the galaxy. Image courtesy Sukanya Chakrabarti, Rochester Institute of Technology.

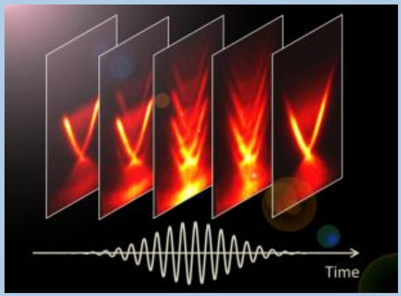
Pure quantum-mechanical mixture of electrons and photons demonstrated in bismuth selenide

In 2013, MIT physicists showed for the first time that shining powerful mid-infrared laser light on solid bismuth selenide produces Floquet-Bloch states, which are characterized by replicas of electronic energy states inside a solid with gaps opening up at crossing points of replica states. The same external light also interacts with free electron states immediately outside the solid producing a competing state, called the Volkov state, which is gapless.

Now, researchers led by Nuh Gedik, the Lawrence C. (1944) and Sarah W. Biedenharn Career Development Associate Professor of Physics, have shown that changing the light's polarization eliminates competition from Volkov states, yielding pure Floquet-Bloch states.

MIT graduate student Fahad Mahmood and post-doc Ching Kit (Chris) Chan, demonstrate experimental proof and offer a mathematical framework for understanding interference between these competing states as a function of electron momentum. The results are published online in Nature Physics.

"Fahad figured out a clever way of quantifying the interference of these two states with each other, and then from this interference, we can deduce selectively, this part is coming from the outside, this part is coming from inside," says Gedik, who is senior author on the new work. "I think this is a big step because if you eventually want to realize a new state of matter based on periodic excitation, you really need to be able to isolate just the contribution of the ...Read More...



Snapshots of the full 3-D band structure of bismuth selenide as it is radiated by light. The coherent interaction between the time-periodic potential of the light pulse and electrons in the Dirac cone results in Floquet-Bloch states, which appear as replicas of the original Dirac cone. Dynamic gaps open up at positions where the replica cones intersect the original cone. Intensity of these replicas is governed by the interference between Floquet-Bloch and Volkov states, free electron-like states coupled ...

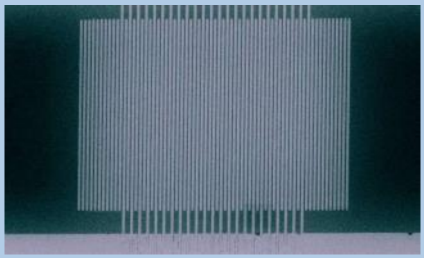
New material for detecting photons captures more quantum information

Detecting individual particles of light just got a bit more precise—by 74 picoseconds to be exact—thanks to advances in materials by National Institute of Standards and Technology (NIST) researchers and their colleagues in fabricating superconducting nanowires.

Although 74 picoseconds may not sound like much—a picosecond is a trillionth of a second—it is a big deal in the quantum world, where light particles, or photons, can carry valuable information. In this case it means that much less "jitter," or uncertainty in the arrival time of a photon. Less jitter means that photons can be spaced more closely together but still be correctly detected. This enables communications at a higher bit rate, with more information transmitted in the same period.

Every little bit helps when trying to receive faint signals reliably. It helped, for example, in NIST's recent quantum teleportation record and difficult tests of physics theories. In such experiments, researchers want to decode as much information as possible from the quantum properties of billions of photons, or determine if "entangled" photons have properties that are linked before—or only after—being measured.

NIST has made many advances in photon detector designs. In the latest work, described in Optics Express, NIST researchers used an electron beam to pattern nanowires into a thin film made of a heat-tolerant ceramic superconductor, molybdenum silicide. The tiny boost in ...Read More.



A colorized micrograph of a NIST single-photon detector made of superconducting nanowires patterned on molybdenum silicide. Credit: Verma/NIST

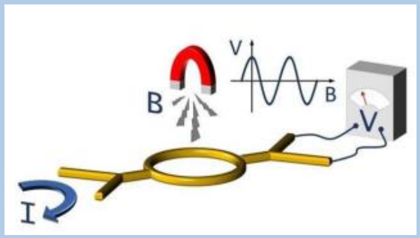
Researchers discover new fundamental quantum mechanical property

Nanotechnologists at the University of Twente research institute MESA+ have discovered a new fundamental property of electrical currents in very small metal circuits. They show how electrons can spread out over the circuit like waves and cause interference effects at places where no electrical current is driven. The geometry of the circuit plays a key role in this so called nonlocal effect. The interference is a direct consequence of the quantum mechanical wave character of electrons and the specific geometry of the circuit. For designers of quantum computers it is an effect to take account of. The results are published in the British journal Scientific Reports.

