INTERNATIONAL YEAR OF LIGHT 2015

Nov. 07, 2015
Muharram 24, 1437
Volume 5, Issue 45

Astronomy & Physics News

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Weekly Scientific News Compiled by Dr. Ilias Fernini

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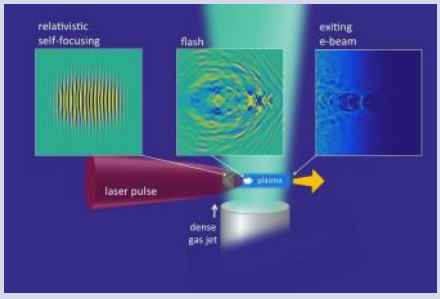
New discovery could enable portable particle accelerators

Conventional particle accelerators are typically big machines that occupy a lot of space. Even at more modest energies, such as that used for cancer therapy and medical imaging, accelerators need large rooms to accommodate the required hardware, power supplies and radiation shielding.

A new discovery by physicists at the University of Maryland could hold the key to the construction of inexpensive, broadly useful, and portable particle accelerators in the very near future. The team has accelerated electron beams to nearly the speed of light using record-low laser energies, thus relieving a major engineering bottleneck in the development of compact particle accelerators. The work appears in the November 6, 2015 issue of the journal Physical Review Letters.

"We have accelerated high-charge electron beams to more than 10 million electron volts using only millijoules of laser pulse energy. This is the energy consumed by a typical household lightbulb in one -thousandth of a second." said Howard Milchberg, professor of Physics and Electrical and Computer Engineering at UMD and senior author of the study. "Because the laser energy requirement is so low, our result opens the way for laser-driven particle accelerators that can be moved around on a cart."...Read More...



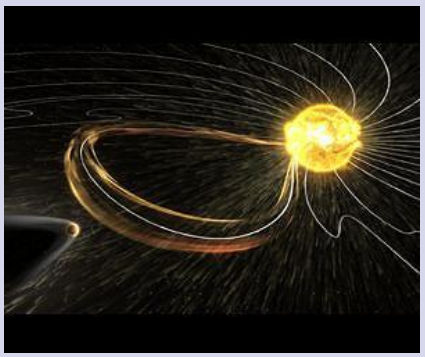
This schematic illustrates the laser-driven electron accelerator experiment at the University of Maryland.

Martian desiccation

Mars has been all over the news, from the blockbuster finding of seasonal water on the Red Planet to the wildly successful film, The Martian. Now, researchers--including those at the University of Iowa--have learned more about what happened to the climate on Mars since it was a warm and watery planet billions of years ago.

The researchers announced on Thursday that NASA's MAVEN (Mars Atmosphere and Volatile Evolution) mission has determined the rate at which the Martian atmosphere currently is losing gas to space via stripping by the solar wind. Loss of gas to space appears to have been an important part of why the Martian climate went from an early, warm, wet one that might have been able to support life at the surface to the cold, dry, desert planet we see today.

Jasper Halekas, associate professor in physics and astronomy at the UI and principal ...Read More...



In March of 2015, the sun launched a coronal mass ejection -- a bubble of energized plasma traveling at about 2 million miles per hour -- toward Mars, compressing the Martian magnetosphere to around two-thirds of its normal size and pushing it inward by almost 600 miles, which exposed more of Mars' atmosphere to the solar wind's electromagnetic fields. Similar events were probably larger and more frequent early in the solar system's history, suggesting they played a significant impact on Mars over its lifetime.

A new dimension to high-temperature superconductivity discovered

A team led by scientists at the Department of Energy's SLAC National Accelerator Laboratory combined powerful magnetic pulses with some of the brightest X-rays on the planet to discover a surprising 3-D arrangement of a material's electrons that appears closely linked to a mysterious phenomenon known as high-temperature superconductivity.

This unexpected twist marks an important milestone in the 30-year journey to better understand how materials known as high-temperature superconductors conduct electricity with no resistance at temperatures hundreds of degrees Fahrenheit above those of conventional metal superconductors but still hundreds of degrees below freezing. The study was published today in Science.

The study also resolves an apparent mismatch in data from previous experiments and charts a new course for fully mapping the behaviors of electrons in these exotic materials under different conditions. Researchers have an ultimate goal to aid the design and development of new superconductors that work at warmer temperatures.

