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Inside this issue:

Single-atom magnet breaks new ground for future data storage

EPFL scientists have built a single-atom magnet that is the most stable to-date. The breakthrough paves the way for the scalable production of miniature magnetic storage devices.

Magnetic storage devices such as computer hard drives or memory cards are widespread today. But as computer technology grows smaller, there is a need to also miniaturize data storage. This is epitomized by an effort to build magnets the size of a single atom. However, a magnet that small is very hard to keep "magnetized", which means that it would be unable to retain information for a meaningful amount time. In a breakthrough study published in Science, researchers led by EPFL have now built a single-atom magnet that, although working at around 40 Kelvin (-233.15 C), is the smallest and most stable to date.

Magnets work because of electron spin, which is a complicated motion best imagined as a spinning top. Electrons can spin up or down (something like clockwise or anti-clockwise), which creates a tiny magnetic field. In an atom, electrons usually come in pairs with opposite spins, thus cancelling out each other's magnetic field. But in a magnet, atoms have unpaired electrons, and their spins create an overall magnetic field.

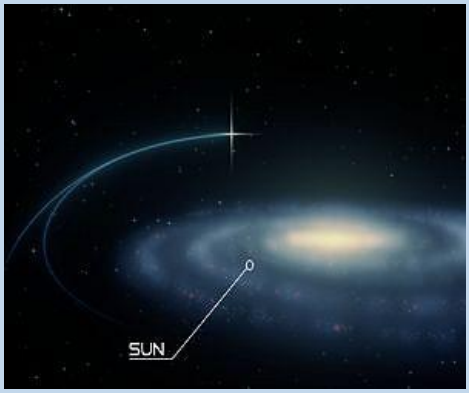
A challenge today is to build smaller and smaller magnets that can be implemented in data storage devices. The problem is ...Read More...

The tiny magnet only remains stable at extremely low temperatures ERIC PIERMONT/AFP/Getty Images

New hypervelocity binary star challenges dark matter, stellar acceleration models

A team of astronomers at the Friedrich Alexander University led by Peter Nemeth has discovered a binary star moving nearly at the escape velocity of our galaxy. There are about two dozen so-called hypervelocity stars known to be escaping the galaxy. While all of them are single stars, PB3877 is the first wide binary star found to travel at such a high speed. Additionally, the results of the new study challenge the commonly accepted scenario that hypervelocity stars are accelerated by the supermassive black hole at the galactic center. The findings are being published in the Astrophysical Journal Letters.

The team, in collaboration with researchers from the California Institute of Technology, showed the binary cannot originate from the Galactic Center, and no other mechanism is known that is able to accelerate a wide binary to such a high velocity without disrupting it. They therefore hypothesized there must be a lot of dark matter to keep the star bound to the Milky Way galaxy; or the binary star, PB3877, could ...Read More...



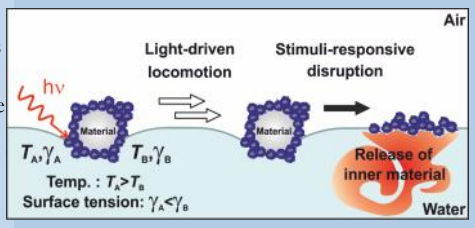
PB3877 is a hyper-velocity wide binary star zooming through the outskirts of the Milky Way galaxy. This image shows its current location as well as our Sun. Image courtesy Thorsten Brand.

Liquid marbles can be caused to move with laser light

A team of researchers with Osaka Institute of Technology in Japan, has developed liquid balls that propel themselves when exposed to laser light. In their paper published in the journal Advanced Functional Materials, the team describes how the liquid balls are made, how they can be used and some possible applications for them.

The idea for the liquid balls came, the team reports, from noting how Stenus beetles propel themselves across the surface of the water—when alarmed, they emit a droplet of stenusin from their anal gland, which causes a change in surface tension behind them, pushing them forward. In this new effort, the researchers used a nanometer-scale powder of polypyrrole (a type of plastic) to accomplish much the same thing—when exposed to light, it heats up and expands.

To make the balls, or liquid marbles, as the team calls them, the researches coated very small drops of water with the plastic. Like the Stenus beetle they float on the surface of the water and also like the beetle, they can be propelled by a change in surface tension behind them—in this case, that comes about by laser light—as the light strikes, the plastic heats up and expands, causing a change in the surface tension on the water behind the marble, which causes it to move forward. The team found that the marble had strength as well—they rigged up a floating apparatus that hooked onto one of their marbles, then shone the light, and in so doing, discovered that the marbles could pull floating structures that weighed up to 150 times more than they did. ...Read More...



