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Inside this issue:

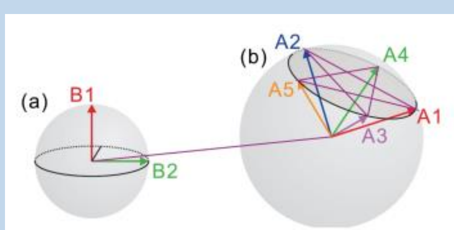
Two defining features of quantum mechanics never appear together

Two of the most important ideas that distinguish the quantum world from the classical one are nonlocality and contextuality. Previously, physicists have theoretically shown that both of these phenomena cannot simultaneously exist in a quantum system, as they are both just different manifestations of a more fundamental concept, the assumption of realism. Now in a new paper, physicists have for the first time experimentally confirmed that these two defining features of quantum mechanics never appear together.

The physicists, Xiang Zhan, et al., have published a paper on the nonlocality-contextuality tradeoff in a recent issue of Physical Review Letters.

In the everyday world that we observe, an object can only be affected by nearby objects (locality), and when we make a measurement, the outcome does not depend on other independent measurements being made at the same time (noncontextuality).

In contrast, the quantum world is nonlocal, as demonstrated by quantum entanglement where two objects can influence each other even when separated by large distances. And in the quantum world, measurements are contextual, so quantum systems do not have predetermined values but instead their values depend on how measurements are made. To show that a quantum system is nonlocal or contextual, physicists have defined inequalities that assume a system ...Read More...



Representation of measurements that demonstrate the contextuality-nonlocality tradeoff. Credit: Zhan, et al. ©2016

Comet Flying by Earth Observed with Radar and Infrared

Astronomers were watching when comet P/2016 BA14 flew past Earth on March 22. At the time of its closest approach, the comet was about 2.2 million miles (3.5 million kilometers) away, making it the third closest comet flyby in recorded history (see "A 'Tail' of Two Comets"). Radar images from the flyby indicate that the comet is about 3,000 feet (1 kilometer) in diameter.

The scientists used the Goldstone Solar System Radar in California's Mojave Desert to track the comet.

"We were able to obtain very detailed radar images of the comet nucleus over three nights around the time of closest approach," said Shantanu Naidu, a postdoctoral researcher at NASA's Jet Propulsion Laboratory in Pasadena, California, who works with the radar team and led the observations during the comet's flyby.

"We can see surface features as small as 8 meters per pixel. The radar images show that the comet has an irregular shape: looks like a brick on one side and a pear on the other," Naidu said.

"We can see quite a few signatures related to topographic features such as large flat regions, small concavities and ridges on the surface of the nucleus." ...Read More...

Illustration only

Physicists demonstrate a quantum Fredkin gate

Researchers from Griffith University and the University of Queensland have overcome one of the key challenges to quantum computing by simplifying a complex quantum logic operation. They demonstrated this by experimentally realising a challenging circuit—the quantum Fredkin gate—for the first time.

"The allure of quantum computers is the unparalleled processing power that they provide compared to current technology," said Dr Raj Patel from Griffith's Centre for Quantum Dynamics.

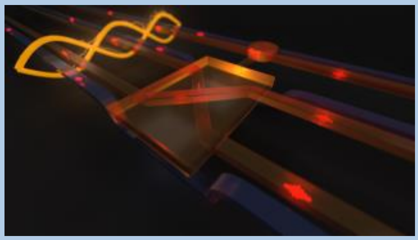
"Much like our everyday computer, the brains of a quantum computer consist of chains of logic gates, although quantum logic gates harness quantum phenomena."

The main stumbling block to actually creating a quantum computer has been in minimising the number of resources needed to efficiently implement processing circuits.

"Similar to building a huge wall out lots of small bricks, large quantum circuits require very many logic gates to function. However, if larger bricks are used the same wall could be built with far fewer bricks," said Dr Patel.

"We demonstrate in our experiment how one can build larger quantum circuits in a more direct way without using small logic gates."

At present, even small and medium scale quantum computer circuits cannot be produced because of the requirement to integrate so many of these gates into the circuits. ...Read More...



An artist's rendering of the quantum Fredkin (controlled-SWAP) gate, powered by entanglement, operating on photonic qubits. Credit: Raj Patel and Geoff Pryde, Center for Quantum Dynamics, Griffith University.

