INTERNATIONAL YEAR OF LIGHT 2015

100 Million Stars in the Andromeda galaxy.

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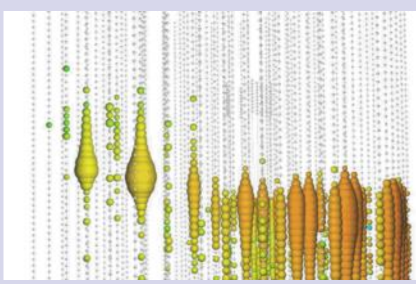
Inside this issue:

Cosmic mystery deepens with discovery of new ultra-high-energy neutrino

Evidence of a fourth ultra-high energy neutrino—the highest-energy neutrino yet—has been detected by the South Pole-based IceCube experiment, a project that Berkeley Lab researchers helped build and to which they currently contribute analysis.

The event was found by researchers at Rheinisch-Westfälische Technische Hochschule Aachen University in Germany as part of a new search for astrophysical muon neutrinos. The researchers' main analysis objective was to confirm previous IceCube measurements of other astrophysical neutrinos. The new ultra-high-energy neutrino was an unexpected bonus.

Scientists have hoped that ultra-high-energy neutrinos could point to sources of ultra-high-energy cosmic rays—supermassive black holes at the centers of galaxies or hypernova star explosions, for instance. But this most-recent neutrino finding, says Berkeley Lab's Spencer Klein, only "deepens the mystery" of cosmic ray origins.
The new neutrino was found thanks to a muon trail observed by an array of …***Read More***….



An IceCube event display showing the latest 'most energetic event.' Each open circle is an un-hit optical module; the filled spheres show hit modules, with the radius indicating the number of detected photons. The colors indicate the relative time (red is first, then orange, yellow, green, and blue), but with the chosen scale, the timing isn't that useful. Credit: Leif Radel

Oxymoronic black hole RGG 118 provides clues to growth

Astronomers using NASA's Chandra X-ray Observatory and the 6.5-meter Clay Telescope in Chile have identified the smallest supermassive black hole ever detected in the center of a galaxy. This oxymoronic object could provide clues to how much larger black holes formed along with their host galaxies 13 billion years or more in the past.

Astronomers estimate this supermassive black hole is about 50,000 times the mass of the Sun. This is less than half the previous lowest mass for a black hole at the center of a galaxy.

The tiny heavyweight black hole is located in the center of a dwarf disk galaxy, called RGG 118, about 340 million light years from Earth. Our graphic shows a Sloan Digital Sky Survey image of RGG 118 and the inset shows a Chandra image of the galaxy's center. The X-ray point source is produced by hot gas swirling around the black hole.

Researchers estimated the mass of the black hole by studying the motion of cool gas near the center of the galaxy using visible light data from the Clay Telescope. They used the Chandra data to figure out the brightness in X-rays of hot gas swirling toward the black hole. They found that the outward push of radiation …***Read More***…

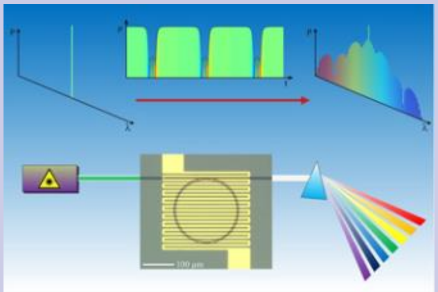
Microresonators could bring optical sensors, communications

Researchers have solved a key obstacle in creating the underlying technology for miniature optical sensors to detect chemicals and biological compounds, high-precision spectroscopy, ultra-stable microwave sources and optical communications systems that transmit greater volumes of information with better quality.

The technology is based on the reliable generation and control of laser pulses containing a number of equally spaced frequencies called "comb lines." By precisely controlling the frequency combs, including their initiation, "coherence" and spacing, researchers hope to create miniature optical devices using ring-shaped "microresonators."

A research team at Purdue Univ. has demonstrated prototypes, and new findings are described in a paper appearing online inNature Photonics. The findings, together with those in another paper published in Laser and Photonics Reviews, detail an optical phenomenon called "dark pulses" and show how to precisely control the comb generation.

