INTERNATIONAL YEAR OF LIGHT 2015

Dec. 19, 2015
Rabi I 07, 1437
Volume 5, Issue 51

Astronomy & Physics News

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Weekly Scientific News Compiled by Dr. Ilias Fernini

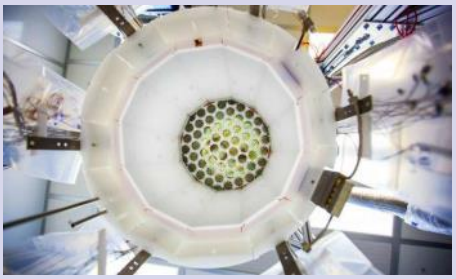
Inside this issue:

New results from world's most sensitive dark matter detector

The Large Underground Xenon (LUX) dark matter experiment, which operates nearly a mile underground at the Sanford Underground Research Facility (SURF) in the Black Hills of South Dakota, has already proven itself to be the most sensitive detector in the hunt for dark matter, the unseen stuff believed to account for most of the matter in the universe. Now, a new set of calibration techniques employed by LUX scientists has again dramatically improved the detector's sensitivity.

Researchers with LUX are looking for WIMPs, or weakly interacting massive particles, which are among the leading candidates for dark matter. "We have improved the sensitivity of LUX by more than a factor of 20 for low-mass dark matter particles, significantly enhancing our ability to look for WIMPs," said Rick Gaitskell, professor of physics at Brown University and co-spokesperson for the LUX experiment. "It is vital that we continue to push the capabilities of our detector in the search for the elusive dark matter particles," Gaitskell said.

LUX improvements, coupled to advanced computer simulations at the U.S. Department of Energy's Lawrence Berkeley National Laboratory's (Berkeley Lab) National Energy Research Scientific Computing Center (NERSC)...Read More….



A view inside the LUX detector. Credit: Matthew Kapust/Sanford Underground Research Facility

The puzzle of the origin of elements in the universe

A rare nuclear reaction that occurs in red giants has been observed for the first time at the Gran Sasso National Laboratory in Italy. This result was achieved by the LUNA experiment, the world's only accelerator facility running deep underground.

The LUNA experiment at the INFN Gran Sasso National Laboratory in Italy has observed a rare nuclear reaction that occurs in giant red stars, a type of star in which our sun will also evolve. This is the first direct observation of sodium production in these stars, one of the nuclear reactions that is fundamental for the formation of the elements that make up the universe. The study has been published in Physical Review Letters.

LUNA (Laboratory for Underground Nuclear Astrophysics) is a compact linear accelerator. It is the only one in the world installed in an underground facility, shielded against cosmic rays. The experiment aims to study the nuclear reactions that take place inside stars where, like in an intriguing and amazing cosmic kitchen, the elements that make up matter are formed and then driven out by gigantic explosions and scattered as cosmic dust.

For the first time, this experiment has observed three "resonances" in the neon-sodium cycle responsible for sodium production ...Read More...

File Image.

Solar cells that can face almost any direction and keep themselves clean

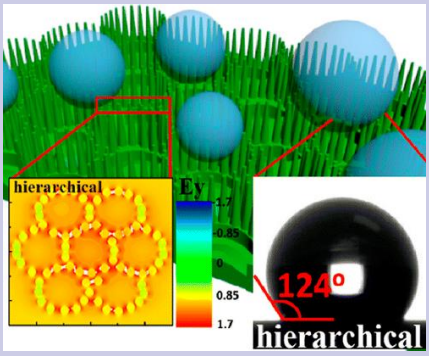
In recent years, a complicated discussion over which direction solar cells should face—south or west—has likely left customers uncertain about the best way to orient their panels. Now researchers are attempting to resolve this issue by developing solar cells that can harvest light from almost any angle, and the panels self-clean to boot. Their report appears in the journal ACS Nano.

Commercial solar panels work best when sunlight hits them at a certain angle. Initially, experts had suggested that solar panels face south to collect the most energy from the sun. But an influential 2013 report by Pecan Street, an energy-research organization, advised that systems tilt westward to maximize efficiency.

Further analysis has found that determining the ideal angle is more complicated—in essence, it depends on where you live. And even if customers get the positioning correct, they're still losing out on prime sunlight because most residential systems can't move or adjust to the sun's track across the sky. Jr-Hau He, Kun-Yu Lai and colleagues wanted to address this shortcoming.

