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Astronomy & Physics News

Department of Physics—United Arab Emirates University
Weekly news from around the world compiled by Dr. Ilias Fernini

100 Million Stars in the Andromeda galaxy.

Inside this issue:

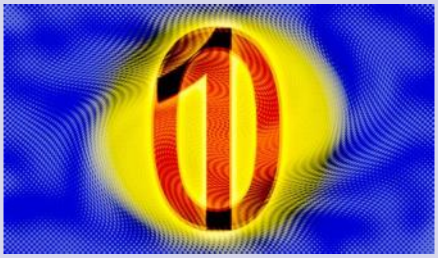
Physicists find a new form of quantum friction

Physicists at Yale University have observed a new form of quantum friction that could serve as a basis for robust information storage in quantum computers in the future. The researchers are building upon decades of research, experimentally demonstrating a procedure theorized nearly 30 years ago.

The results appear in the journal Science and are based on work in the lab of Michel Devoret, the F.W. Beinecke Professor of Applied Physics.

Quantum computers, a technology still in development, would rely on the laws of quantum mechanics to solve certain problems exponentially faster than classical computers. They would store information in quantum systems, such as the spin of an electron or the energy levels of an artificial atom. Called "qubits," these storage units are the quantum equivalent of classical "bits." But while bits can be in states like 0 or 1, qubits can simultaneously be in the 0 and 1 state. This property is called quantum superposition; it is a powerful resource, but also very fragile. Ensuring the integrity of quantum information is a major challenge of the field.

Zaki Leghtas, first author on the paper and a postdoctoral researcher at Yale, offered the following metaphor to explain this new form of quantum friction:
Imagine a hill surrounded by two basins. If you put a ball at the top of the hill, it will roll down the sides and settle in one of …***Read More***…



Credit: Michael S. Helfenbein

Monster black hole at cosmic dawn

A black hole 12 billion times more massive than our sun – at the heart of the brightest quasar in the early universe – as the dark ages of the universe were just ending.

The farther away we look in space, the deeper we are looking into the past. Astronomers looked 12.8 billion light-years from Earth – to a time only 900 million years after the Big Bang – to see what is currently the brightest quasar known in the early universe. They say it's seven times brighter than the most distant quasar known. What's more, it harbors a black hole with mass of 12 billion suns. So it's the most luminous quasar, with the most massive black hole, among all the known very distant quasars. As if that weren't enough, this quasar and its monster black hole are located at a special place and time in our universe, at what's sometimes called the cosmic dawn. An international team led by astronomers from Peking University in China and the University of Arizona announced these findings February 26, 2015 in the journal Nature.

Astronomer Xiaohui Fan at the University of Arizona's Steward Observatory, who co-authored the study, described the massive size of the black hole in a statement. …***Read More***…

Artist's impression of a quasar with a supermassive black hole in the distant and early universe. Image via Zhaoyu Li/NASA/JPL-Caltech/Misti Mountain Observatory.

Ultra-thin nanowires can trap electron "twisters"

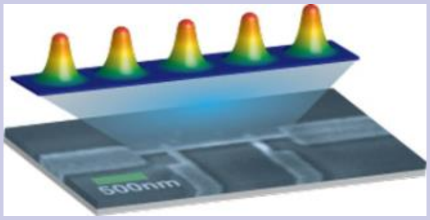
Superconductor materials are prized for their ability to carry an electric current without resistance, but this valuable trait can be crippled or lost when electrons swirl into tiny tornado-like formations called vortices. These disruptive mini-twisters often form in the presence of magnetic fields, such as those produced by electric motors.

To keep supercurrents flowing at top speed, Johns Hopkins scientists have figured out how to constrain troublesome vortices by trapping them within extremely short, ultra-thin nanowires. Their discovery was reported in Physical Review Letters.

"We have found a way to control individual vortices to improve the performance of superconducting wires," said Nina Markovic, an associate professor in the Dept. of Physics and Astronomy in the university's Krieger School of Arts and Sciences.