Whereas conventional optical communication requires many lasers to transmit various frequencies, the new devices might require only a single light source, which is then transformed to emit light at multiple wavelengths. Such an innovation would reduce cost and make possible more compact optical systems small enough to fit on electronic chips, said Minghao Qi (pronounced Ming-how Chee), an associate professor of electrical and computer engineering….***Read More***...



Researchers are developing "microresonators" for miniature optical sensors and other potential applications. The technology is based on the reliable generation and control of laser pulses containing a number of equally spaced frequencies called "comb lines." This graphic depicts the optical spectrum of a "pump laser" used in the technology and an intriguing optical phenomenon called "dark pulses," which might be harnessed to precisely control the comb lines. Image: Birck Nanotechnology Center, Purdue Univ.

Protons and antiprotons appear to be true mirror images

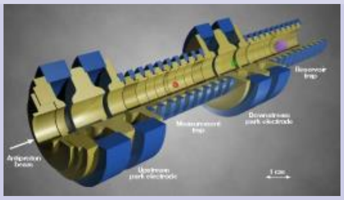
In a stringent test of a fundamental property of the standard model of particle physics, known as CPT symmetry, researchers from the RIKEN-led BASE collaboration at CERN have made the most precise measurements so far of the charge-to-mass ratio of protons and their antimatter counterparts, antiprotons.

The work, published in Nature, was carried out using CERN's Antiproton Decelerator, a device that provides low-energy antiprotons for antimatter studies.

CPT invariance—which the experiment was meant to test —means that a system remains unchanged if three fundamental properties are reversed—C (charge), which distinguishes matter from antimatter, P (parity), which implies a 180 degree flip in space, and T (time). It is a central tenet of the standard model, and implies that antimatter particles must be perfect mirror images of matter, with only their charges reversed.

"This is an important issue," says Stefan Ulmer, who led the research, "because it helps us to understand why we live in a universe that has practically no antimatter, despite the fact that the Big Bang must have led to the creation of both. If we had found violations of CPT, it would mean that matter and antimatter might have different properties—for example that antiprotons might decay faster than protons—but we have found within quite strict limits that the charge-to-mass ratios are the same."

To perform the research, the team used a scheme similar to that developed by the TRAP ...***Read More***..



A cut-away schematic of the Penning trap system used by BASE. The experiment receives antiprotons from CERN's AD; negative hydrogen ions are formed during injection into the apparatus. The set-up works with only a pair of particles at a time, while a cloud of a few hundred others are held in the reservoir trap, for future use. Here, an antiproton is in the measurement trap, while the negative hydyrogen ion is in held by the downstream park electrode. When the antiproton has been measured, it is moved to the upstream park electrode and the hydrogen ion is brought in to ….

Caltech Announces Discovery in Fundamental Physics

When the transistor was invented in 1947 at Bell Labs, few could have foreseen the future impact of the device. This fundamental development in science and engineering was critical to the invention of handheld radios, led to modern computing, and enabled technologies such as the smartphone. This is one of the values of basic research.

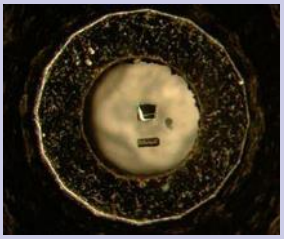
In a similar fashion, a branch of fundamental physics research, the study of so-called correlated electrons, focuses on interactions between the electrons in metals.

The key to understanding these interactions and the unique properties they produce-information that could lead to the development of novel materials and technologies-is to experimentally verify their presence and physically probe the interactions at microscopic scales.

To this end, Caltech's Thomas F. Rosenbaum and colleagues at the University of Chicago and the Argonne National Laboratory recently used a synchrotron X-ray source to investigate the existence of instabilities in the arrangement of the electrons in metals as a function of both temperature and pressure, and to pinpoint, for the first time, how those instabilities arise.

Rosenbaum, professor of physics and holder of the Sonja and William Davidow Presidential Chair, is the corresponding author on the paper that was published on July 27, 2015, in the journal Nature Physics.