The researchers developed a glass coating that incorporates ultrathin nanorods and honeycomb nanowalls that can help underlying solar cells harvest sunlight from multiple angles. The cell efficiency can be boosted by 5.2 to 27.7 percent, depending on the angle of the light, and the efficiency enhancement can be up to 46 percent during long-term use.

The material also repelled dust and pollution that would otherwise block some rays ...Read More….



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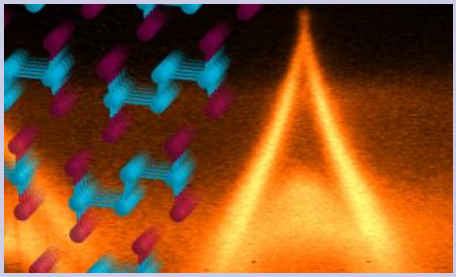
Spintronics, low-energy electricity take a step closer: A new class of topological insulators discovered

Topological insulators are materials that let electric current flow across their surface while keeping it from passing it through their bulk. This exotic property makes topological insulators very promising for electricity with less energy loss, spintronics, and perhaps even quantum computing. EPFL scientists have now identified a new class of topological insulators, and have discovered its first representative material, which could propel topological insulators into applications. The work, which was carried out within the framework of the EPFL-led NCCR Marvel project, is published in Nature Materials.

The technological promise of topological insulators has led to an intense search for optimal natural and man-made materials with such properties. Such research combines theoretical work that predicts what properties the structure of a particular material would have. The "candidate" materials that are identified with computer simulations are then passed for experimental examination to see if their topological insulating properties match the theoretical predictions.

This is what the lab of Oleg Yazyev at EPFL's Institute of Theoretical Physics has accomplished, working with experimentalist colleagues from around the world. By theoretically ...Read More...



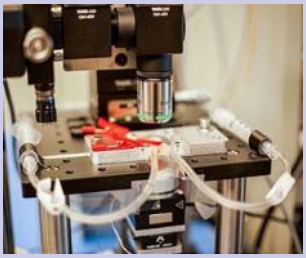
An illustration of topological surface states in bismuth iodide as seen by angle-resolved photoemission spectroscopy. Credit: Oleg Yazyev (EPFL)

Microscope creates near-real-time videos of nanoscale processes

State-of-the-art atomic force microscopes (AFMs) are designed to capture images of structures as small as a fraction of a nanometer - a million times smaller than the width of a human hair. In recent years, AFMs have produced desktop-worthy close-ups of atom-sized structures, from single strands of DNA to individual hydrogen bonds between molecules. But scanning these images is a meticulous, time-consuming process. AFMs therefore have been used mostly to image static samples, as they are too slow to capture active, changing environments.

Now engineers at MIT have designed an atomic force microscope that scans images 2,000 times faster than existing commercial models. With this new high-speed instrument, the team produced images of chemical processes taking place at the nanoscale, at a rate that is close to real-time video. In one demonstration of the instrument's capabilities, the researchers scanned a 70- by-70-micron sample of calcite as it was first immersed in deionized water and later exposed to sulfuric acid. The team observed the acid eating away at the calcite, expanding existing nanometer-sized pits in the material that quickly merged and led to a layer-by-layer removal of calcite along the material's crystal pattern, over a period of several seconds.

Kamal Youcef-Toumi, a professor of mechanical engineering at MIT, says the instrument's sensitivity and speed will enable scientists to ...Read More...



A new high-speed microscope produces images of chemical processes taking place at the nanoscale, at a rate that is close to real-time video. This closeup shot of the microscope shows transparent tubes used to inject various liquids into the imaging environment. This liquid can be water, acid, buffer solution for live bacteria, cells, or ...

NASA studies high clouds, Saharan dust from EPIC view

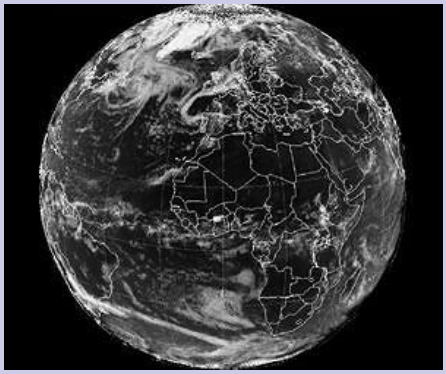
From a dusty atmosphere stretching across the Atlantic Ocean to daily views of clouds at sunrise, a new NASA camera keeping a steady eye on the sunlit side of Earth is yielding new insights about our changing planet.

