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# Astronomy & Physics News

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*Weekly Scientific News Compiled by Dr. Ilias Fernini*

INTERNATIONAL YEAR OF LIGHT 2015

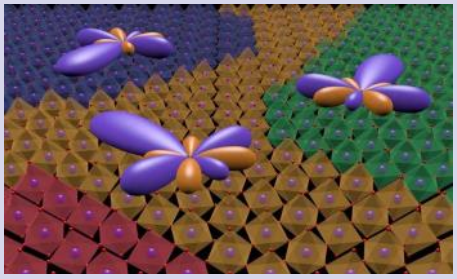
**Inside this issue:**



## *Physicists uncover novel phase of matter*

A team of physicists led by Caltech's David Hsieh has discovered an unusual form of matter—not a conventional metal, insulator, or magnet, for example, but something entirely different. This phase, characterized by an unusual ordering of electrons, offers possibilities for new electronic device functionalities and could hold the solution to a long-standing mystery in condensed matter physics having to do with high-temperature superconductivity—the ability for some materials to conduct electricity without resistance, even at "high" temperatures approaching -100 degrees Celsius.

"The discovery of this phase was completely unexpected and not based on any prior theoretical prediction," says Hsieh, an assistant professor of physics, who previously was on a team that discovered another form of matter called a topological insulator. "The whole field of electronic materials is driven by the discovery of new phases, which provide the playgrounds in which to search for new macroscopic physical properties." Hsieh and his colleagues describe their findings in the November issue of Nature Physics, and the paper is now available online. Liuyan Zhao, a postdoctoral scholar in Hsieh's group, is lead author on the paper….Read More...



*Artist's rendition of spatially segregated domains of multipolar order in the Sr2IrO4 crystal. The orientation of the multipolar order in each domain is depicted by the multi-lobed object. Credit: Liuyan Zhao*

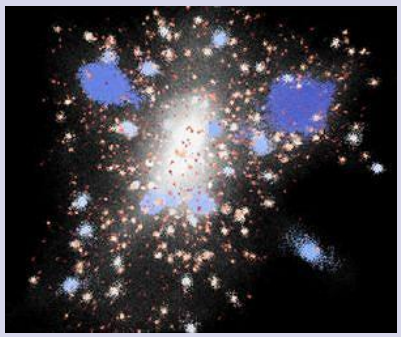
## *Birth of universe modeled in massive data simulation*

Researchers are sifting through an avalanche of data produced by one of the largest cosmological simulations ever performed, led by scientists at the U.S. Department of Energy's (DOE) Argonne National Laboratory.

The simulation, run on the Titan supercomputer at DOE's Oak Ridge National Laboratory, modeled the evolution of the universe from just 50 million years after the Big Bang to the present day - from its earliest infancy to its current adulthood. Over the course of 13.8 billion years, the matter in the universe clumped together to form galaxies, stars and planets; but we're not sure precisely how.

These kinds of simulations help scientists understand dark energy, a form of energy that affects the expansion rate of the universe, including the distribution of galaxies, composed of ordinary matter, as well as dark matter, a mysterious kind of matter that no instrument has directly measured so far.

Intensive sky surveys with powerful telescopes, like the Sloan Digital Sky Survey ...Read More..



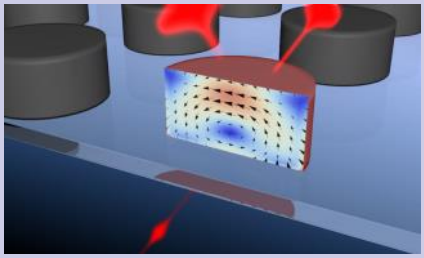
*Galaxies have halos surrounding them, which may be composed of both dark and regular matter. This image shows a substructure within a halo in the Q Continuum simulation, with "subhalos" marked in different colors. Image courtesy Heitmann et al.*

## The world's fastest nanoscale photonics switch

An international team of researchers from Lomonosov Moscow State University and the Australian National University in Canberra created an ultrafast all-optical switch on silicon nanostructures. This device may become a platform for future computers and permit to transfer data at an ultra-high speed. An article with the description of the device was published in theNano Letters journal and highlighted in Nature Materials.

