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Inside this issue:

Physicists investigate unusual form of quantum mechanics

In a new study, physicists at Penn State University have for the first time proposed a way to test a little-understood form of quantum mechanics called nonassociative quantum mechanics. So far, all other tests of quantum mechanics have dealt with the associative form, so the new test provides a way to explore this relatively obscure part of the theory.

"Nonassociative quantum mechanics has been of mathematical interest for some time (and has recently shown up in certain models of String Theory), but it has been impossible to obtain a physical understanding," coauthor Martin Bojowald at Penn State told Phys.org. "We have developed methods which allow us to do just that, and found a first application with a characteristic and instructive result. One of the features that makes this setting interesting is that much of the usual mathematical toolkit of quantum mechanics is inapplicable."

Standard quantum mechanics is considered associative because mathematically it obeys the associative property. One of the fundamental concepts of standard quantum mechanics is the wave function, which gives the probability of finding a quantum system in a particular state. (The wave function is what determines the likelihood of Schrödinger's cat being dead or alive, before the box is opened.) Mathematically, wave functions are vectors, and the mathematical ...Read More...

Credit: Advexon

Did 'dark matter' or a star called Nemesis kill the dinosaurs?

The dinosaur extinction 66m years ago was most likely caused by a comet or big asteroid hitting the Earth. But given that asteroids don't actually hit our planet very often, could this really be the whole story? Many scientists are now asking whether some sort of cosmological event could have boosted the number of comets at the time, making such a collision more likely.

In a recent book, American cosmologist Lisa Randall suggests that a huge disk of "dark matter" – a type of invisible matter that is five times more common than "normal" matter – could have been responsible. When sweeping past our solar system such a disk would cause a tiny perturbation in space, amounting to a flicker in the gravitational force that can knock comets out of the solar system's Kuiper belt or the Oort cloud just outside and send them towards the Earth.

But how credible is this theory? And are there other cosmological events that could explain the issue?

A tricky question

Mounting astrophysical and cosmological evidence suggests that there is a lot more dark matter in our galaxy than normal matter. Although it is invisible, we know it is there because of the gravitational pull it has on objects surrounding it.

The fact that it is dark simply means that it does not emit or absorb light, which ...Read More….

Credit: ESO/Y. Beletsky, CC BY-SA

German physicists see landmark in nuclear fusion quest

Scientists in Germany said Thursday they had reached a milestone in a quest to derive energy from nuclear fusion, billed as a potentially limitless, safe and cheap source.

Nuclear fusion entails fusing atoms together to generate energy -- a process similar to that in the Sun -- as opposed to nuclear fission, where atoms are split, which entails worries over safety and long-term waste.

After spending a billion euros ($1.1 billion) and nine years' construction work, physicists working on a German project called the "stellarator" said they had briefly generated a super-heated helium plasma inside a vessel -- a key point in the experimental process.

"We're very satisfied," said Hans-Stephan Bosch at the Max Planck Institute for Plasma Physics in Greifswald.

"Everything went according to plan."

For all its promise, nuclear fusion has proven elusive and highly costly to achieve.

The idea is to heat atoms to temperatures of more than 100 million degrees Celsius (212 million degrees Fahrenheit) so that their nuclei fuse.

The fusion would take place in a special vacuum chamber where the atoms, in a hot ionised gas called a plasma, are held floating in place by superconducting magnets so that they do not touch the vessel's cold sides.

The German experiment, using a machine called Wendelstein 7-X, was aimed at seeing whether it was possible to heat helium atoms with a microwave laser and to briefly contain ...Read More...

File Image.

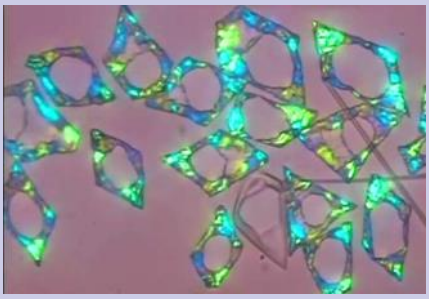
New understanding of how shape and form develop in nature

Researchers have developed a new method for generating complex shapes, and have found that the development of form in nature can be driven by the physical properties of materials themselves, in contrast with earlier findings. The results, reported in the journal Nature, could enable the construction of complex structures from simple components, with potential applications in pharmaceuticals, paints, cosmetics and household products such as shampoo.

Using a simple set-up—essentially droplets of oil in a soapy water solution which were slowly frozen—the researchers found that recently-discovered 'plastic crystal' phases formed on the inside surfaces of the droplets cause them to shape-shift into a wide variety of forms, from octahedrons and hexagons to triangles and fibres.