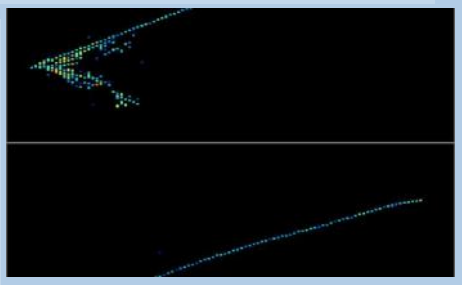
Scheme illustrating the light-driven delivery of material using liquid marbles (LMs). Credit: © WILEY-VCH (2016)

Probing the transforming world of neutrinos

Every second, trillions of neutrinos travel through your body unnoticed. Neutrinos are among the most abundant particles in the universe, but they are difficult to study because they very rarely interact with matter. To find traces of these elusive particles, researchers from Caltech have collaborated with 39 other institutions to build a 14,000-ton detector the size of two basketball courts called NuMI Off-Axis Electron Neutrino Appearance, or NOvA. The experiment, located in northern Minnesota, began full operation in November 2014 and published its first results in Physical Review Letters this month.

The experiment aims to observe neutrino oscillations—or the conversion of one type of neutrino into another—to learn about the subatomic composition of the universe. There are three different types, or "flavors," of neutrinos—muon-, tau-, and electron-type. The NOvA experiment has made successful detections of the transformation of muon-type neutrinos into electron-type neutrinos. Discovering more about the frequency and nature of neutrino oscillations is an important step to determining the masses of different types of neutrinos, a crucial unknown component in every cosmological model of the universe.

Though neutrinos rarely interact with matter, one in every 10 billion neutrinos that passes through the detector will interact with an atom in the detector. To observe these collisions..Read More..



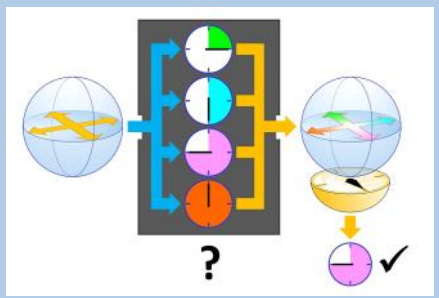
A muon-type neutrino interaction in the NOvA detector, as viewed by the vertically oriented cells (top panel) and horizontally oriented cells (bottom panel). By using cells oriented both ways, researchers can build a three-dimensional version of the event. The neutrino entered from the left in this image, from the direction of Fermilab. Each colored pixel represents an individual detector cell, with warmer colors corresponding to more observed light and thus more energy deposited by traversing particles. The muon produced in this collision left …..

Physicists quantify the usefulness of 'quantum weirdness'

For the past 100 years, physicists have been studying the weird features of quantum physics, and now they're trying to put these features to good use. One prominent example is that quantum superposition (also known as quantum coherence)—which is the property that allows an object to be in two states at the same time—has been identified as a useful resource for quantum communication technologies.

Recently, physicists have been developing ways to measure the amount of quantum coherence in a system. Now in two new papers, a team of physicists and mathematicians (Carmine Napoli, et al., and Marco Piani, et al.) has introduced a way to quantify the usefulness of quantum coherence by looking at this property from a purely operational perspective. The new measurement method can answer questions such as "how useful will a system's quantum coherence be for a task like encoding and decoding secret messages?" In other words, the new method quantifies the advantage of using quantum mechanics.

"We introduce a new way to quantify quantum coherence, the quintessential signature of quantum mechanics, capturing the extent to which a system can live in a superposition of distinct states (like a coin being simultaneously heads and tails, or a famous cat dead and alive)," the researchers wrote. As the scientists explain, the usefulness of quantum coherence can be described by a ...Read More...



A scheme of a phase discrimination task. The "robustness of coherence" of the input probe quantifies the quantum advantage. Credit: Gerardo Adesso, University of Nottingham

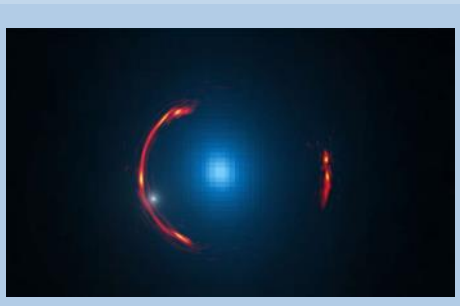
Dwarf dark galaxy hidden in ALMA gravitational lens image

Subtle distortions hidden in ALMA's stunning image of the gravitational lens SDP.81 are telltale signs that a dwarf dark galaxy is lurking in the halo of a much larger galaxy nearly 4 billion light-years away. This discovery paves the way for ALMA to find many more such objects and could help astronomers address important questions on the nature of dark matter.

