INTERNATIONAL YEAR OF LIGHT 2015

100 Million Stars in the Andromeda galaxy.

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Department of Physics—United Arab Emirates University
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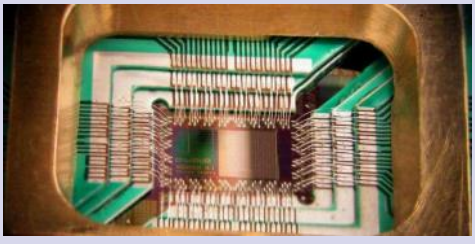
Inside this issue:

Quantum computing will bring immense processing possibilities

The one thing everyone knows about quantum mechanics is its legendary weirdness, in which the basic tenets of the world it describes seem alien to the world we live in. Superposition, where things can be in two states simultaneously, a switch both on and off, a cat both dead and alive. Or entanglement, what Einstein called "spooky action-at-distance" in which objects are invisibly linked, even when separated by huge distances.

But weird or not, quantum theory is approaching a century old and has found many applications in daily life. As John von Neumann once said: "You don't understand quantum mechanics, you just get used to it." Much of electronics is based on quantum physics, and the application of quantum theory to computing could open up huge possibilities for the complex calculations and data processing we see today.

Imagine a computer processor able to harness super-position, to calculate the result of an arbitrarily large number of permutations of a complex problem simultaneously. Imagine how entanglement could be used to allow systems on different sides of the world to be linked and their efforts combined, despite their physical separation. Quantum computing has immense potential, making light work of some of the most difficult tasks, such as simulating the body's response to drugs, predicting weather patterns, or analysing big datasets….Read More...



D-wave.

Made from solar concentrate

By combining designer quantum dot light-emitters with spectrally matched photonic mirrors, a team of scientists with the Lawrence Berkeley National Laboratory (Berkeley Lab) and the University of Illinois created solar cells that collect blue photons at 30 times the concentration of conventional solar cells, the highest luminescent concentration factor ever recorded. This breakthrough paves the way for the future development of low-cost solar cells that efficiently utilize the high-energy part of the solar spectrum.

"We've achieved a luminescent concentration ratio greater than 30 with an optical efficiency of 82-percent for blue photons," says Berkeley Lab director Paul Alivisatos, who is also the Samsung Distinguished Professor of Nanoscience and Nanotechnology at the University of California Berkeley, and director of the Kavli Energy Nanoscience Institute (ENSI), was the co-leader of this research. "To the best of our knowledge, this is the highest luminescent concentration factor in literature to date."

Alivisatos and Ralph Nuzzo of the University of Illinois are the the corresponding ...Read More...

Bathing the Earth with enough energy in one hour to meet human needs for an entire year, the sun represents the ultimate source of clean, green sustainable energy.

'Littlest' quark-gluon plasma revealed by physicists using Large Hadron Collider

Researchers at the University of Kansas working with an international team at the Large Hadron Collider have produced quark-gluon plasma - a state of matter thought to have existed right at the birth of the universe - with fewer particles than previously thought possible.

The material was discovered by colliding protons with lead nuclei at high energy inside the supercollider's Compact Muon Solenoid detector. Physicists have dubbed the resulting plasma the "littlest liquid."

"Before the CMS experimental results, it had been thought the medium created in a proton on lead collisions would be too small to create a quark-gluon plasma," said Quan Wang, a KU postdoctoral researcher working with the team at CERN, the European Organization for Nuclear Research. Wang performed key analysis for a paper about the experiment recently published in APS Physics.

"Indeed, these collisions were being studied as a reference for collisions of two lead nuclei to explore the non-quark-gluon-plasma aspects of the collisions," Wang said. "The analysis presented in this paper indicates, contrary to expectations, a quark-gluon plasma can be created in very asymmetric proton on lead collisions."

The unexpected discovery was said by senior scientists associated with the CMS detector to shed new light on high-energy physics.

"This is the first paper that clearly shows multiple particles are correlated to each ...Read More...

The KU research into quark-gluon plasma utilized the massive CMS detector at CERN's Large Hadron Collider. Image courtesy CERN.

Scientists 'squeeze' light one particle at a time

A team of scientists has successfully measured particles of light being "squeezed", in an experiment that had been written off in physics textbooks as impossible to observe.