With NASA's Earth Polychromatic Imaging Camera (EPIC), affixed to NOAA's Deep Space Climate Observatory (DSCOVR) about one million miles from Earth, scientists are getting a new view of our planet's clouds, land surfaces, aerosols and more. Science results from the first EPIC images were discussed Monday at a media briefing at the American Geophysical Union meeting in San Francisco.

EPIC captures a color image of the sunlit side of Earth at least once every two hours, allowing researchers to track features as the planet rotates in the instrument's field of view.

"With EPIC, you see cloud structure from sunrise on the left to sunset on the right," said Jay Herman, EPIC instrument lead investigator at NASA's Goddard Space Flight Center in Greenbelt, Maryland, and the University of Maryland, Baltimore County. "It's the only view we have like this where everything is at the exact same instant in time, even though the local times are different."

EPIC takes measurements in visible, ultraviolet and near-infrared wavelengths. With the ultraviolet channels, Herman can watch as dust from the Sahara travels westward across the Atlantic. While other low-Earth ...Read More...



The 10 wavelengths captured by NASA's Earth Polychromatic Imaging Camera provide data on Earth's surface and atmosphere. The 388 nanometer UV channel here allows scientists to study the energy reflected by ice sheets and clouds, an important measurement in climate studies. Image courtesy NASA.

Gamma rays from distant galaxy tell story of an escape

A flare of very high-energy gamma rays emitted from a galaxy halfway across the universe has put new bounds on the amount of background light in the universe and given astrophysicists clues to how and where such gamma rays are produced.

The galaxy, known as PKS 1441+25, is a rare type of galaxy called a blazar, a tremendously bright beacon powered by a supermassive black hole at the heart of the galaxy. Blazars are intrinsically unsteady light sources and can sometimes emit flares ten to a hundred times brighter than their baseline emissions.

A flare from PKS 1441+25 was detected in April 2015 and observed by a range of telescopes sensitive to different wavelengths, including the Very Energetic Radiation Imaging Telescope Array System (VERITAS) in Arizona.

"With VERITAS, we detected gamma rays from this unusual object at the highest energies observed on Earth," said Jonathan Biteau, who led the analysis of the data as a postdoctoral researcher at UC Santa Cruz. .. Read More….

Black-hole-powered galaxies called blazars are the most common sources detected by NASA's Fermi Gamma-ray Space Telescope. As matter falls toward the supermassive black hole at the galaxy's center, some of it is accelerated outward at nearly the speed of light along jets pointed ...

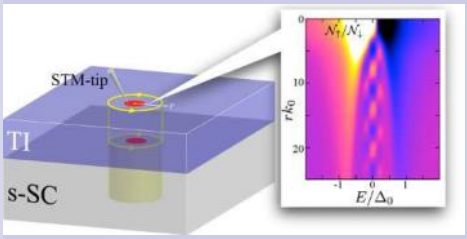
Major step toward confirming the existence of the majorana particle

A NIMS MANA group theoretically demonstrated that the results of the experiments on the peculiar superconducting state reported by a Chinese research group in January 2015 prove the existence of the Majorana-type particles.

A research group led by NIMS Special Researcher Takuto Kawakami and MANA Principal Investigator Xiao Hu of the International Center for Materials Nanoarchitectonics (WPI-MANA), National Institute for Materials Science (NIMS) theoretically demonstrated that the results of the experiments on the peculiar superconducting state reported by a Chinese research group in January 2015 can be taken as a proof of the existence of Majorana-type particle.

The existence of Majorana particle was predicted in 1937 by the Italian theoretical physicist Ettore Majorana. Though it is fermion, it is equivalent to its own antiparticle. While its existence as an elementary particle still has not been confirmed today—nearly 80 years after the prediction, it was pointed out theoretically in recent years that quasiparticle excitations in special materials called topological superconductors behave in a similar way as Majorana particles. However, it is difficult to capture these Majorana particles in materials due to their unique properties of being charge neutral and carrying zero energy. There have been intense international competitions to confirm their existence.