'Totally Unexpected' Physics

"This was totally unexpected, and also very exciting. This experiment has identified a new ingredient to consider in this field of study. Nobody had seen this 3-D picture before," said Jun-Sik Lee, a SLAC staff scientist and one of the leaders of the experiment conducted at SLAC's Linac Coherent Light Source (LCLS) X-ray laser. "This is an important step in understanding the physics of high-temperature superconductors."...Read More...

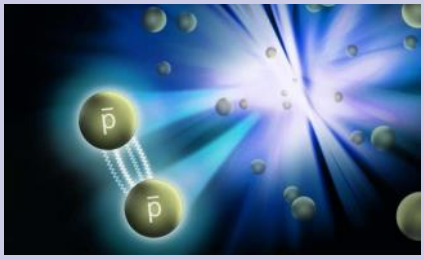
In this artistic rendering, a magnetic pulse (right) and X-ray laser light (left) converge on a high-temperature superconductor to study the behavior of its electrons. Credit: SLAC National Accelerator Laboratory

Physicists measure force that makes antimatter stick together

Peering at the debris from particle collisions that recreate the conditions of the very early universe, scientists have for the first time measured the force of interaction between pairs of antiprotons. Like the force that holds ordinary protons together within the nuclei of atoms, the force between antiprotons is attractive and strong.

The experiments were conducted at the Relativistic Heavy Ion Collider (RHIC), a U.S. Department of Energy Office of Science User Facility for nuclear physics research at DOE's Brookhaven National Laboratory. The findings, published in the journal Nature, could offer insight into larger chunks of antimatter, including antimatter nuclei previously detected at RHIC, and may also help scientists explore one of science's biggest questions: why the universe today consists mainly of ordinary matter with virtually no antimatter to be found.

"The Big Bang-the beginning of the universe-produced matter and antimatter in equal amounts. But that's not the world we see today. Antimatter is extremely rare. It's a huge mystery!" said Aihong Tang, a Brookhaven physicist involved in the analysis, which used data collected by RHIC's STAR detector. "Although this puzzle has been known for decades and little clues have emerged, it remains one of the big challenges of science. Anything we learn about the nature of antimatter can potentially contribute to solving this puzzle."...Read More...



A new measurement by RHIC's STAR collaboration reveals that the force between antiprotons (p with bar above it) is attractive and strong--just like the force that holds ordinary protons together within the nuclei of atoms. Credit: Brookhaven National Laboratory

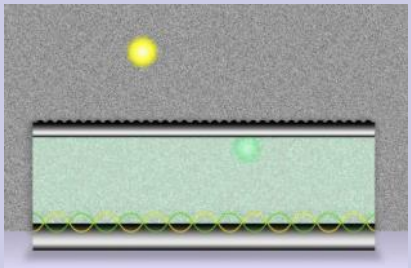
Quantum process increases the number of electrons produced when light strikes a metal-dielectric interface

Researchers at MIT and elsewhere have found a way to significantly boost the energy that can be harnessed from sunlight, a finding that could lead to better solar cells or light detectors.

The new approach is based on the discovery that unexpected quantum effects increase the number of charge carriers, known as electrons and "holes," that are knocked loose when photons of light of different wavelengths strikes a metal surface coated with a special class of oxide materials known as high-index dielectrics. The photons generate what are known as surface plasmons—a cloud of oscillating electrons that has the same frequency as the absorbed photons.

The surprising finding is reported this week in the journal Physical Review Letters by authors including MIT's Nicholas Fang, an associate professor of mechanical engineering, and postdoc Dafei Jin. The researchers used a sheet of silver coated with an oxide, which converts light energy into polarization of atoms at the interface.

"Our study reveals a surprising fact: Absorption of visible light is directly controlled by how deeply the electrons spill over the interface between the metal and the dielectric," Fang says. The strength of the effect, he adds, depends directly on ...Read More..



