INTERNATIONAL YEAR OF LIGHT 2015

100 Million Stars in the Andromeda galaxy.

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Weekly news from around the world compiled by Dr. Ilias Fernini

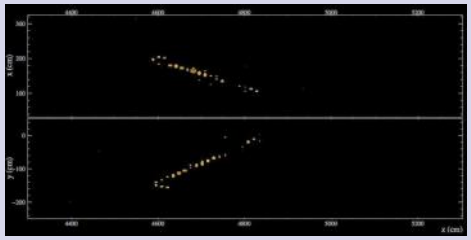
Inside this issue:

Fermilab experiment sees neutrinos change over 500 miles

Scientists on the NOvA experiment saw their first evidence of oscillating neutrinos, confirming that the extraordinary detector built for the project not only functions as planned but is also making great progress toward its goal of a major leap in our understanding of these ghostly particles.

NOvA is on a quest to learn more about the abundant yet mysterious particles called neutrinos, which flit through ordinary matter as though it weren't there. The first NOvA results, released this week at the American Physical Society's Division of Particles and Fields conference in Ann Arbor, Michigan, verify that the experiment's massive particle detector—50 feet tall, 50 feet wide and 200 feet long—is sitting in the sweet spot and detecting neutrinos fired from 500 miles away. Scientists have sorted through millions of cosmic ray strikes and zeroed in on neutrino interactions.

"People are ecstatic to see our first observation of neutrino oscillations," said NOvA co-spokesperson Peter Shanahan of the U.S. Department of Energy's Fermi ...***Read More***...



A candidate electron neutrino interaction seen in the NOvA far detector on March 23, 2015. The upper panel shows the top view, looking down into the detector; the bottom panel shows the side view. Each golden box shows a cell of the detector in which particles from the interaction were spotted. The longer of the two tracks in each view is identified as a high-energy electron, telling us that this is likely an electron neutrino interaction. The shorter track is most likely a proton. Credit: NOvA

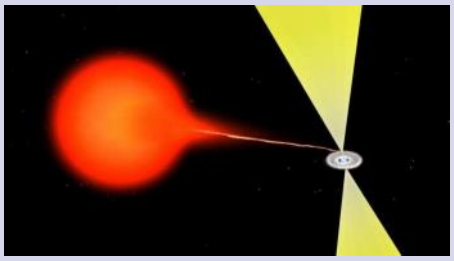
Neutron stars strike back at black holes in jet contest

Some neutron stars may rival black holes in their ability to accelerate powerful jets of material to nearly the speed of light, astronomers using the Karl G. Jansky Very Large Array (VLA) have discovered.

"It's surprising, and it tells us that something we hadn't previously suspected must be going on in some systems that include a neutron star and a more-normal companion star," said Adam Deller, of ASTRON, the Netherlands Institute for Radio Astronomy.

Black holes and neutron stars are respectively the densest and second most dense forms of matter known in the Universe. In binary systems where these extreme objects orbit with a more normal companion star, gas can flow from the companion to the compact object, producing spectacular displays when some of the material is blasted out in powerful jets at close to the speed of light

Previously, black holes were the undisputed kings of forming powerful jets. Even when only nibbling on a small amount of material, the radio emission that traces the jet outflow ...***Read More***...



Artist's impression of material flowing from a companion star onto a neutron star. The material forms an accretion disk around the neutron star and produces a superfast jet of ejected material. The material closest to the neutron star is so hot that it glows in X-rays, while the jet is most prominent at radio wavelengths. A similar mechanism is at work with black holes. Credit: Bill Saxton, NRAO/AUI/NSF.

Researchers explore nanoscale structure of thin films

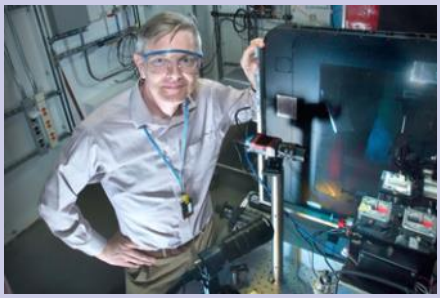
The world's newest and brightest synchrotron light source—the National Synchrotron Light Source II (NSLS-II) at the U.S. Dept. of Energy (DOE)'s Brookhaven National Laboratory—has produced one of the first publications resulting from work done during the facility's science commissioning phase.