Storage density beyond 10 Tb/in2 possible for heat-assisted magnetic recording

Global demand for data storage is constantly increasing, driven by new technologies such as Big Data and the Internet of Things, as well as personal and enterprise storage. The hard disk drives that currently store the majority of the world's data have storage densities of just under 1 Terabit per square inch (Tb/in2). One of the promising technologies being researched for increasing the storage density is heat-assisted magnetic recording (HAMR), which uses lasers to heat individual magnetic grains that are just a few nanometers long. The method requires controlling heat and magnetism on a tiny scale, which has made developing HAMR very challenging.

In a new paper published in Applied Physics Letters, a team of physicists from TU Wien in Vienna, Austria, has developed simulations that realistically model the HAMR write process. Using the simulations, the researchers could independently control a variety of parameters that affect the storage density, and identify the circumstances under which HAMR can achieve its optimal storage density, which they found could be more than 13 Tb/in2.

"The resulting storage density of 13.23 Tb/in^2 would definitely be the highest density of any commercially available memory to date," coauthor Christoph Vogler at TU Wien told Phys.org. "With such a density, a conventional hard disk drive could have more than 10 times the capacity of today's devices, at the same size. ...Read More..

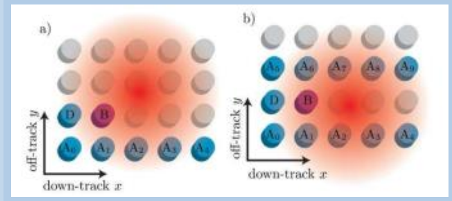


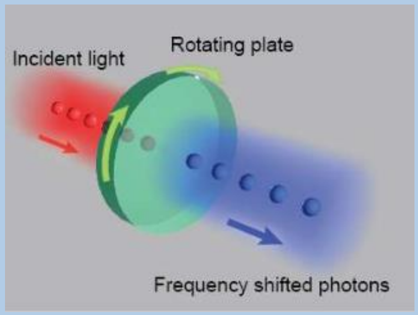
Illustration of two versions of the HAMR writing procedure, showing a laser being used to heat bit B, which enables the bit to be written by a much smaller magnetic field than would otherwise be required. All of the surrounding A bits remain in their original states because they have not been heated (enough), and so cannot be written by the magnetic field. Credit: Vogler, et al. ©2016 AIP Publishing

Nonlinear rotational Doppler effect in light observed for the first time

Experimental physicist Prof. Thomas Zentgraf and his two colleagues from the University of Birmingham, Dr. Guixin Li and Prof. Shuang Zhang, have for the first time proved experimentally the nonlinear rotational Doppler effect of light—nearly 50 years after its theoretical prediction by the Dutch Nobel Laureate Nicolaas Bloembergen.

The acoustic Doppler effect can be experienced day in the real world every: An ambulance siren sounds sharper closer to the emergency vehicle; when the vehicle pulls away, the siren sound descends. This is due to the change of wavelength of the sound waves, which are compressed or stretched during the movement of the sound source, thus changing its pitch. The effect applies to all kinds of waves, including light waves. Similarly, as a star moves away from Earth, its emitted light wave is stretched, creating the so-called red-shift, i.e. a longer wavelength of light.

Conversely, a light wave emitted from a star approaching Earth will be compressed, which causes a blue shift. In 1842, the Austrian physicist Christian Andreas Doppler predicted this optical effect in his paper "On the colored light of the double stars and certain other stars of heaven," and presented this phenomenon to the Royal Bohemian Society of Sciences in Prague. Three years later, the Dutch physicist Christoph H. D. Buys-Ballot observed the acoustic Doppler effect ...Read More...



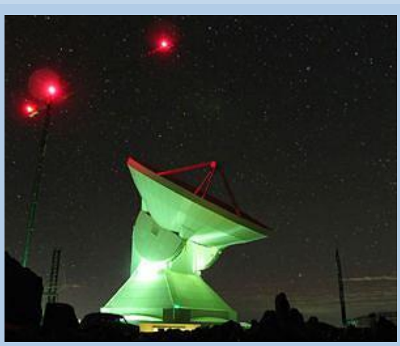
For a circularly polarized pumping laser passing through the nonlinear optical crystal along its rotation axis, second harmonic generation with opposite spin state has a frequency shifts of $\pm 3\Omega$. Credit: University of Birmingham

Most 'outrageously' luminous galaxies ever observed

Astronomers at the University of Massachusetts Amherst report that they have observed the most luminous galaxies ever seen in the Universe, objects so bright that established descriptors such as "ultra-" and "hyper-luminous" used to describe previously brightest known galaxies don't even come close. Lead author and undergraduate Kevin Harrington says, "We've taken to calling them 'outrageously luminous' among ourselves, because there is no scientific term to apply."