Credit: Christine Daniloff/MIT

Out With the Old, In With the New: Telescope Mirrors Get New Shape

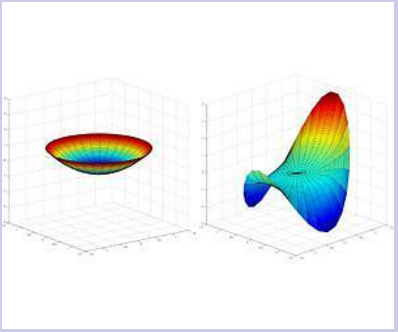
Telescope mirrors of old basically came in one shape: they were round and fit nicely inside a tube. No longer. An emerging optics technology now allows these light-gathering devices to take almost any shape, potentially providing improved image quality over a larger field of view - all in a smaller package.

Called freeform optics, this emerging mirror technology, brought about by advances in computer-controlled fabrication and testing, has triggered a sea change in optical engineering. Seeing the benefit of "potato chip-shape" or asymmetrical optics, NASA optical engineers at the Goddard Space Flight Center in Greenbelt, Maryland, have moved quickly to establish an expertise in this emerging technology.

"The use of freeform optics can significantly reduce the package size as well as improve the image quality," said Joseph Howard, who is working with Goddard engineer Garrett West to ultimately design, integrate, and test a two-mirror freeform optical telescope for imaging and spectroscopic applications.

According to both Howard and West, the technology holds great promise for scientists who want to develop compact telescopes for CubeSat and other small satellites - an increasingly popular and cost-effective alternative to more traditional missions that are more expensive to build and launch.

"If you want to put these telescopes into a smaller box, you need to let the ...Read More...



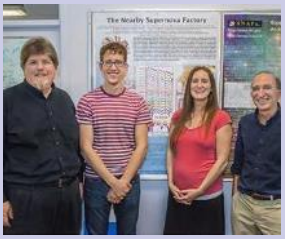
A rotationally symmetric optic is traditionally used in telescopes. The freeform optic on the right takes a different shape and is now being investigated for use in space-based instruments. Image courtesy NASA.

Supernova twins: Making standard candles more standard than ever

Less than 20 years ago the world learned that the universe is expanding ever faster, propelled by dark energy. The discovery was made possible by Type Ia supernovae; extraordinarily bright and remarkably similar in brightness, they serve as "standard candles" essential for probing the universe's history.

In fact, Type Ia supernovae are far from standard. Intervening dust can redden and dim them, and the physics of their thermonuclear explosions differs - a single white dwarf (an Earth-sized star as massive as our sun) may explode after borrowing mass from a companion star, or two orbiting white dwarfs may collide and explode. These "normal" Type Ia's can vary in brightness by as much as 40 percent. Brightness dispersion can be reduced by well-proven methods, but cosmology continues to be done with catalogues of supernovae that may differ in brightness by as much as 15 percent.

Now members of the international Nearby Supernova Factory (SNfactory), based at the U.S. Department of Energy's Lawrence Berkeley National Laboratory (Berkeley Lab), have dramatically reduced the scatter in ..Read More..



From left, Greg Aldering, Kyle Boone, Hannah Fakhouri and Saul Perlmutter of the Nearby Supernova Factory, who found that matching the spectra of Type Ia supernovae can double the accuracy of distance measurements. Image courtesy Roy Kaltschmidt, Lawrence Berkeley National Laboratory.

Europe comes together for space weather

Working with scientists in 14 countries across Europe, ESA is developing a warning network that will help protect us from the effects of our Sun's activity.

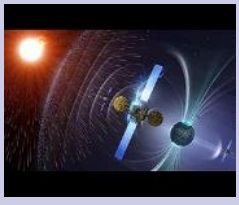
ESA's Space Situational Awareness efforts now generate almost 60 'products' - including high-quality measurements, forecasts, alerts and expert analysis - from teams participating in the Agency's space weather network, heading for over 140 next year.

Many use realtime data on our Sun and the resulting disturbances detected in the environment around Earth, our atmosphere and down to the surface. The raw information is gathered from a large and increasing number of ground and space sensors, and delivered through a network of Expert Service Centres, established by ESA to combine and build on existing facilities in Member States.

"The Centres federate the wealth of space weather expertise and capabilities that exist at the national level," says ESA's Alexi Glover, responsible for network development. "This provides a large added value not only to our Member States and their industries but to Europe as a whole."