Published July 7 in the online edition of the International Union of Crystallography Journal, the paper discusses a new way to apply a widely used local-structure analysis tool—known as atomic pair distribution function (PDF) analysis—to x-ray scattering data from thin films, quickly yielding high-quality information on the films' atomic structure. The work creates new avenues for studies of nanocrystalline thin films.

This work shows that NSLS-II—a DOE Office of Science User Facility with ultra-bright, ultra-concentrated x-ray beams—is already proving to be a game-changer in studies of thin films, which play a vital role in a large number of technologies, including computer chips and solar cells.

Thin-film challenges

In applications and during experiments, thin films (defined as having thicknesses from just a few to more than 1,000 nm, or billionths of a meter) are deposited onto a thick base, called a substrate, often made of crystalline wafers of silicon, silicon dioxide, or aluminum oxide. It is extremely difficult to study the structure of materials in this geometry because of the small amount of film material and large amount of substrate. To minimize the scattering of x-rays off the..***Read More***...



Simon Billinge, author on the paper and a physicist with a joint position at Brookhaven National Laboratory and Columbia Univ.'s School of Engineering and Applied Science.

World's quietest gas lets physicists hear faint quantum effects

Physicists at the University of California, Berkeley, have cooled a gas to the quietest state ever achieved, hoping to detect faint quantum effects lost in the din of colder but noisier fluids.

While the ultracold gas's temperature - a billionth of a degree above absolute zero - is twice as hot as the record cold, the gas has the lowest entropy ever measured. Entropy is a measure of disorder or noise in a system; a record low temperature gas isn't necessarily the least noisy.

"This 'lowest entropy' or 'lowest noise' condition means that the quantum gas can be used to bring forth subtle quantum mechanical effects which are a main target for modern research on materials and on many-body physics," said co-author Dan Stamper-Kurn, a UC Berkeley professor of physics. "When all is quiet and all is still, one might discern the subtle music of many-body quantum mechanics."

The quantum gas, a so-called Bose-Einstein condensate, consisted of about a million rubidium atoms trapped by a beam of light, isolated in a vacuum and cooled to their lowest energy state. The entropy and temperature were so low that the researchers had to develop a new type of thermometer to measure them.

While achieving extremely low temperatures may make the record books, UC Berkeley graduate student Ryan Olf said, what scientists aim for today are low-entropy states they can study to understand more interesting but difficult-to-study materials...***Read More***...

When the noise or entropy in a system is reduced, subtle information becomes visible, such as the faint word 'Berkeley.' Credit: Ryan Olf image

Magnetism at nanoscale

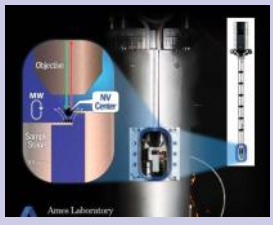
As the demand grows for ever smaller, smarter electronics, so does the demand for understanding materials' behavior at ever smaller scales. Physicists at the U.S. Department of Energy's Ames Laboratory are building a unique optical magnetometer to probe magnetism at the nano- and mesoscale.

The device, called a NV-magnetoscope, makes use of the unique quantum mechanical properties of nitrogen-vacancy (NV) centers in diamond. The low temperature NV-magnetoscope setup incorporates a confocal microscope (CFM) and an atomic-force scanning microscope (AFM). The NV-magnetoscope will be able to sense the extremely weak magnetic fields of just a handful of electrons with the spatial resolution of about 10 nanometers.

"We want to determine magnetic textures more precisely than ever before, at smaller scales than ever before," said Ames Laboratory physicist Ruslan Prozorov. "Our hope is to understand nano- and mesoscale magnetism, learn how to control it and, eventually, use that to create a new generation of technologies."

NV Centers

Usually, diamonds are most valued when they're perfect and big. But physicists see special value in diamonds' tiny flaws: a certain kind of imperfection, called a nitrogen vacancy (NV) center, serves as a very sensitive sensor of the magnetic field exactly at the location of the NV center. NV centers are created when a carbon atom is ...***Read More***...