Many materials can become superconducting when cooled to a temperature of nearly 460 below zero F, which is achieved by using liquid helium.

The new method of maintaining resistance-free current within these superconductors is important because these materials play a key role in devices such MRI medical scanners, particle accelerators, photon detectors and the radio frequency filters used in cell phone systems. In addition, superconductors are expected to become critical components in future quantum computers, which will be able to do more ..***Read More***...



This illustration depicts a short row of vortices held in place between the edges of a nanowire developed by Johns Hopkins scientists. Image: Nina Markovic and Tyler Morgan-Wall

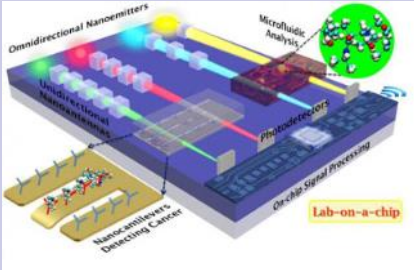
Optical nanoantennas set the stage for a NEMS lab-on-a-chip revolution

Newly developed tiny antennas, likened to spotlights on the nanoscale, offer the potential to measure food safety, identify pollutants in the air and even quickly diagnose and treat cancer, according to the Australian scientists who created them. The new antennas are cubic in shape. They do a better job than previous spherical ones at directing an ultra-narrow beam of light where it is needed, with little or no loss due to heating and scattering, they say.

In a paper published in the Journal of Applied Physics, Debabrata Sikdar of Monash Univ. in Victoria, Australia, and colleagues describe these and other envisioned applications for their nanocubes in "laboratories-on-a-chip." The cubes, composed of insulating, rather than conducting or semiconducting materials as were the spherical versions, are easier to fabricate as well as more effective, he says.

Sikdar's paper presents analysis and simulation of 200-nm dielectric (nonconductive) nanocubes placed in the path of visible and near-infrared light sources. The nanocubes are arranged in a chain, and the space between them can be adjusted to fine-tune the light beam as needed for various applications. As the separation between cubes increases, the angular width of the beam narrows and directionality improves, the researchers say.

"Unidirectional nanoantennas induce directionality to any omnidirectional light emitters like microlasers, nanolasers or spasers, and even quantum dots," Sikdar said in an interview…***Read More***...



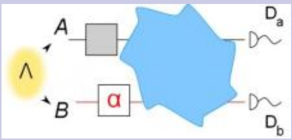
This is a schematic representation of unidirectional cubic nanoantennas inducing directionality to omnidirectional nanoemitters (light sources, e.g., spasers, quantum dots), to precisely focus light with adjustable beam width and intensity, which can be tuned by adjusting the length of nanocube chain or intercube spacing. ...

Could classical theory be just as weird as quantum theory?

Quantum mechanics is often described as "weird" and "strange" because it abandons many of the intuitive traits of classical physics. For example, the ideas that the world is objective, is deterministic, and exists independent of measurement are basic features of classical theory, but do not always hold up in quantum theory. But what if it turns out that these intuitive ideas are not true features of classical physics, either? Would classical theory be just as weird as quantum theory?

In a new study published in Physical Review Letters, physicists Radu Ionicioiu, et al., have shown that the three apparently reasonable classical assumptions mentioned above—objectivity, determinism, and independence—are mutually incompatible with any theory, not only with quantum mechanics. The scientists show that, while any two of the three assumptions are compatible, all three are not. All told, our seemingly reasonable classical assumptions may not be so reasonable after all.

"Sometimes classical ideas may seem 'natural' and 'logical' simply because we do not test them too strongly," coauthor Daniel Terno at Macquarie University in Sydney, Australia, told Phys.org. "Quantum mechanics may be weird, but our classical illusions may be weird too—or simply impossible to maintain, no matter how the world really operates."
The findings could have widespread implications. For many decades, physicists have assumed that our everyday classical ideas are consistent with each other, and have used them to investigate the tensions between the classical and ...***Read More***...