Interference is a common phenomenon in nature and occurs when one or more propagating waves interact coherently. Interference of sound, light or water waves is well known, but also the carriers of electrical current – electrons – can interfere. It shows that electrons need to be considered as waves as well, at least in nanoscale circuits at extremely low temperatures: a canonical example of the quantum mechanical wave-particle duality.

Gold ring

The researchers from the University of Twente have demonstrated electron interference in a gold ring with a diameter of only 500 nanometers (a nanometer is a million times smaller than a millimeter). One side of the ring was connected to a miniature wire through which an electrical ...Read More...



Schematic representation of the nonlocal electron interference experiment. A dc current is driven from the upper left to the lower left contact. A nonlocal, oscillating voltage is measured between the upper and lower right contacts due the magnetic-field induced single-electron interference in the 500 nanometer ring in the middle.

Black hole affecting galactic climate

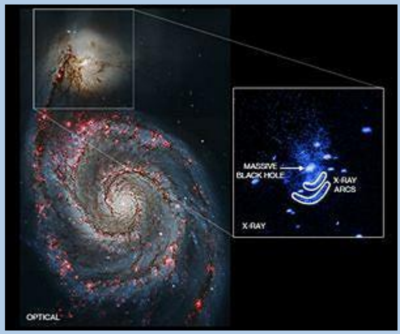
A team of researchers led by Eric Schlegel, Vaughn Family Endowed Professor in Physics at The University of Texas at San Antonio (UTSA), has discovered a powerful galactic blast produced by a giant black hole about 26 million light years from Earth. The black hole is the nearest supermassive black hole to Earth that is currently undergoing such violent outbursts.

Schlegel's team used NASA's Earth-orbiting Chandra X-ray Observatory to find the black hole blast in the famous Messier 51 system of galaxies. The system contains a large spiral galaxy, NGC 5194, colliding with a smaller companion galaxy, NGC 5195.

"Just as powerful storms here on Earth impact their environments, so too do the ones we see out in space," Schlegel said. "This black hole is blasting hot gas and particles into its surroundings that must play an important role in the evolution of the galaxy."

Schlegel and his colleagues detected two X-ray emission arcs close to the center of NGC 5195, where the supermassive black hole is located. "We think these arcs represent artifacts from two enormous gusts when the black hole expelled material outward into the galaxy," said co-author Christine Jones, astrophysicist and lecturer at the Harvard-Smithsonian Center for Astrophysics (CfA). "We think this activity has had a big effect on the galactic landscape."

Just beyond the outer arc, the researchers detected a slender region of ...Read More...



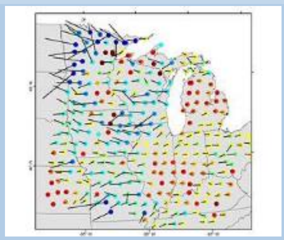
Spiral galaxy NGC 5195 and the X-ray arcs Schlegel's team identified. Image courtesy Eric Schlegel, the University of Texas at San Antonio.

Getting Down to Earth with Space Hazards

Magnetic storms can interfere with the operation of electric power grids and damage grid infrastructure. They can also disrupt directional drilling for oil and gas, radio communications, communication satellites and GPS systems. While magnetic storms are caused by variable conditions in the space weather above our heads, an accurate evaluation of the resulting hazards requires a detailed understanding of the electrical conductivity of the Earth beneath our feet.

A new USGS article examines the feasibility of mapping ground-level hazards from magnetic storms by using magnetotelluric (MT) survey data. The article was recently published in Geophysical Research Letters.

The Sun is constantly emitting a wind of electrically charged particles. However, when a large sunspot emerges on the face of the Sun, there is an increased chance for an abrupt ejection of concentrated solar wind. A magnetic storm can result from the interaction of these concentrated bursts of solar wind with the Earth's surrounding magnetosphere. During a magnetic storm, geoelectric fields are induced in the Earth's interior….Read More...



Graphic showing how the geoelectric vectors (black) can vary with location during a magnetic storm. Locations with cool colors (blue and green) and long lines represent relatively higher hazards for impacts on Earth's surface from a magnetic storm. Locations with warm colors (red and orange) and short vectors represent relatively lower hazards for impacts from a ...

Most distant massive galaxy cluster identified

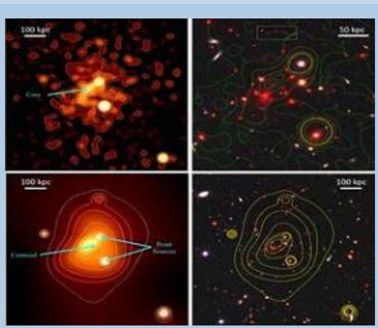
The early universe was a chaotic mess of gas and matter that only began to coalesce into distinct galaxies hundreds of millions of years after the Big Bang. It would take several billion more years for such galaxies to assemble into massive galaxy clusters - or so scientists had thought.