This work belongs to the field of photonics, an optics discipline which appeared in the 1960-s, simultaneously with the invention of lasers. Photonics has the same goals as electronics, but uses photons—the quanta of light—instead of electrons. The biggest advantage of using photons is the absence of interactions between them. As a consequence, photons address the data transmission problems better than electrons. This property can primarily be used for in computing where IPS (instructions per second) is the main attribute to be maximized. The typical scale of eletronic transistors, the basis of contemporary electronic devices, is less than 100 nanometers, whereas the typical scale of photonic transistors stays on the scale of several micrometers. Nanostructures that are able to compete with the electronic structures—for example, plasmonic nanoparticles—are characterized by low efficiency and significant losses. Therefore, coming up with a compact photonic switch was a very challenging task.

Three years ago, several groups of researchers simultaneously discovered an important effect: They found out that silicon nano...Read More….



*"Device" is a disc 250 nm in diameter that is capable of switching optical pulses at femtosecond rates (femtosecond is a one millionth of one billionth of a second). Credit: Maxim Scherbakov et al*

## Entanglement at heart of '2-for-1' fission in next-generation solar cells

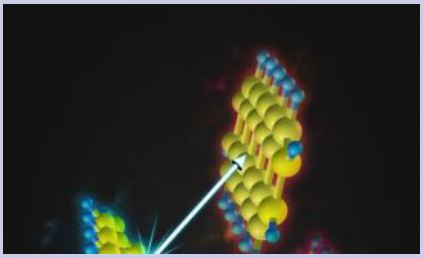
An international team of scientists have observed how a mysterious quantum phenomenon in organic molecules takes place in real time, which could aid in the development of highly efficient solar cells.

The researchers, led by the University of Cambridge, used ultrafast laser pulses to observe how a single particle of light, or photon, can be converted into two energetically excited particles, known as spin-triplet excitons, through a process called singlet fission. If the process of singlet fission can be controlled, it could enable solar cells to double the amount of electrical current that can be extracted.

In conventional semiconductors such as silicon, when one photon is absorbed it leads to the formation of one free electron that can be harvested as electrical current. However certain materials undergo singlet fission instead, where the absorption of a photon leads to the formation of two spin-triplet excitons.

Working with researchers from the Netherlands, Germany and Sweden, the Cambridge team confirmed that this 'two-for-one' transformation involves an elusive intermediate state in which the two triplet excitons are 'entangled', a feature of quantum theory that causes the properties of each exciton to be intrinsically linked to that of its partner.

By shining ultrafast laser pulses - just a few quadrillionths of a second - on a sample of pentacene, an organic material which ...Read More...

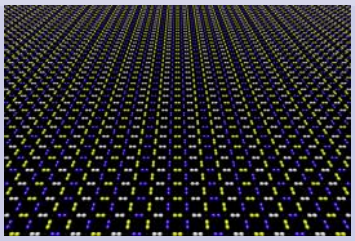


*Pentacene molecules convert a single photon into two molecular excitations via the quantum mechanics of singlet fission. Credit: Lawrence W Chin, David Turban and Alex W Chin*

## Unraveling the complex, intertwined electron phases in a superconductor

A team led by researchers from the U.S. Department of Energy's Brookhaven National Laboratory and Cornell University has characterized a key arrangement of electrons in a high-temperature superconductor, a material that can conduct electricity with almost no energy loss without being ultra-chilled. The material is a member of a family of copper-oxygen-based superconducting compounds-the cuprates-that are prime candidates for numerous potential high-impact applications, including extremely efficient electricity generation, storage, and transmission across the nation's power grid.

The phenomenon they studied is known as an electron density wave. Unlike the other electrons in the material, which move about freely, the density wave is a periodic, fixed electron phase that seems to compete with and hinder the superconducting phase. Many researchers believe that the density wave is the key to unlocking the cuprates: If they can thoroughly understand the electron density wave, they say, they may be able to determine how to suppress or remove it to induce superconductivity, possibly even at room temperature. But to achieve this goal, they first must gain a thorough understanding of the causes of the electron density wave. This study, published in the October 26, 2015, online edition of Nature Physics...Read More.