The research group carefully examined the physical conditions of the experiments mentioned above, conducted extensive and highly precise theoretical analysis on superconducting quasiparticle excitations, and ...Read More….



Schematic of Majorana particles localized inside the core of quantum vortex of a topological superconductor and the distribution of density of states of superconducting quasiparticle excitations based on the theoretical calculations.

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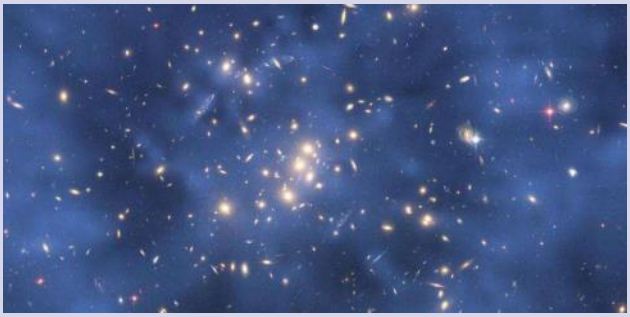
From MACHOs to WIMPs—meet the top five candidates for 'dark matter'

When we look out at the universe – even with the most powerful of telescopes – we can only see a fraction of the matter we know must be there. In fact, for every gram's worth of atoms in the universe, there is at least five times more invisible material called "dark matter". So far scientists have failed to detect it, despite spending decades searching.

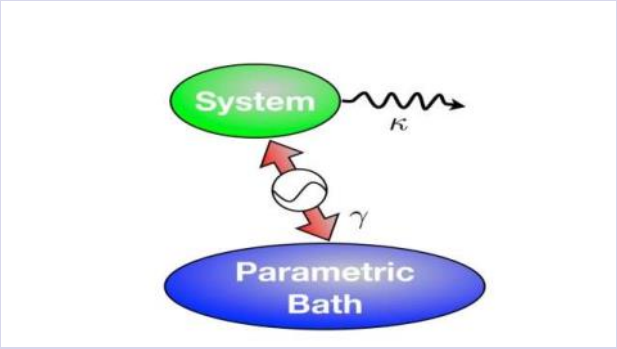
The reason we know it exists is because of the gravitational pull of galaxy clusters and other phenomena we observe. The matter we can see in a cluster isn't enough to hold it together by gravity alone, meaning some additional invisible or obscure matter must be present. But we have no idea what it is – it could be made up of new, yet undiscovered particles. There are four fundamental forces that a dark matter particle could interact with. There is the strong force that binds together the atomic nucleus; the weak force which ...Read More….



Astronomers believe that the dark blue ring in this image must be mysterious dark matter. Credit: NASA/ESA/wikimedia

Controlling the thermodynamics of light

The concept of temperature is critical in describing many physical phenomena, such as the transition from one phase of matter to another. Turn the temperature knob and interesting things can happen. But other knobs might be just as important for some studying some phenomena. One such knob is chemical potential, a thermodynamic parameter first introduced in the nineteenth century scientists for keeping track of potential energy absorbed or emitted by a system during chemical reactions.
In these reactions different atomic species rearranged themselves into new configuration while conserving the overall inventory of atoms. That is, atoms could change their partners but the total number of identity of the atoms remained invariant. ...Read More...



A system of photons (green blob) interacts with a thermal bath (blue blue) bringing the bath particles into thermal equilibrium with the light particles. Gamma denotes energy exchange between the system and the bath. Kappa detnotes some slight leadage of energy.

Hubble sees the force awakening in a newborn star

Just in time for the release of the movie "Star Wars Episode VII: The Force Awakens," NASA's Hubble Space Telescope has photographed what looks like a cosmic, double-bladed lightsaber.
In the center of the image, partially obscured by a dark, Jedi-like cloak of dust, a newborn star shoots twin jets out into space as a sort of birth announcement to the universe.

"Science fiction has been an inspiration to generations of scientists and engineers, and the film series Star Wars is no exception," said John Grunsfeld, astronaut and associate administrator for the NASA Science Mission directorate. "There is no stronger case for the motivational power of real science than the discoveries that come from the Hubble Space Telescope as it unravels the mysteries of the universe." This celestial lightsaber does not lie in a galaxy far, far away, but rather inside our home galaxy, the Milky Way. ...Read More….