"We spent over 10 years developing the instrumentation to perform these studies," says Yejun ...***Read More***….



One of the metallic samples studied, niobium diselenide, is seen here - the square in the center-as prepared for an X-ray diffraction experiment. Image courtesy University of Chicago/Argonne National Laboratory.

Tenth transiting 'Tatooine'

Astronomers at the 29th International Astronomical Union General Assembly will announce the discovery of a new transiting "circumbinary" planet, bringing the number of such known planets into double digits. A circumbinary planet orbits two stars, and like the fictional planet "Tatooine" from Star Wars, this planet has two suns in its sky. The discovery marks an important milestone and comes only four years after the first Kepler circumbinary planet was detected.

Once thought to be rare or even impossible, these ten discoveries confirm that such planets are common in our galaxy. The research was recently published in the Astrophysical Journal.

The new planet, known as Kepler-453 b, also presented astronomers with a surprising twist--the tilt of the orbit of the planet rapidly changes, making transits visible only 9 percent of the time. "The detection was a lucky catch for Kepler," said William Welsh, professor of astronomy at San Diego State University and lead author of the study. "Most of the time, transits would not be visible from Earth's vantage point."

The change of orientation of the planet's orbital plane, known as precession, brought it into proper alignment halfway through the space telescope's lifetime, allowing three transits to be observed before the end of the mission.

"The low probability for witnessing transits means that for every system like Kepler-453 we see, there are likely to be 11 times as many that we don't see," added co-author Jerome Orosz, also a professor of astronomy at San Diego State University. The precession period is estimated to be approximately 103 years. The next set of transits won't be visible again until the year 2066.

Kepler-453 b is the third Kepler circumbinary planet found to lie in the habitable zone of its host pair of stars. The astonishingly high rate of occurrence in the habitable ...**Read More**...

File Image.

One decade after launch, Mars Orbiter still going strong

Ten years after launch, NASA's Mars Reconnaissance Orbiter (MRO) has revealed the Red Planet's diversity and activity, returning more data about Mars every week than all six other missions currently active there. And its work is far from over.

The workhorse orbiter now plays a key role in NASA's Journey to Mars planning. Images from the orbiter, revealing details as small as a desk, aid the analysis of potential landing sites for the 2016 InSight lander and Mars 2020 rover. Data from the orbiter will also be used as part of NASA's newly announced process to examine and select candidate sites where humans will first explore the Martian surface in the 2030s.

An Atlas V rocket launched the orbiter on an early Florida morning from Cape Canaveral Air Force Station on Aug. 12, 2005, propelling it on a course toward Mars. "The most crucial event after launch was orbit insertion on March 10, 2006," said JPL's Dan Johnston, MRO project manager. "The 27-minute burn of the spacecraft's main engines, necessary for orbit capture, was scheduled for completion while the spacecraft was behind Mars, so we had to wait in suspense for confirmation that it went well. It did. As planned, the initial orbit was highly elliptical. Then we had nearly five months of ...**Read More**...

Among the many discoveries by NASA's Mars Reconnaissance Orbiter since the mission was launched on Aug. 12, 2005, are seasonal flows on some steep slopes, possibly shallow seeps of salty water. This July 21, 2015, image from the orbiter's HiRISE camera shows examples within Mars' Valles Marineris. Credit: NASA/JPL-Caltech/Univ. of Arizona

Quantum computing advance locates neutral atoms

For any computer, being able to manipulate information is essential, but for quantum computing, singling out one data location without influencing any of the surrounding locations is difficult. Now, a team of Penn State physicists has a method for addressing individual neutral atoms without changing surrounding atoms.

"There are a set of things that we have to have to do quantum computing," said David S. Weiss, professor of physics. "We are trying to step down that list and meet the various criteria. Addressability is one step."