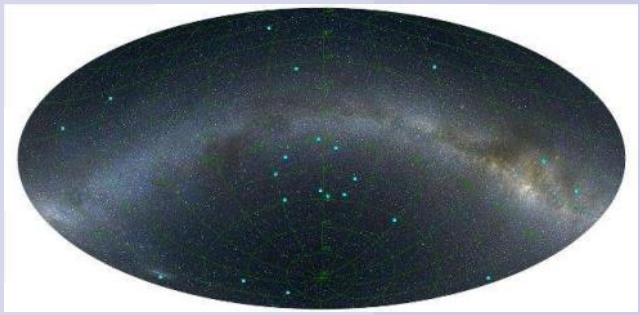
Physicists at the U.S. Department of Energy's Ames Laboratory are using an NV-magnetoscope to make use of nitrogen-vacancy centers in diamond to sense extremely weak magnetic fields in nano- and mesoscale magnetic materials.

5 billion light years across—the largest feature in the universe

A Hungarian-US team of astronomers have found what appears to be the largest feature in the observable universe: a ring of nine gamma ray bursts – and hence galaxies - 5 billion light years across. The scientists, led by Prof Lajos Balazs of Konkoly Observatory in Budapest, report their work in a paper in Monthly Notices of the Royal Astronomical Society.

Gamma-ray bursts (GRBs) are the most luminous events in the universe, releasing as much energy in a few seconds as the Sun does over its 10 billion year lifetime. They are thought to be the result of massive stars collapsing into black holes. Their huge luminosity helps astronomers to map out the location of distant galaxies, something the team exploited.

The GRBs that make up the newly discovered ring were observed using a variety of space- and ground-based observatories (the sample is listed in the Gamma Ray Burst Online Index). They appear to be at very similar distances from us – around 7 billion light years – in a circle 36° across on the sky, or more than 70 times the diameter of the Full Moon. This implies that the ring is more than 5 billion light years across, and according to Prof Balazs there is only a 1 in 20,000 probability of the GRBs being in this distribution by chance.



An image of the distribution of GRBs on the sky at a distance of 7 billion light years, centred on the newly discovered ring. The positions of the GRBs are marked by blue dots and the Milky Way is indicated for reference, running from left to right across the image. Credit: L. Balazs

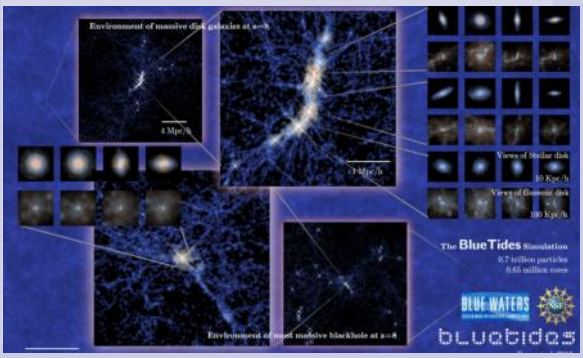
Most current models indicate that the structure of the cosmos is uniform on the largest scales. This 'Cosmological Principle' is backed up by observations of the early universe and ...***Read More***...

Milky Way-like galaxies may have existed in the early universe

A new, large-scale computer simulation has shown for the first time that large disk galaxies, much like our own Milky Way, may have existed in the early days of the universe.

The simulation, created by physicists at Carnegie Mellon University's McWilliams Center for Cosmology and the University of California Berkeley, shows that the early universe —a mere 500 million years after the Big Bang—might have had more order and structure than previously thought.

Their findings, which will be published in The Astrophysical Journal Letters, will help guide researchers using next-generation telescopes like the Wide Field Infrared Survey Telescope (WFIRST) .***Read More***...



Disk galaxies and black holes found in the BlueTides simulation of the early universe. The simulation, created by Carnegie Mellon and UC Berkeley researchers, is 100 times larger than previous simulations. Credit: bluetides-project.org

Image: Hubble sees a dying star's final moments

A dying star's final moments are captured in this image from the NASA/ESA Hubble Space Telescope. The death throes of this star may only last mere moments on a cosmological timescale, but this star's demise is still quite lengthy by our standards, lasting tens of thousands of years!