*A rendering of the charge density wave. This pattern of dumbbells, each representing the electronic orbital on an oxygen atom, may look static, but if you look closely you'll see that the colors of the orbitals change as you move from left to right. This color change (yellow, white, blue, white, yellow, white, blue...) represents changes in charge density (high, medium, low, medium, high, medium, low...) moving across the plane ...*

## Study reveals origin of organic matter in Apollo lunar samples

A team of NASA-funded scientists has solved an enduring mystery from the Apollo missions to the moon - the origin of organic matter found in lunar samples returned to Earth. Samples of the lunar soil brought back by the Apollo astronauts contain low levels of organic matter in the form of amino acids. Certain amino acids are the building blocks of proteins, essential molecules used by life to build structures like hair and skin and to regulate chemical reactions.

Since the lunar surface is completely inhospitable for known forms of life, scientists don't think the organic matter came from life on the moon. Instead, they think the amino acids could have come from four possible sources. First, since traces of life are everywhere on Earth, the amino acids could be simply contamination from terrestrial sources, either from material brought to the moon by the missions, or from contamination introduced while the samples were being handled back on Earth.

Second, rocket exhaust from the lunar modules contains precursor molecules used to build amino acids (such as hydrogen cyanide or HCN). This contamination could produce amino acids during lunar sample analysis in the lab.

Third, the solar wind - a thin stream of electrically conducting gas continuously blown off the surface of the Sun - contains the elements used to make amino acids, such as hydrogen, carbon, and nitrogen. Just like contamination from lunar module exhaust, ...Read More….

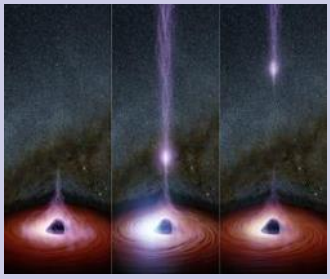
*Astronaut Alan L. Bean, Lunar Module pilot for the Apollo 12 lunar landing mission, holds a container filled with lunar soil collected while exploring the lunar surface. Astronaut Charles "Pete" Conrad Jr., commander, who took this picture, is reflected in the helmet visor. Image courtesy NASA.*

## Black Hole Has Major Flare

The baffling and strange behaviors of black holes have become somewhat less mysterious recently, with new observations from NASA's Explorer missions Swift and the Nuclear Spectroscopic Telescope Array, or NuSTAR. The two space telescopes caught a supermassive black hole in the midst of a giant eruption of X-ray light, helping astronomers address an ongoing puzzle: How do supermassive black holes flare?

The results suggest that supermassive black holes send out beams of X-rays when their surrounding coronas - sources of extremely energetic particles - shoot, or launch, away from the black holes.

"This is the first time we have been able to link the launching of the corona to a flare," said Dan Wilkins of Saint Mary's University in Halifax, Canada, lead author of a new paper on the results appearing in the Monthly Notices of the Royal Astronomical Society. "This will help us understand how supermassive black holes power some of the brightest objects in the universe." Supermassive black holes don't give off any light themselves, but they are often encircled by disks of hot, glowing ...Read More...



*This diagram shows how a shifting feature, called a corona, can create a flare of X-rays around a black hole. Image courtesy NASA/JPL-Caltech*

## Space Junk Predicted to Enter Earth's Atmosphere

Millions of bits of space junk - leftover fragments from spacecraft and related debris - orbit Earth, and the majority of these will eventually fall into Earth's atmosphere and incinerate. Astronomers believe they have recently observed one of these pieces and, for the first time, can predict when and where it will enter the atmosphere. Such forecasts could allow scientists the opportunity to observe these events to better understand what happens when space debris - manmade or natural - comes in contact with the atmosphere and determine which objects might be hazardous to humans.

The object was detected on October 3 by the Catalina Sky Survey (CSS), a project based near Tucson that searches the sky for comets and asteroids, particularly those that could potentially impact Earth.

Soon after this discovery, astronomers realized that the CSS had also imaged the object in 2013; comparing the two observations allowed the scientists to determine its orbit, which looked much more like that of typical space junk than a natural body. They also concluded that it will enter Earth's atmosphere on November 13 over the Indian Ocean, in the vicinity of Sri Lanka.

Lowell Observatory planetary astronomer Nick Moskovitz, one of many observers around the world helping to study the debris, said, "We're not 100% sure it's artificial but we're trying to solve that over the next couple of nights. Its orbit shows us that the object will undergo a close encounter with Earth this week, so we'll be able to collect data on it."...Read More...