Watching out for space weather

Numerous sectors are potentially affected by space weather in Europe's economy, ranging from telecoms, broadcasting, drilling, exploration, navigation and power distribution, the latter especially at northern latitudes...Read More...



As part of ESA's Space Situational Awareness programme, the Space Weather segment is focussing on services for owners and operators of satellites in space and infrastructure on the ground. The services will enable end-users in a wide range of affected sectors to mitigate the effects of space weather on their systems, reducing costs and improving reliability. In Europe's economy today, numerous sectors are potentially affected by space weather, ranging from space-based telecommunications, broadcasting, weather services and navigation through to power distribution and terrestrial communications, especially at northern latitudes.

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Have scientists found evidence of a parallel universe?

Caltech cosmologist Ranga-Ram Chary thinks he may have found evidence of a parallel universe.

In a new study, published in the Astrophysical Journal, Chary suggests cosmic bruising -- one universe bumping up against another universe -- could explain an anomaly he found in the map of the cosmic microwave background.

The cosmic microwave background is the light leftover from the mess of the newly born universe, the ancient shrapnel of the Big Bang. Chary developed a cosmic microwave background map using data from the European Space Agency's Planck telescope. When he compared it with a map of the entire night sky, he found an unexplained blob of bright light.

The cosmic background features bursts of ancient light, revealing the radiation signatures of the universe just a few hundred ...Read More..

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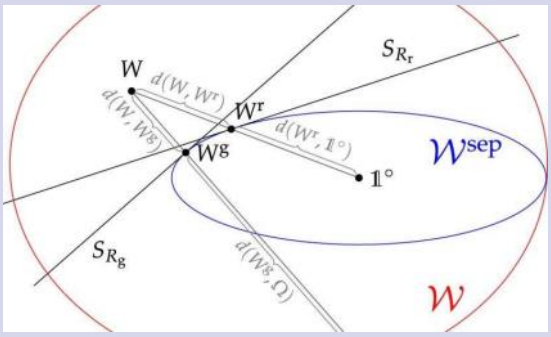
Quantum process demonstrates superposition of ordered events

In a quantum superposition, a quantum object can be in two incompatible states at the same time, which is famously illustrated by Schrödinger's dead-and-alive cat. Recent research has shown that it's possible to have a superposition not only of incompatible states, but also of incompatible orders of events. We often think of events occurring in a definite chronological order, with event A happening (and causing) event B, or vice versa. But in certain quantum processes, events don't happen in a single definite order, but instead both orders (A before B, and B before A) occur at the same time. This counterintuitive superposition-like phenomenon is called "causal nonseparability." ...Read More….

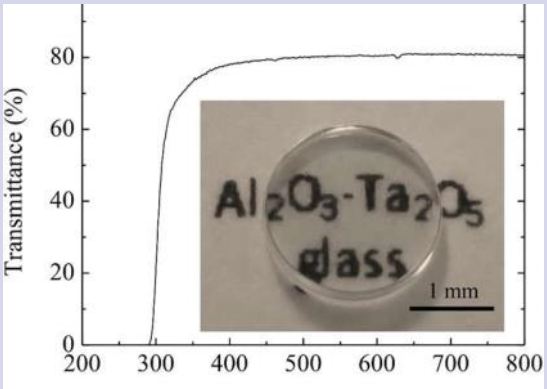


This figure illustrates the test for causal nonseparability, which can determine whether any quantum processes is causally nonseparable. Credit: Araújo, et al.

New glass almost as tough as steel

A team of researchers with The University of Tokyo and Japan Synchrotron Radiation Research Institute has created a type of glass that is stronger than many metals. In their paper published in the journal Scientific Reports, the researchers describe how they overcame one of the major hurdles in creating glass imbued with extra amounts of an oxide of aluminum, by using what they call aerodynamic levitation.

Glass that does not break when dropped or when struck by another object would be useful in a wide variety of applications, from automobile windows, to skyscrapers to smartphones and tablets. For that reason, scientists have been searching for ways to make ..Read More..



Transmittance spectrum of the 54Al2O3-46Ta2O5 glass in the UV/vis region. The inset picture shows the glass sample used for the transmittance experiment. Credit: (c) 2015 Scientific Reports (2015). DOI: 10.1038/srep15233