In 2014, as part of ALMA's Long Baseline Campaign, astronomers studied a variety of astronomical objects to test the telescope's new, high-resolution capabilities. One of these experimental images was that of an Einstein ring, which was produced by the gravity of a massive foreground galaxy bending the light emitted by another galaxy nearly 12 billion light-years away. This phenomenon, called gravitational lensing, was predicted by Einstein's general theory of relativity and it offers a powerful tool for studying galaxies that are otherwise too distant to observe. It also sheds light on the properties of the nearby lensing galaxy because of the way its gravity distorts and focuses light from more distant objects.

In a new paper accepted for publication in the Astrophysical Journal, astronomer Yashar Hezaveh at Stanford University in California and his team explain how detailed analysis of this widely publicized image uncovered signs of a hidden dwarf dark galaxy in the halo of the more nearby galaxy.

"We can find these invisible objects in the same way that you can see rain droplets..Read More...



Composite image of the gravitational lens SDP.81 showing the distorted ALMA image of the more distant galaxy (red arcs) and the Hubble optical image of the nearby lensing galaxy (blue center object). By analyzing the distortions in the ring, astronomers have determined that a dark dwarf galaxy (data indicated by white dot near left lower arc segment) is lurking nearly 4 billion light-years away. Credit: Y. Hezaveh, Stanford Univ.; ALMA (NRAO/ESO/NAOJ); NASA/ESA Hubble Space Telescope

Supernova iron found on the moon

A dying star ends its life in a cataclysmic explosion, shooting the majority of the star's material, primarily new chemical elements created during the explosion, out into space. One or more such supernovae appear to have occurred close to our solar system approximately two million years ago. Evidence of the fact has been found on the earth in the form of increased concentrations of the iron isotope 60Fe detected in Pacific ocean deep-sea crusts and in ocean-floor sediment samples.

This evidence is highly compelling: The radioactive 60Fe isotope is created almost exclusively in supernova explosions. And with a half-life of 2.62 million years, relatively short compared to the age of our solar system, any radioactive 60Fe originating from the time of the solar system's birth should have long ago decayed into stable elements and thus should no longer be found on the earth.

Lunar samples from the Apollo missions

This supernova hypothesis was first put forth in 1999 by researchers at the Technical University of Munich (TUM) who had found initial evidence in a deep-sea crust. Now ...Read More...

Apollo 12-astronaut Alan L. Bean with a sample of the lunar surface. Image courtesy NASA.

Saturn spacecraft samples interstellar dust

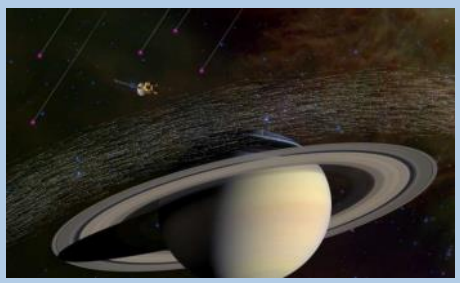
NASA's Cassini spacecraft has detected the faint but distinct signature of dust coming from beyond our solar system. The research, led by a team of Cassini scientists primarily from Europe, is published this week in the journal Science.

Cassini has been in orbit around Saturn since 2004, studying the giant planet, its rings and its moons. The spacecraft has also sampled millions of ice-rich dust grains with its cosmic dust analyzer instrument. The vast majority of the sampled grains originate from active jets that spray from the surface of Saturn's geologically active moon Enceladus.

But among the myriad microscopic grains collected by Cassini, a special few—just 36 grains—stand out from the crowd. Scientists conclude these specks of material came from interstellar space—the space between the stars.

Alien dust in the solar system is not unanticipated. In the 1990s, the ESA/NASA Ulysses mission made the first in-situ observations of this material, which were later confirmed by NASA's Galileo spacecraft. The dust was traced back to the local interstellar cloud: a nearly empty bubble of gas and dust that our solar system is traveling through with a distinct direction and speed.

"From that discovery, we always hoped we would be able to detect these interstellar interlopers at Saturn with Cassini. We knew that if we looked in the right direction, we should find them," said Nicolas Altobelli, Cassini project scientist at ESA (European Space Agency) and lead author of the study. "Indeed...Read More...