Quantum computers are constructed and operate in completely different ways from the conventional digital computers used today. While conventional computers store information in bits, 1's and 0's, quantum computers store information in qubits. Because of a strange aspect of quantum mechanics called superposition, a qubit can be in both its 0 and 1 state at the same time. The methods of encoding information onto neutral atoms, ions or Josephson junctions—electronic devices used in precise measurement, to create quantum computers—are currently the subject of much research. Along with superposition, quantum computers will also take advantage of the quantum mechanical phenomena of entanglement, which can create a mutually dependent group of qubits that must be considered as a whole rather than individually.

"Quantum computers can solve some problems that classical computers can't," said Weiss. "But they are unlikely to replace your laptop."

According to the researchers, one area where quantum computers will be valuable is in factoring very large numbers created by multiplying ...**Read More**...

"We are studying neutral atom qubits because it is clear that you can have thousands in an apparatus," said Weiss. "They don't take up much space and they don't interact with each other unless we want them to." Credit: © iStock Photo monsitj

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Using an electron to probe the tiny magnetic core of an atom

Precise information about the magnetic properties of nuclei is critical for studies of what's known as the 'weak force.' While people do not feel this force in the same way they feel electricity or gravity, its effects are universal. The weak force allows stuff to become unglued and form new elements through decay—the sun, for example, is powered through deuterium fuel, which is generated via weak force mediated interactions. The weak force is elusive as it operates between objects that are separated by miniscule distances deep within atomic nuclei. To study its properties physicists must be able to extract the weak interactions out of a jumbled sea of other, more dominant phenomena that, alongside the weak force, work to govern particle behavior. Physicists from the Francium Parity Non-Conservation (FrPNC) collaboration, which includes researchers from JQI Fellow Luis Orozco's group, believe that the radioactive element francium is the perfect "laboratory" for uncovering the secrets of ...***Read More***...

A view of the apparatus that is used to capture francium. Credit: P. Schewe/JQI

World's most powerful laser is 2,000 trillion watts – but what's it for?

The most powerful laser beam ever created has been recently fired at Osaka University in Japan, where the Laser for Fast Ignition Experiments (LFEX) has been boosted to produce a beam with a peak power of 2,000 trillion watts – two petawatts – for an incredibly short duration, approximately a trillionth of a second or one picosecond.

Values this large are difficult to grasp, but we can think of it as a billion times more powerful than a typical stadium floodlight or as the overall power of all of the sun's solar energy that falls on London. Imagine focusing all that solar power onto a surface as wide as a human hair for the duration of a trillionth of a second: that's essentially the LFEX laser.

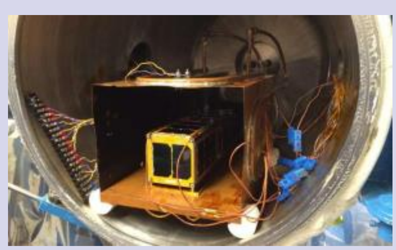
LFEX is only one of a series of ultra-high power lasers that are being built across the world, ranging from the gigantic 192-beam National Ignition Facility in California, to the CoReLS laser in South Korea, and the Vulcan laser at the Rutherford Appleton Laboratory outside Oxford, UK, to mention but a few. ...***Read More***...

One of the acceleration beams of the LFEX laser in Osaka. Credit: Osaka University

How CubeSats are revolutionizing radio science

Next time you tune in to public radio or the hottest Top 40 radio station, you'll be using some of the same tools NASA uses to unravel the mysteries of the universe.

Courtney Duncan, an engineer at NASA's Jet Propulsion Laboratory in Pasadena, California, says studying radio waves coming from a known source in space can reveal a great deal about objects in our solar system. Of course, there is nothing new in that. NASA scientists have been turning the transmissions of their spacecraft's radio into scientific gold since almost the beginning of the space age. And ground-based astronomers have not been left outside of the radio spectrum looking in. Radio astronomers have been studying naturally occurring extraterrestrial radio waves since the 1930s. But the kind of radio science Duncan is interested in requires a well-understood transmitter—the kind that is built and tested by human beings before being rocketed into space as part of a mission of exploration….***Read More***….



A thermal vacuum test of the Low Mass Radio Science Transponder-Satellite (LMRST-Sat) was performed at California Polytechnic State University, San Luis Obispo, California, in February of this year. The six-hour test, carried out in a partial vacuum….