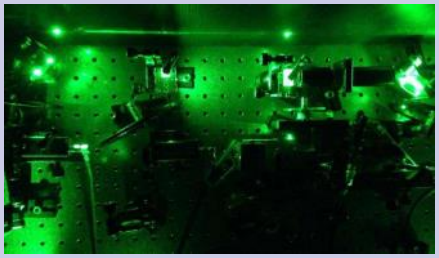
Squeezing is a strange phenomenon of quantum physics. It creates a very specific form of light which is "low-noise" and is potentially useful in technology designed to pick up faint signals, such as the detection of gravitational waves.

The standard approach to squeezing light involves firing an intense laser beam at a material, usually a non-linear crystal, which produces the desired effect.

For more than 30 years, however, a theory has existed about another possible technique. This involves exciting a single atom with just a tiny amount of light. The theory states that the light scattered by this atom should, similarly, be squeezed.

Unfortunately, although the mathematical basis for this method - known as squeezing of resonance fluorescence - was drawn up in 1981, the experiment to observe it was so difficult that one established quantum physics textbook despairingly concludes: "It seems hopeless to measure it".

So it has proven - until now. In the journal Nature, a team of physicists report that they have successfully demonstrated the squeezing of individual light particles, or photons, using an artificially constructed atom, known ..Read More..



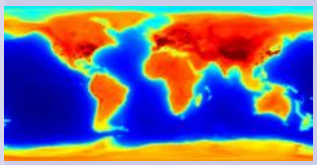
An image from an experiment in the quantum optics laboratory in Cambridge. Laser light was used to excite individual tiny, artificially constructed atoms known as quantum dots, to create "squeezed" single photons. Credit: Mete Atature

First global antineutrino emission map highlights Earth's energy budget

The neutrino and its antimatter cousin, the antineutrino, are the tiniest subatomic particles known to science. These particles are byproducts of nuclear reactions within stars (including our sun), supernovae, black holes and human-made nuclear reactors. They also result from radioactive decay processes deep within the Earth, where radioactive heat and the heat left over from the planet's formation fuels plate tectonics, volcanoes and Earth's magnetic field.

Now, a team of geologists and physicists has generated the world's first global map of antineutrino emissions. The map, published online in the journal Scientific Reports on September 1, 2015, provides an important baseline image of the energy budget of Earth's interior and could help scientists monitor new and existing human-made sources of radiation. The study was led by the National Geospatial-Intelligence Agency with contributions from researchers at the University of Maryland, the University of Hawaii, Hawaii Pacific University and Ultralytics, LLC.

"The interior of Earth is quite difficult to see, even with modern technology. Locating the activity of antineutrinos allows us to create images that our predecessors had only dreamed of," said William McDonough, professor of geology at UMD and a co-author of the study. "This map should prove particularly useful for future studies of processes within the lower crust and mantle." Neutrinos are notoriously difficult to study; their tiny size and lack of electrical charge enables them to pass straight through matter ...Read More..



The first-ever global map of antineutrino flux, which accounts for natural and human-made sources of antineutrinos, with the latter making up less than 1 percent of the total flux. Credit: National Geospatial-Intelligence Agency/AGM2015

Hubble survey unlocks clues to star birth in neighboring galaxy

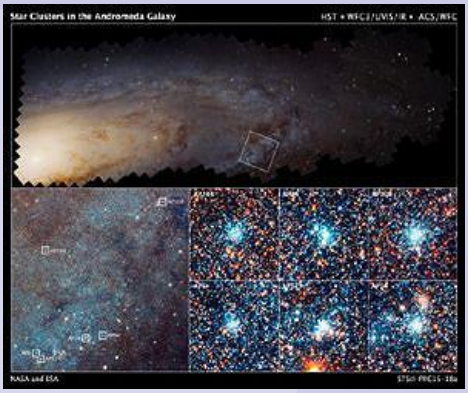
In a survey of NASA's Hubble Space Telescope images of 2,753 young, blue star clusters in the neighboring Andromeda galaxy (M31), astronomers have found that M31 and our own galaxy have a similar percentage of newborn stars based on mass.

By nailing down what percentage of stars have a particular mass within a cluster, or the Initial Mass Function (IMF), scientists can better interpret the light from distant galaxies and understand the formation history of stars in our universe.