An illustration of the delayed-choice experiment, which shows that a photon exhibits both particle and wave behaviors. The physicists used this experiment to show that seemingly reasonable classical assumptions may not be so reasonable after all. Credit: Ionicioiu, et al. ©2015 American Physical Society

NASA missions may re-elevate Pluto and Ceres from dwarf planets to full-on planet

Ceres is the largest object in the asteroid belt, and NASA's Dawn spacecraft will arrive at this dwarf planet on March 6, 2015.

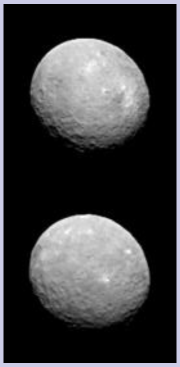
Pluto is the largest object in the Kuiper belt, and NASA's New Horizons spacecraft will arrive at this dwarf planet on July 15, 2015.

These two events will make 2015 an exciting year for solar system exploration and discovery. But there is much more to this story than mere science. I expect 2015 will be the year when general consensus, built upon our new knowledge of these two objects, will return Pluto and add Ceres to our family of solar system planets.

The efforts of a very small clique of Pluto-haters within the International Astronomical Union (IAU) plutoed Pluto in 2006. Of the approximately 10,000 internationally registered members of the IAU in 2006, only 237 voted in favor of the resolution redefining Pluto as a "dwarf planet" while 157 voted against; the other 9,500 members were not present at the closing session of the IAU General Assembly in Prague at which the vote to demote Pluto was taken. Yet Pluto's official planetary status was snatched away.

Ceres and Pluto are both spheroidal objects, like Mercury, Earth, Jupiter and Saturn. That's part of the agreed upon definition of a planet. They both orbit a star, the Sun, like Venus, Mars, Uranus and Neptune. That's also part of the widely accepted definition of a planet.

Unlike the larger planets, however, Ceres, like Pluto, according to the IAU definition, "has not cleared the neighborhood around its orbit." The asteroid belt is, apparently, Ceres' neighborhood while the Kuiper Belt is Pluto's neighborhood – though no definition of a planet's neighborhood exists, and no agreed upon understanding of what "clearing the neighborhood" yet exists. Furthermore, no broad...***Read More***...



Two views of Ceres acquired by NASA's Dawn spacecraft ten hours apart on Feb. 12, 2015, from a distance of about 52,000 miles as the dwarf planet rotated. Credit: NASA/JPL-

Looking deeply into the universe in 3-D

The MUSE instrument on ESO's Very Large Telescope has given astronomers the best ever three-dimensional view of the deep Universe. After staring at the Hubble Deep Field South region for only 27 hours, the new observations reveal the distances, motions and other properties of far more galaxies than ever before in this tiny piece of the sky. They also go beyond Hubble and reveal previously invisible objects.

By taking very long exposure pictures of regions of the sky, astronomers have created many deep fields that have revealed much about the early Universe. The most famous of these was the original Hubble Deep Field, taken by the NASA/ESA Hubble Space Telescope over several days in late 1995. This spectacular and iconic picture rapidly transformed our understanding of the content of the Universe when it was young. It was followed two years later by a similar view in the southern sky—the Hubble Deep Field South.

But these images did not hold all the answers—to find out more about the galaxies in the deep field images, astronomers had to carefully look at each one with other instruments, a difficult and time-consuming job. But now, for the first time, the new MUSE ...***Read More***...

The background image in this composite shows the NASA/ESA Hubble Space Telescope image of the region known as the Hubble Deep Field South. New observations using the MUSE instrument on ESO's Very Large Telescope have detected remote galaxies that are not visible to Hubble.

New insight found in black hole collisions

New research by an astrophysicist at The University of Texas at Dallas provides revelations about the most energetic event in the universe—the merging of two spinning, orbiting black holes into a much larger black hole.