The star's agony has culminated in a wonderful planetary nebula known as NGC 6565, a cloud of gas that was ejected from the star after strong stellar winds pushed the star's outer layers away into space. Once enough material was ejected, the star's luminous core was exposed, enabling its UV radiation to excite the surrounding gas to varying degrees and causing it to radiate in an attractive array of colors. These same colors can be seen in the famous and impressive Ring Nebula (heic1310), a prominent example of a nebula like this one.

Planetary nebulae are illuminated for around 10,000 years before the central star begins to cool and shrink to become a white dwarf. When this happens, the star's light drastically diminishes and ceases to excite the surrounding gas, so the nebula fades from view.

Credit: ESA/Hubble & NASA, Acknowledgement: Matej Novak

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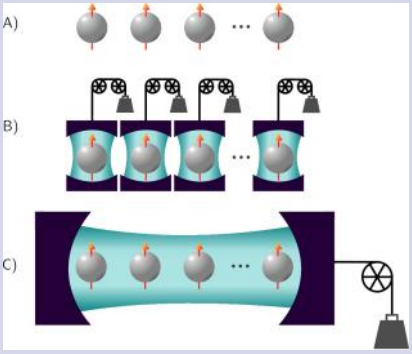
For faster battery charging, try a quantum battery?

Physicists have shown that a quantum battery—basically, a quantum system such as a qubit that stores energy in its quantum states—can theoretically be charged at a faster rate than conventional batteries. This "quantum speedup" arises from quantum entanglement among multiple qubits, which essentially provides a shortcut between the qubits' uncharged and charged states, allowing for faster charging.

The physicists, Felix C. Binder, et al., have published a paper on the quantum battery, which they call "quantacell," in a recent issue of the New Journal of Physics. "There has been much interest in the question if quantum physics can provide any advantage in thermodynamic processes (thermodynamics being the study of work and heat and their interconversion)," Binder, a physicist at the University of Oxford, told Phys.org. "Our paper demonstrates with an example that a significant advantage ...***Read More***...



(A) An array of qubits can be charged either (B) in parallel or (C) globally. The results show that, when global entangling operations are allowed on the array during charging, the charging rate increases as the number of qubits increases. Credit: Binder, et al. CC-BY-4.0

Physicist unveils plan for entangling massive objects

Roman Schnabel, a physics professor at the Max Planck Institute for Gravitational Physics has published a paper in the journal Physical Review Letters outlining a plan for entangling two "massive" objects. He and his team are still working on a way to actually carry out the plan, but if successful, the group would succeed in entangling two 0.1 kg mass mirrors, which would represent a much larger example of entanglement than anything that has come before—up till now the largest objects to be entangled were of micron size.

Entanglement is of course the odd and perhaps a little eerie situation where two or more objects are connected in a way that cannot yet be explained—measuring one causes the other to be impacted instantaneously. The phenomenon was predicted back in the 1930's by Einstein, Podolsky, and Rosen. Over the years, scientists have developed ways to cause particles and then tiny objects to become entangled, but it still was not clear if a way could be found to cause objects large enough to be governed by classical physics to be ...***Read More***...

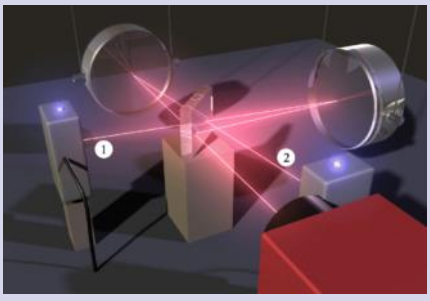


Illustration of the Michelson interferometer setup for the generation of an EPR-entangled motion of two massive mirrors that are suspended as pendula.

From a million miles away, NASA camera shows moon crossing face of Earth

A NASA camera aboard the Deep Space Climate Observatory (DSCOVR) satellite captured a unique view of the moon as it moved in front of the sunlit side of Earth last month. The series of test images shows the fully illuminated "dark side" of the moon that is never visible from Earth.

The images were captured by NASA's Earth Polychromatic Imaging Camera (EPIC), a four megapixel CCD camera and telescope on the DSCOVR satellite orbiting 1 million miles from Earth. From its position between the sun and Earth, DSCOVR conducts its primary mission of real-time solar wind monitoring for the National Oceanic and Atmospheric Administration (NOAA)….***Read More***...

Click on the image to see the animation.