Of the millions of dust grains Cassini has sampled at Saturn, a few dozen appear to have come from beyond our solar system. Scientists believe these special grains have interstellar origins because they moved much faster and in different directions compared to dusty material native to Saturn. Credit: NASA/JPL-Caltech

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SCASS Tuesday Monthly Lecture Series:

The Hubble Space Telescope Legacy

Speaker:
Mr. Marwan Shawkat
Planetarium Manager

Date:
Apr. 19, 2016

Time:
14-15:00

Location:
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How does an invisible underwater crater prove an asteroid killed the dinosaurs?

A team of scientists recently set off to drill a 1,500m-deep hole into the seabed off the coast of Mexico. Their goal is to learn more about the asteroid impact some 66m years ago that many scientists believe killed the dinosaurs. But how do we know that this now-invisible crater, measuring some 180km across, is responsible for such devastation to life across the globe?

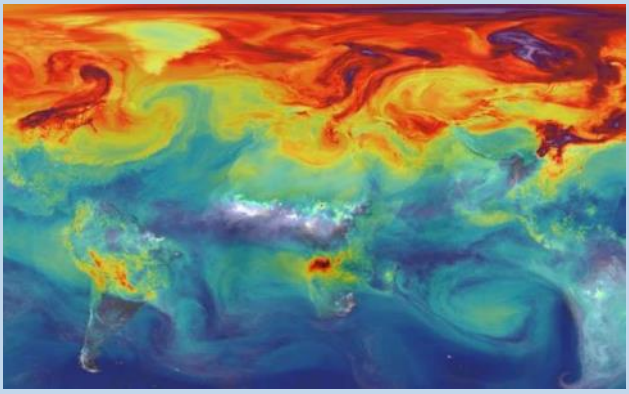
In one of the greatest titled books ever, T. rex and the Crater of Doom, Walter Alvarez told the story of how he and his nobel prize-winning physicist father Luis revolutionised our understanding of the end of the dinosaurs. We now think that rather than just suffering a long decline caused by natural climate change, dinosaurs and many other species of the time effectively disappeared overnight following a massive asteroid impact. This theory has changed remarkably little since the Alvarezes first published their theory in 1980. Walter had been studying sedimentary rocks that were laid down at the time of the dinosaurs' extinction, known as the Cretaceous-...Read More...

Credit: Shutterstock

What causes air pollution?

By definition, pollution refers to any matter that is "out of place". In other words, it is what happens when toxins, contaminants, and other harmful products are introduced into an environment, disrupting its normal patterns and functions. When it comes to our atmosphere, pollution refers to the introduction of chemicals, particulates, and biological matter that can be harmful to humans, plants and animals, and cause damage to the natural environment.

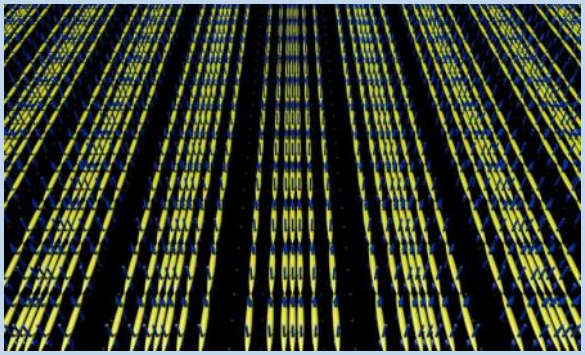
Whereas some causes of pollution are entirely natural – being the result of sudden changes in temperature, seasonal changes, or regular cycles – others are the result of human impact (i.e. anthropogenic, or man-made). More and more, the effects of air pollution ...Read More..



Carbon dioxide in Earth's atmosphere if half of global-warming emissions are not absorbed. Credit: NASA/JPL/GSFC

Elusive state of superconducting matter discovered after 50 years

Scientists at the U.S. Department of Energy's Brookhaven National Laboratory, Cornell University, and collaborators have produced the first direct evidence of a state of electronic matter first predicted by theorists in 1964. The discovery, described in a paper published online April 13, 2016, in Nature, may provide key insights into the workings of high-temperature superconductors. ...Read More...



A schematic image representing a periodic variation in the density of Cooper pairs (pairs of blue arrows pointing in opposite directions) within a cuprate superconductor. Densely packed rows of Cooper pairs alternate with regions having lower pair density and no pairs at all. Such a "Cooper pair density wave" was predicted 50 years ago but was just discovered using a unique "scanning Josephson tunneling microscope. Credit: Brookhaven National Laboratory