Previous efforts to create such complex shapes and structures have used top-down processing methods, which allow a high degree of control, but are not efficient in terms of the amount of material used or the expensive equipment necessary to make the shapes. The new method, developed by researchers from the University of Cambridge and Sofia University in Bulgaria, uses a highly efficient, extremely simple bottom-up approach to create complex shapes.

"There are many ways that non-biological things take shape," said Dr Stoyan Smoukov from Cambridge's Department of Materials Science & Metallurgy, who led the research. ...Read More...



Morphogenesis. Credit: Stoyan Smoukov

Researchers show presence of charge-density waves in superconductive material

Ultrafast laser techniques helped MIT physics graduate student Fahad Mahmood and colleagues establish that electrons form charge-density waves in the thin-film superconductive material LSCO cuprate.

"The question is how does this fluctuating charge-density wave compete or not interfere with superconductivity, and what we found is that it actually competes with superconductivity," Mahmood explains. "Electrons for a very short amount of time are in this charge-density wave state, and in another time scale, if you take another snapshot, they'll be in the superconductivity state."

Charge-density waves occur when electron density in a conductor is distributed in a sinusoidal pattern, like ripples on water, instead of the common uniform density.

"It's a fluctuating order that lasts for a very short amount of time and equilibrium probes won't be able to detect it," he says. Using ultrafast spectroscopy, Mahmood and co-authors of a 2013 Nature Materials paper were able to show that for extremely short periods of time—up to about 2 picoseconds—electrons clustered in a density wave that could be measured by its amplitude and phase. "This was kind of the very first observation in that particular material that [that] kind of charge-density wave exists, and we were able to make .Read More..

Graduate student Fahad Mahmood (pictured) uses ultrafast optical setups to study electron dynamics and competing phases in high temperature superconductors. Credit: Denis Paiste/ Materials Processing Center

Zooming in on Pluto's Pattern of Pits

On July 14 the telescopic camera on NASA's New Horizons spacecraft took the highest resolution images ever obtained of the intricate pattern of "pits" across a section of Pluto's prominent heart-shaped region, informally named Tombaugh Regio.

Mission scientists believe these mysterious indentations may form through a combination of ice fracturing and evaporation.

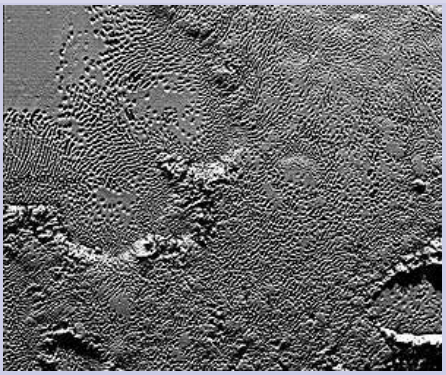
The scarcity of overlying impact craters in this area also leads scientists to conclude that these pits - typically hundreds of yards across and tens of yards deep - formed relatively recently.

Their alignment provides clues about the ice flow and the exchange of nitrogen and other volatile materials between the surface and the atmosphere.

The image is part of a sequence taken by New Horizons' Long Range Reconnaissance Imager (LORRI) as the spacecraft passed within 9,550 miles (15,400 kilometers) of Pluto's surface, just 13 minutes before the time of closest approach.

The small box on the global view shows the section of the region imaged in the southeast corner of the giant ice sheet informally named Sputnik Planum.

The magnified view is 50-by-50 miles (80-by-80 kilometers) across. The large ring-like structure near the bottom right of the ...Read More...



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A 'ghost from the past' recalls the infancy of the Milky Way

When our galaxy was born, around 13,000 million years ago, a plethora of clusters containing millions of stars emerged. But over time, they have been disappearing. However, hidden behind younger stars that were formed later, some old and dying star clusters remain, such as the so -called E 3. European astronomers have now studied this testimony to the beginnings of our galaxy.

Globular clusters are spherical-shaped or globular stellar groupings - hence its name- which can contain millions of stars. There are about 200 of them in the Milky Way, but few are as intriguing to astronomers as the E 3 cluster.

It is situated around 30,000 light years away, in the southern constellation of Chameleon. A team of Spanish and Italian astronomers have named it "a ghost from the Milky Way's past" in an article published recently in the Astronomy and Astrophysics journal.

"This globular cluster, and a few similar ones - such as Palomar 5 or Palomar 14 - are `ghosts' because they appear to be in the last stages of their existence, and we say 'from ...Read More..

The Milky Way arcs into a panorama in the southern sky, taken from the Paranal Observatory, Chile. Image courtesy ESO/H.H. Heyer.

What spawned the Jellyfish Nebula?