Now astronomers at MIT, the University of Missouri, the University of Florida, and elsewhere, have detected a massive, sprawling, churning galaxy cluster that formed only 3.8 billion years after the Big Bang. Located 10 billion light years from Earth and potentially comprising thousands of individual galaxies, the megastructure is about 250 trillion times more massive than the sun, or 1,000 times more massive than the Milky Way galaxy.

The cluster, named IDCS J1426.5+3508 (or IDCS 1426), is the most massive cluster of galaxies yet discovered in the first 4 billion years after the Big Bang.

IDCS 1426 appears to be undergoing a substantial amount of upheaval: The researchers observed a bright knot of X-rays, slightly off-center in the cluster, indicating that the cluster's core may have shifted some hundred thousand light years from its center. The scientists surmise that the core may have been dislodged from a violent collision with another massive galaxy cluster, causing the gas within the cluster to slosh around, like wine in a glass that has been suddenly moved.

Michael McDonald, assistant professor of physics and a member of MIT's Kavli Center for Astrophysics and Space Research ..Read More...



To get a more precise estimate of the galaxy cluster's mass, Michael McDonald and his colleagues used data from several of NASA's Great Observatories: the Hubble Space Telescope, the Keck Observatory, and the Chandra X-ray Observatory. Image courtesy of the researchers.

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Sharjah Center for Astronomy and Space Sciences: First of its Kind in the Arab World

The Sharjah Center for Astronomy and Space Sciences (SCASS), located in the University City of Sharjah, is the first center in the Arab world that encompasses a large planetarium that can sit 209-persons, several science and historic exhibition halls, an observatory equipped with three telescopes (45 and 18 cm, plus a solar telescope), space sciences laboratories, and a cosmic garden for families. The GoogleEarth aerial view below shows the central golden dome (representing the Sun) that hosts the planetarium and the cosmic garden in several circular patterns, one for each planet. The observatory is to the lower right, at the end of the curved road.

The center was opened by His Highness Dr. Sheikh Sultan Bin Mohammed Al Qasimi, Supreme Council Member and Ruler of Sharjah and President of the University of Sharjah, on May 07, 2015. Following the opening ceremony, Sheikh Sultan toured the new center and was briefed by Professor Hamid Al Naimiy, Chancellor of the University of Sharjah, on the new facility which offers educational programs as well as research and studies taking place in its special labs. We will cover more on the center in our future editions...*Stay Tuned...*

Researchers ride new sound wave to health discovery

Acoustics experts have created a new class of sound wave - the first in more than half a century - in a breakthrough they hope could lead to a revolution in stem cell therapy.

The team at RMIT University in Melbourne, Australia, combined two different types of acoustic sound waves called bulk waves and surface waves to create a new hybrid: "surface reflected bulk waves".

The first new class of sound wave discovered in decades, the powerful waves are gentle enough to use in biomedical devices to manipulate highly fragile stem cells without causing damage or affecting their integrity, opening new possibilities in stem cell treatment.

Dr Amgad Rezk, from RMIT's Micro/Nano Research Laboratory, said the team was already using the discovery to dramatically improve the efficiency of an innovative new "nebuliser" that could deliver vaccines and other drugs directly to the lung.

"We have used the new sound waves to slash the time required for inhaling vaccines through the nebuliser device, from 30 minutes to as little as 30 seconds," Rezk said. ...Read More...

Dr Amgad Rezk and his research colleagues at RMIT University have created a new class of sound wave -- the first in more than half a century -- in a breakthrough they hope could lead to a revolution in stem cell therapy. Credit: RMIT University

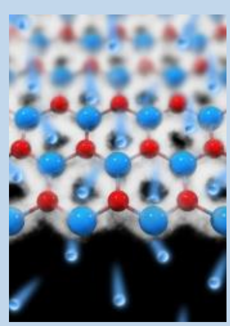
Graphene, the finest filter

Graphene can simplify production of heavy water and help clean nuclear waste by filtering different isotopes of hydrogen, University of Manchester research indicates.

Writing in Science, a team led by Sir Andre Geim demonstrated that using membranes made from graphene can act as a sieve, separating protons – nuclei of hydrogen – from heavier nuclei of hydrogen isotope deuterium.

The process could mean producing heavy water for nuclear power plants could be ten times less energy intensive, simpler and cheaper using graphene.

One of the hydrogen isotopes, deuterium, is widely used in analytical and chemical tracing technologies and, also, as heavy water required in thousands of tons for operation of nuclear power stations.



The heaviest isotope, tritium, is radioactive and needs to be safely removed as a byproduct of electricity generation at nuclear fission plants. Future nuclear technology is based on fusion of the two heavy isotopes.

The current separation technologies for production of heavy water are extremely energy intensive, and have presented a major scientific and industrial problem. Now graphene promises do so efficiently. Researchers tested whether ...Read More...