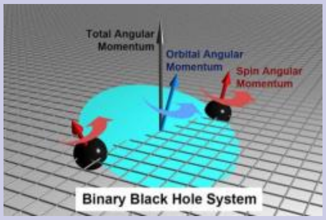
The work by Dr. Michael Kesden, assistant professor of physics at UT Dallas, and his colleagues provides for the first time solutions to decades-old equations that describe conditions as two black holes in a binary system orbit one another and spiral in toward collision.

The research is available online and in the Feb. 27 issue of the journal Physical Review Letters.

Kesden, who this month was selected as a 2015 Alfred P. Sloan Foundation Research Fellow, said the solutions should significantly impact not only the study of black holes, but also the search for gravitational waves in the cosmos. Albert Einstein's general theory of relativity predicts that two massive objects orbiting in a binary system should move closer together as the system emits a type of radiation called gravitational waves.

"An accelerating charge, like an electron, produces electromagnetic radiation, including visible light waves. Similarly, any time you have an accelerating mass, you can produce gravitational waves," Kesden said.

"In a binary black hole system, where you have two massive objects orbiting each other and exerting forces on each other, they are accelerating and emitting gravitational waves. The energy lost to gravitational waves causes the black holes to spiral closer and closer together until they merge, which is the most energetic event ...***Read More***...



In a binary black hole system, the directions of the spin angular momentum of each black hole (red cone arrows) and of the orbital angular momentum for the system (blue cone arrow) change, or precess, over time. Credit: Midori Kitagawa

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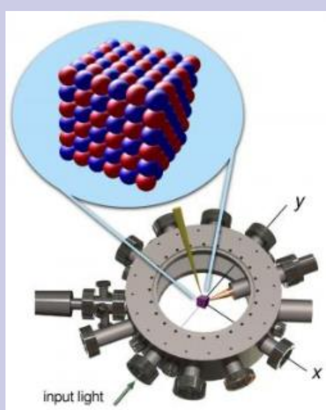
Simulating superconducting materials with ultracold atoms

Using ultracold atoms as a stand-in for electrons, a Rice University-based team of physicists has simulated superconducting materials and made headway on a problem that's vexed physicists for nearly three decades.

The research was carried out by an international team of experimental and theoretical physicists and appears online this week in the journal Nature. Team leader Randy Hulet, an experimental physicist at Rice, said the work could open up a new realm of unexplored science.

Nearly 30 years have passed since physicists discovered that electrons can flow freely through certain materials—superconductors—at relatively elevated temperatures. The reasons for this high-temperature, or "unconventional" superconductivity are still largely unknown. One of the most promising theories to explain unconventional superconductivity—called the Hubbard model—is simple to express mathematically but is impossible to solve with digital computers.

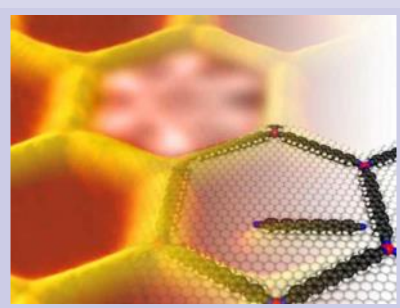
"The Hubbard model is a set of mathematical equations that could hold the ...***Read More***…



Rice University physicists trapped ultracold atomic gas in grids of intersecting laser beams to mimic the antiferromagnetic order observed in the parent compounds of nearly all high-temperature superconductors. Credit: P. Duarte/Rice University

Caging of molecules allows investigation of equilibrium thermodynamics

High performance materials for gas storage, thermal insulators or nanomachines need a thorough understanding of the behavior of the material down to the molecular level. Thermodynamics, which have been developed two hundred years ago to increase the efficiency of steam engines, typically observes and averages over a large number of molecules. Now a team of scientists has developed a methodology, to investigate the equilibrium thermodynamics of single molecules….***Read More***...



The nanopore restricts the the freedom of movement of the adsorbed single molecule thus enabling scientists at Technische Universitat Munchen and University Lingkoping to model the equilibrium thermodynamics of single molecules. Credit: Carlos-Andres Palma / TUM