Details appear in the current early online edition of Monthly Notices of the Royal Astronomical Society.

Harrington is a senior undergraduate in astronomy professor Min Yun's group, which uses the 50-meter diameter Large Millimeter Telescope (LMT), the largest, most sensitive single-aperture instrument in the world for studying star formation. It is operated jointly by UMass Amherst and Mexico's Instituto Nacional de Astrofisica, Optica y Electronica and is located on the summit of Sierra Negra, a 15,000-foot extinct volcano in the central state of Puebla, a companion peak to Mexico's highest mountain. Yun, Harrington and colleagues also used the latest generation of satellite telescope and a cosmology experiment on the NASA/ESA collaboration Planck satellite that detects the glow of the Big Bang and microwave background for this work. They estimate that the newly observed galaxies they identified are about 10 billion years old and were formed only about 4 billion years ...Read More...



The 50-meter diameter Large Millimeter Telescope is the largest, most sensitive single-aperture instrument in the world for studying star formation. Operated jointly by UMass Amherst and Mexico's Instituto Nacional de Astrofisica, Optica y Electronica, it was recently used to observe the most luminous galaxies ever seen. Image courtesy UMass Amherst/Smith College/James Lowenthal.

New research shows quasars slowed star formation

Research led by Johns Hopkins University scientists has found new persuasive evidence that could help solve a longstanding mystery in astrophysics: Why did the pace of star formation in the universe slow down some 11 billion years ago?

A paper published in the Monthly Notices of the Royal Astronomical Society finds evidence supporting the argument that the answer was energy feedback from quasars within the galaxies where stars are born. That is, intense radiation and galaxy-scale winds emitted by the quasars - the most luminous objects in the universe - heats up clouds of dust and gas. The heat prevents that material from cooling and forming more dense clouds, and eventually stars.

"I would argue that this is the first convincing observational evidence of the presence of quasar feedback when the universe was only a quarter of its present age, when the cosmic star formation was most vigorous," said Tobias Marriage, an assistant professor in the university's Henry A. Rowland Department of Physics and Astronomy. While the findings appearing in the journal published by the Oxford University Press are not conclusive, Marriage said, the evidence is very compelling and ...Read More...

In an artist's conception, heated galactic wind shown in the hazy portion of the picture emanates from the bright quasar at the edge of a black hole, scattering dust and gas. If allowed to cool and condense, that dust and gas would instead begin to form stars. Image courtesy Johns Hopkins University

First Discovery of a Binary Companion for a Type Ia Supernova

A team of astronomers led by The University of Texas at Austin's Howie Marion has detected a flash of light from the companion to an exploding star. This is the first time astronomers have witnessed the impact of an exploding star on its neighbor. It provides the best evidence on the type of binary star system that leads to Type Ia supernovae.

This study reveals the circumstances for the violent death of some white dwarf stars and provides deeper understanding for their use as tools to trace the history of the expansion of the universe. These types of stellar explosions enabled the discovery of dark energy, the universe's accelerating expansion that is one of the top problems in science today. The work is published in The Astrophysical Journal.

The subject of how Type Ia supernovae arise has long been a topic of debate among astronomers. "We think that Type Ia supernovae come from exploding white dwarfs with a binary companion," Marion said. "The theory goes back 50 years or so, but there hasn't been any concrete evidence for a companion star before now."

Astronomers have battled over competing ideas, debating whether the companion was a normal star or another white dwarf. "This is the first time a normal Type Ia has been associated with a binary companion star," team member J. Craig Wheeler said. "This is a big deal." Wheeler is a supernova expert and professor of astronomy at the university.

The binary star progenitor theory for Type Ia supernovae starts with a burnt-...Read More...

The blue-white dot at the center of this image is supernova 2012cg, seen by the 1.2-meter telescope at Fred Lawrence Whipple Observatory. At 50 million light-years away, this supernova is so distant that its host galaxy, the edge-on spiral NGC 4424, appears here as only an extended smear of purple light. Image courtesy Peter Challis and Harvard-Smithsonian CfA.