The intensive survey, assembled from 414 Hubble mosaic photographs of M31, was a unique collaboration between astronomers and "citizen scientists," volunteers who provided invaluable help in analyzing the mountain of data from Hubble.

"Given the sheer volume of Hubble images, our study of the IMF would not have been possible without the help of citizen scientists," said Daniel Weisz of the University of Washington in Seattle. Weisz is lead author on a paper that appeared in the June 20 issue of the Astrophysical Journal.

Measuring the IMF was the primary driver behind Hubble's ambitious panoramic survey of our neighboring galaxy, called the Panchromatic Hubble Andromeda Treasury (PHAT) program. Nearly 8,000 ...Read More...



This is a Hubble mosaic of 414 photographs of the M31, or the Andromeda galaxy. On the bottom left is an enlargement of the boxed field (top) reveals myriad stars and numerous open star clusters as bright blue knots,spanning 4,400 light-years across. On the bottom right are six bright blue clusters extracted from the field. Each cluster square is 150 light-years across. Image courtesy NASA/ESA, J. Dalcanton, B.F. Williams, L.C. Johnson (Univ. of Washington), PHAT team, and R. Gendler

Cosmic Tangles Expanded Universe at a Rate of Knots

Scientists have come up with a knotty theory to explain why the early universe expanded after the Big Bang.

The early inflation of the Universe which took place a fraction of a second after the Big Bang may have been powered by tangled knots of flux tubes that provided energy, according to a new theory from a team of researchers at the University of Edinburgh.

"If you take your headphones and put them in your backpack, they tend to get tangled," says Arjun Berera of the University of Edinburgh, a lead author of the study.

"That's exactly the picture we're describing."
The scientists believe that the energy to drive inflation could have come from particles in the early Universe that resembled gluons, the exchange particles which mediate the force between quarks, the elementary particles that form protons and neutrons.

These particles in the early Universe are thought to have given rise to flux tubes, a cylindrical region of space containing a magnetic field, which formed between the particles and contained the energy to power the ..Read More...

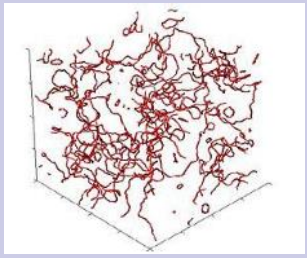


Illustration only.

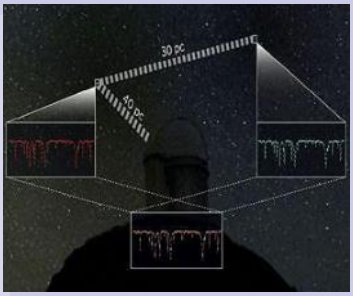
Using Stellar 'Twins' to Reach the Outer Limits of the Galaxy

Astronomers from the University of Cambridge have developed a new, highly accurate method of measuring the distances between stars, which could be used to measure the size of the galaxy, enabling greater understanding of how it evolved.

Using a technique which searches out stellar 'twins', the researchers have been able to measure distances between stars with far greater precision than is possible using typical model-dependent methods. The technique could be a valuable complement to the Gaia satellite - which is creating a three-dimensional map of the sky over five years - and could aid in the understanding of fundamental astrophysical processes at work in the furthest reaches of our galaxy.

"Determining distances is a key problem in astronomy, because unless we know how far away a star or group of stars is, it is impossible to know the size of the galaxy or understand how it formed and evolved," said Dr Paula Jofre Pfeil of Cambridge's Institute of Astronomy, the paper's lead author. "Every time we make an accurate distance measurement, we take another step on the cosmic distance ladder."

The best way to directly measure a star's distance is by an effect known as parallax, which is the apparent displacement of an object when viewed along two different lines of sight - for example, if you hold out your hand in front of you and look at it with your left eye closed and then with your right eye closed, your hand will appear to move against the background. The same effect can be used to calculate the distance to stars, by measuring the apparent motion of a nearby star compared to more distant background stars. By measuring the angle of inclination between the two ...Read More...



The parallax method can only be applied for stars which are reasonably close to us, since beyond distances of 1600 light years, the angles of inclination are too small to be measured by the Hipparcos satellite, a precursor to Gaia. Consequently, of the 100 billion stars in the Milky Way, we have accurate measurements for just 100,000.