*File Image.*

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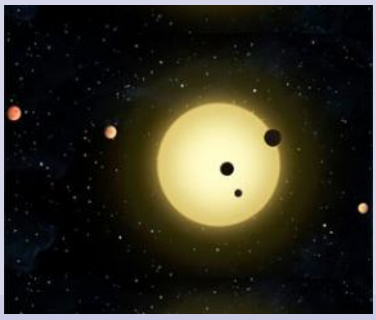
## *The Exoplanet Era*

Throughout the history of science, moments periodically arrive when new fields of knowledge and discovery just explode. Cosmology was a kind of dream world until Edwin Hubble established that the universe was expanding, and doing so at an ever-faster rate. A far more vibrant and scientific discipline was born.

On a more practical level, it was only three decades ago that rudimentary personal computers were still a novelty, and now computer-controlled, self-driving cars are just on the horizon. And not that long ago, genomics and the mapping of the human genome also went into hyperspeed, and turned the mysterious into the well known.

Most frequently, these bursts of scientific energy and progress are the result of technological innovation, coupled with the far-seeing (and often lonely and initially unsupported) labor and insights of men and women who are simply ahead of the curve.

We are at another of those scientific moments right now, and the subject is exoplanets - the billions (or is it billions of billions?) of planets orbiting stars other than our sun. ...Read More….



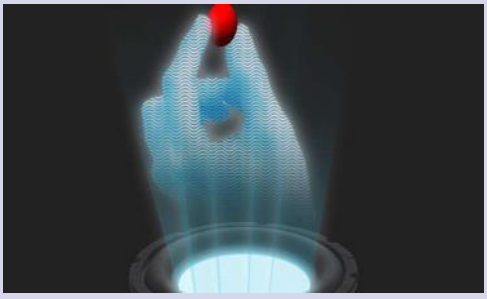
*Many, and perhaps most stars have solar systems with numerous planets, as in this artist rendering of Kepler 11. Image courtesy NASA.*

## *Sonic tractor beam invented*

A team of researchers from the Universities of Bristol and Sussex in collaboration with Ultrahaptics have built the world's first sonic tractor beam that can lift and move objects using sound waves.

Tractor beams are mysterious rays that can grab and lift objects. The concept has been used by science-fiction writers, and programmes like Star Trek, but has since come to fascinate scientists and engineers. Researchers have now built a working tractor beam that uses high-amplitude sound waves to generate an acoustic hologram which can pick up and move small objects.

The technique, published in Nature Communications, could be developed for a wide range of applications, for example a sonic production line could transport delicate objects and assemble them ...Read More...



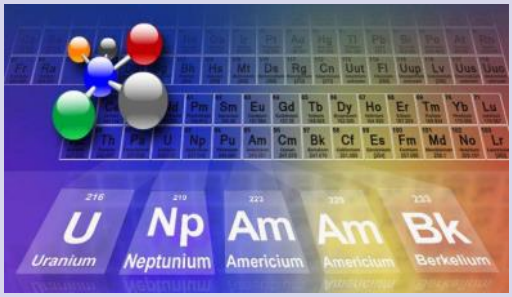
*The research team has created three-dimensional acoustic fields with shapes such as fingers, twisters and cages. These acoustic fields are the first acoustic holograms that can exert forces on particles to levitate and manipulate them. Credit: : Image courtesy of Asier Marzo, Bruce Drinkwater and Sriram Subramanian, (c) 2015*

## *Lab scientists discover five new nuclei*

Lawrence Livermore scientists, in conjunction with international researchers, have discovered five new atomic nuclei to be added the chart of nuclides.

The study, conducted this fall, focuses on developing new methods of synthesis for super heavy elements. The newly discovered, exotic nuclei are one isotope each of heavy elements berkelium, neptunium and uranium and two isotopes of the element americium.

Other participants include scientists from Manipal University, India; GSI-Giessen, Germany; Justus Liebig University Giessen, Germany; Japan Atomic Energy Agency; and the joint Institute for Nuclear Research in Russia. The results are published in the journal Physics Letters B. The Lab's Dawn Shaughnessy, Ken Moody, Roger Henderson and Mark Stoyer participated in the experiments. ...Read More...




*Lawrence Livermore National Laboratory scientists were part of an international team that discovered five new nuclei: U 218, Np 219, Bk 233, Am 223 and Am 229.*