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APOD: Close Comet and the Milky Way
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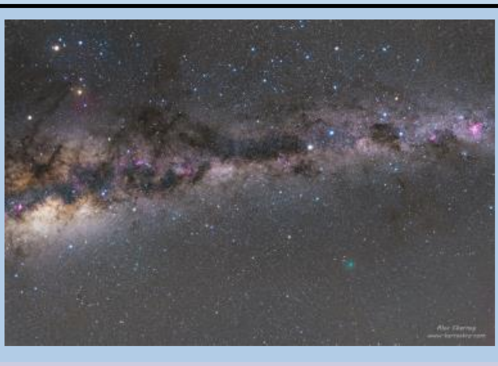
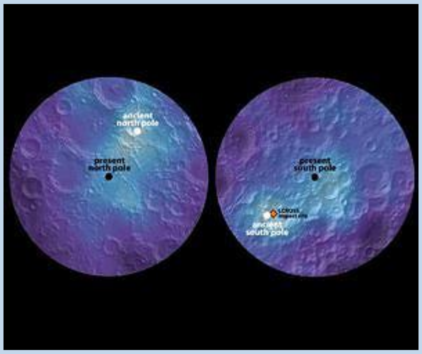


Ancient Polar Ice Reveals Tilting of Earth's Moon

New NASA-funded research provides evidence that the spin axis of Earth's moon shifted by about five degrees roughly three billion years ago. The evidence of this motion is recorded in the distribution of ancient lunar ice, evidence of delivery of water to the early solar system.

"The same face of the moon has not always pointed towards Earth," said Matthew Siegler of the Planetary Science Institute in Tucson, Arizona, lead author of a paper in Nature. "As the axis moved, so did the face of the 'man in the moon.' He sort of turned his nose up at the Earth."

Water ice can exist on Earth's moon in areas of permanent shadow. If ice on the moon is exposed to direct sunlight it evaporates into space. Authors of the Nature article show evidence that a shift of the lunar spin axis billions of years ago enabled sunlight to creep into areas that were once shadowed and likely previously contained ice...Read More..



This polar hydrogen map of the moon's northern and southern hemispheres identifies the location of the moon's ancient and present day poles. In the image, the lighter areas show higher concentrations of hydrogen and the darker areas show lower concentrations. Image courtesy James Keane, University of Arizona; Richard Miller, University of Alabama at Huntsville.

Physicists prove energy input predicts molecular behavior

The world within a cell is a chaotic space, where the quantity and movement of molecules and proteins are in constant flux. Trying to predict how widely a protein or process may fluctuate is essential to knowing how well a cell is performing. But such predictions are hard to pin down in a cell's open system, where everything can look hopelessly random.

Now physicists at MIT have proved that at least one factor can set a limit, or bound, on a given protein or process' fluctuations: energy. Given the amount of energy that a cell is spending, or dissipating, the fluctuations in a particular protein's quantity, for example, must be within a specific range; fluctuations outside this range would be deemed impossible, according to the laws of thermodynamics.
This idea also works in the opposite direction: Given a range of fluctuations in, say, the rate of a motor protein's rotation, the researchers can determine the minimum amount of energy that the cell must be expending to drive that rotation. ...Read More...

An artist's interpretation of a nanomachine on a molecule. Knowing how energy and microscopic fluctuations relate will help scientists design more reliable nanomachines for applications ranging from drug delivery to fuel cell technology. Credit: MIT News

Solar Wind Induces Jupiter's X-ray Aurora

Jupiter boasts some of the most powerful auroras in the solar system. Compared to the Earth's aurora, Jupiter's is a few hundred times more powerful and brighter across the entire spectrum. What causes Jupiter's powerful aurora? Several hypotheses have been proposed, but it has remained a mystery due to a lack of observational evidence.

Jupiter's X-ray aurora, which is observed in the X-ray spectrum region, is thought to sparkle when oxygen and sulfur ion particles moving at nearly the velocity of light strike Jupiter's atmosphere. How can these ions be accelerated to such high speed? There are two leading hypotheses. The first one assumes that the solar wind speeds up the ions, similar to the case of the Earth's aurora. The other proposes that the ions are being accelerated by the rapid spin of Jupiter, Jupiter's own magnetic field, and plasma provided by Jupiter's satellite Io.

Monitor observations of Jupiter's X-ray aurora are essential to compare several parameters of the X-ray aurora, such as brightness at each location, with the changes in the solar wind. For example, a correlation between the solar wind and the X-ray aurora supports the first hypothesis (the ions are accelerated by the solar wind) observationally. Using the Spectroscopic Planet Observatory for Recognition of Interaction ...Read More...

Artistic rendering of the Jupiter's aurora and magnetosphere.