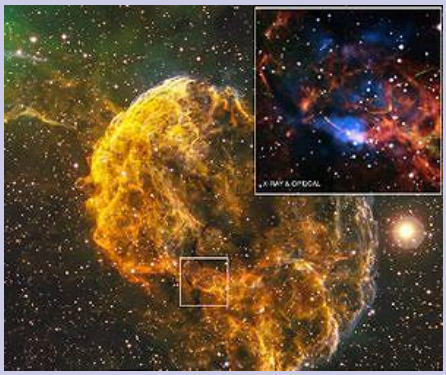
The Jellyfish Nebula, also known by its official name IC 443, is the remnant of a supernova lying 5,000 light years from Earth. New Chandra observations show that the explosion that created the Jellyfish Nebula may have also formed a peculiar object located on the southern edge of the remnant, called CXOU J061705.3+222127, or J0617 for short. The object is likely a rapidly spinning neutron star, or pulsar.

When a massive star runs out of thermonuclear fuel, it implodes, forming a dense stellar core called a neutron star. The outer layers of the star collapse toward the neutron star then bounce outward in a supernova explosion.

A spinning neutron star that produces a beam of radiation is called a pulsar. The radiation sweeps by like a beacon of light from a lighthouse and can be detected as pulses of radio waves and other types of radiation.

This new composite image includes a wide-field view from an astrophotographer that shows the spectacular filamentary structure of IC 443. Within the inset box, another optical image from the Digitized Sky Survey (red, green, orange, and cyan) has been combined with X-ray data from Chandra (blue). The inset shows a close-up view of the region around J0617.

The Chandra image reveals a small, circular structure (or ring) surrounding the pulsar and a jet-like feature pointing roughly in an up-down direction that passes through the pulsar. It is unclear if the long, pink wisp of optical emission is related to the pulsar, as similar wisps found in IC 443 are unrelated to ...Read More...



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High-energy X-rays give industry affordable way to optimize cast iron

Cast iron can be modified through the manufacturing process to optimize its mechanical and physical properties, such as strength and durability.

This makes it a material of choice for use in the transportation and machinery industries, which rely on cast iron's resistance to wear, deformation, and rusting to design high-performance bridges, tools, and engine parts.

But the manufacturing process is as much art as science, producing good results yet not capturing cast iron's full potential. ...Read More..

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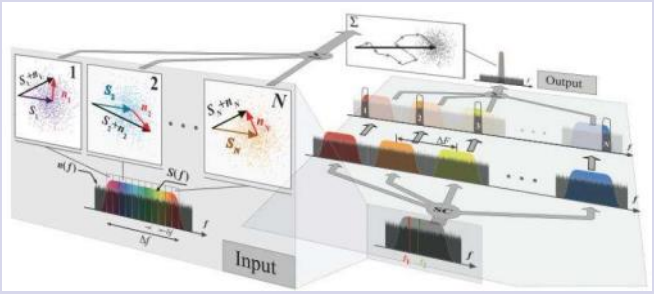
New optical technique able to detect a single radio signal amongst background noise

A small team of researchers with the University of California has found a way to pick out a single short radio signal burst among a barrage of background noise. In their paper published in the journal Science, the team describes their technique, how it works, how accurate it is and the possible applications it might be used for. Michael Vasilyev, with the University of Texas offers a Perspectives piece on the work done by the team in the same journal issue, noting how some human organs have senses that rely on using a similar technique to make sense of the environment.

As Vasilyev notes, there are a lot of areas in science that could benefit from an ability to isolate a single short signal amongst a stream of noise—astronomy, is just one example. Currently it is impossible to separate out a unique signal if there is just one burst ...Read More...



Single-event noise discrimination. Credit: (c) Science 11 December 2015: Vol. 350 no. 6266 pp. 1343-1346, DOI: 10.1126/science.aac8446

Quantum physics problem proved unsolvable: Godel and Turing enter quantum physics

A mathematical problem underlying fundamental questions in particle and quantum physics is provably unsolvable, according to scientists at UCL, Universidad Complutense de Madrid - ICMAT and Technical University of Munich.

It is the first major problem in physics for which such a fundamental limitation could be proven. The findings are important because they show that even a perfect and complete description of the microscopic properties of a material is not enough to predict its macroscopic behaviour.

A small spectral gap - the energy needed to transfer an electron from a low-energy state to an excited state - is the central property of semiconductors. In a similar way, the spectral gap plays an important role for many other materials. When this energy becomes very small, i.e. the spectral gap closes, it becomes possible for the material to transition to a completely different state. An example of this is when a material becomes superconducting.

Mathematically extrapolating from a microscopic description of a material to the bulk solid is considered one of the key tools in the search for materials exhibiting superconductivity at ambient temperatures or other desirable properties. A study, published today in Nature, however, shows crucial limits to this approach. Using sophisticated mathematics, the authors proved that, even with a complete microscopic description of a quantum material, determining whether it has a spectral gap is, in fact, an undecidable question. ...Read More...