Physics Department

College of Science - United Arab Emirates University
POB 15551
Al-Ain
United Arab Emirates

Phone: 00-971-3-7136336
Fax: 00-971-3-713-6909
E-mail: physics@uaeu.ac.ae

http://www.cos.uaeu.ac.ae/en/departments/physics/index.shtml

UAEU College of Science

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United Arab Emirates University

'Hedgehog' Robots Hop, Tumble in Microgravity

Hopping, tumbling and flipping over are not typical maneuvers you would expect from a spacecraft exploring other worlds. Traditional Mars rovers, for example, roll around on wheels, and they can't operate upside-down. But on a small body, such as an asteroid or a comet, the low-gravity conditions and rough surfaces make traditional driving all the more hazardous.

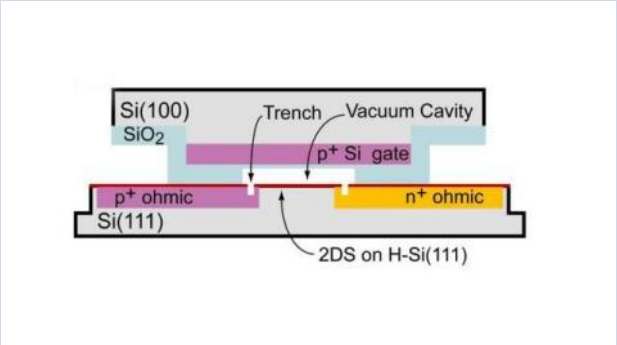
Enter Hedgehog: a new concept for a robot that is specifically designed to overcome the challenges of traversing small bodies. The project is being jointly developed by researchers at NASA's Jet Propulsion Laboratory in Pasadena, California; Stanford University in Stanford, California; and the Massachusetts Institute of Technology in Cambridge.

"Hedgehog is a different kind of robot that would hop and tumble on the surface instead of rolling on wheels. It is shaped like a cube and can operate no matter which side it lands on ...Read More...

While a Mars rover can't operate upside down, the Hedgehog robot can function regardless of which side lands up. Image courtesy NASA/JPL-Caltech/Stanford.

The first two-way, 2-D, ultra-high mobility Si (111) transistor

The two-dimensional physical properties of semiconductor materials depend keenly on a number of factors, such as material purity, surface orientation, flatness, surface reconstruction, charge carrier polarity, and temperature. JQI scientists have optimized a number of these parameters to produce the first ever ultra-high mobility, two-dimensional Si(111) transistor that allows charge carriers (electrons or holes) to flow through the same conduction channel by merely changing an external gate voltage….Read More...

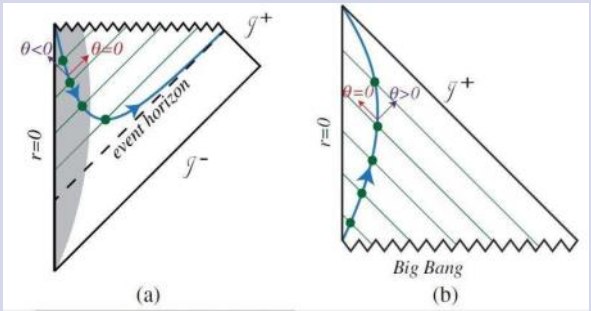


The upper half of the structure (using a different kind of silicon, Si100), constitutes the gate. Beneath the gate (the white region) is a small vacuum cavity. Directly beneath the vacuum region is the slab of silicon (111) material. The very topmost layer is impregnated with hydrogen atoms (H) is the crucial real estate. This layer supports a 2-dimensional electron system (2DES) of charges running between the source and the drain.

New law implies thermodynamic time runs backwards inside black holes

Black holes are known to have many strange properties, such as that they allow nothing—not even light—to escape after falling in. A lesser known but equally bizarre property is that black holes appear to "know" what happens in the future in order to form in the first place. However, this strange property arises from the way in which black holes are defined, which has motivated some physicists to explore alternative definitions.

In a new paper published in Physical Review Letters, Raphael Bousso, a professor at the University of California, Berkeley, and Lawrence Berkeley National Laboratory, and Netta Engelhardt, a graduate student at the University of California, Santa ...Read More...



The new area law states that the area of a future holographic screen (the solid blue line in [a]) is always increasing in one direction, while the area of a past holographic screen (the solid blue line in [b.]) is always increasing in a different direction. Credit: Bousso and Engelhardt. ©2015 American Physical Society