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Device can theoretically trap a light 'bit' for an infinite amount of time

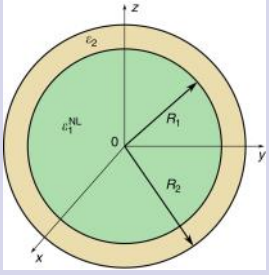
Researchers have designed a nanoscale device that, under ideal conditions, can confine a "bit" of light (that is, light with a single precise energy value) for an infinite amount of time. Although a physically realized device would inevitably lose some of the trapped light due to material imperfections, the researchers expect that it should be possible to completely compensate for this loss by incorporating some form of optical gain like that used in lasers, so that in principle the lifetime can be infinitely large even in a real device.

Sylvain Lannebère and Mário G. Silveirinha at the University of Coimbra in Portugal have published a paper on the new light-trapping device in a recent issue of Nature Communications.

As the researchers explain in their paper, previous research has confined light for finite periods of time using mirrors and specially engineered materials, but confining light indefinitely—even in theory—remains elusive.

"Light is an object difficult to tame," the researchers wrote in their paper. "No matter how elaborate and intricate are the material constructions that may be used to screen it from the exterior environment, there is always some residual coupling with the radiation continuum, and hence light—if not absorbed by the material walls—always finds its way out."

But now the scientists may have ...Read More...



The optical meta-atom has a core (with radius R1) and shell (with radius R2). Light of a specific wavelength (quantized energy) can be trapped inside the core. Credit: Lannebère , et al. CC-BY-4.0

Close-up view of galaxies prompts re-think on star formation

Astronomers have identified for the first time one of the key components of many stars, a study suggests. A type of gas found in the voids between galaxies - known as atomic gas - appears to be part of the star formation process under certain conditions, researchers say.

The findings overturn a long-standing theory about the conditions needed for star formation to take place - a process that happens when dense clouds of dust and gas inside galaxies collapse. It was previously thought that stars could form only in the presence of a different type of gas - called molecular gas.

Atomic gas is composed of individual hydrogen atoms. It is usually found in regions of space that do not contain any planets or stars and are largely empty, researchers say. Molecular gas is made up of pairs of hydrogen atoms bound together, and is present in the densest parts of galaxies, where most planets and stars form.

The new study, led by the University of Edinburgh, provides the first evidence that atomic gas can fuel star formation. This happens when atomic gas flows into galaxies but does not have time to convert to the molecular ...Read More...

File Image.

Lasers could rapidly make materials hotter than the Sun

Lasers could heat materials to temperatures hotter than the centre of the Sun in only 20 quadrillionths of a second, according to new research.

The method, proposed here for the first time, could be relevant to new avenues of research in thermonuclear fusion energy, where scientists are seeking to replicate the Sun's ability to produce clean energy.

The heating would be about 100 times faster than rates currently seen in fusion experiments using the world's most energetic laser system at the Lawrence Livermore National Laboratory in California. The race is now on for fellow scientists to put the team's method into practice.

Researchers have been using high-power lasers to heat material as part of the effort to create fusion energy for many years. In this new study, the physicists at Imperial were looking for ways to directly heat up ions – particles which make up the bulk of matter.

When lasers are used to heat most materials, the energy from the laser first heats up the electrons in the target. These in turn heat up the ions, making the process slower than targeting the ions directly.

The Imperial team discovered that when a high-intensity laser is fired at a certain type of material, it will create an electrostatic shockwave that can heat ions directly. Their discovery is published today in the journal Nature Communications. "It's a completely unexpected result. ...Read More...

File Image.

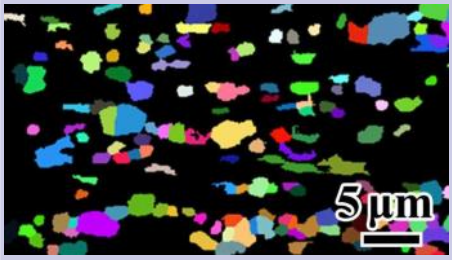
Researchers find way to make metals stronger without sacrificing ductility

Researchers at North Carolina State University and the Chinese Academy of Sciences have developed a technique to make titanium stronger without sacrificing any of the metal's ductility - a combination that no one has achieved before. The researchers believe the technique could also be used for other metals, and the advance has potential applications for creating more energy-efficient vehicles.

"Historically, a material is either strong or ductile, but almost never both at the same time," says Yuntian Zhu, a professor of materials science and engineering at North Carolina State University and co-corresponding author of a paper describing the work. "We've managed to get the best of both worlds. This will allow us to create strong materials for use in making lighter vehicles, but that are sufficiently ductile to prevent the material from suffering catastrophic failure under strain."

The key idea here is grain size, or the size of the crystals in the metal. Metals with a small grain size are stronger - meaning they can withstand more force before they start to deform. But metals with a small grain size are also less ductile, which means they can withstand less strain before breaking. Materials that aren't ductile won't bend or stretch much - they just snap. Conversely, metals with a large grain size are more ductile, but have lower strength.

The new technique manipulates the grain size to give the metal the strength of ...Read More...



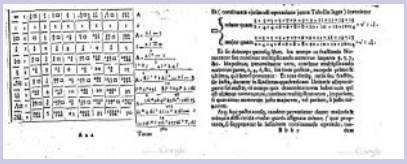
By creating a patchwork of large, soft-grained columns (shown here in multiple colors) in a harder, ultrafine-grained matrix (shown here in black), researchers have found a way to increase metal strength without sacrificing ductility. Credit: Yuntian Zhu, North Carolina State University

New derivation of pi links quantum physics and pure math

In 1655 the English mathematician John Wallis published a book in which he derived a formula for pi as the product of an infinite series of ratios. Now researchers from the University of Rochester, in a surprise discovery, have found the same formula in quantum mechanical calculations of the energy levels of a hydrogen atom.

"We weren't looking for the Wallis formula for pi. It just fell into our laps," said Carl Hagen, a particle physicist at the University of Rochester. Having noticed an intriguing trend in the solutions to a problem set he had developed for students in a class on quantum mechanics, Hagen recruited mathematician Tamar Friedmann and they realized this trend was in fact a manifestation of the Wallis formula for pi.

"It was a complete surprise - I jumped up and down when we got the Wallis formula out of equations for the hydrogen atom," said Friedmann. "The special thing is that it brings out a beautiful connection between physics and math. I find it fascinating that a purely mathematical formula from the 17th century characterizes a physical system that was discovered 300 years later." The researchers report their findings in the Journal of Mathematical Physics. In quantum mechanics, a technique called the variational approach can be used to approximate the energy states of quantum systems, like molecules, that can't be solved exactly. Hagen was ...Read More...



Two pages from the book "Arithmetica Infinitorum," by John Wallis. In the table on the left page, the square that appears repeatedly denotes 4/pi, or the ratio of the area of a square to the area of the circumscribed circle. Wallis used the table to obtain the inequalities shown at the top of the page on the right that led to his formula. Credit: Digitized by Google

NASA's Beach Ball Coronagraph

What's better at blocking sunlight: a traditional flat occulter disk or a beach ball? NASA scientist Phillip Chamberlin is putting his money on the latter. He and his team at NASA's Goddard Space Flight Center in Greenbelt, Maryland, now are developing a formation-flying CubeSat mission to study the sun's atmosphere or corona.

The path-finding mission would deploy a never-before-flown tennis ball-size titanium occulter, a device that blocks bright light. It would fly in formation with a CubeSat equipped with an imaging spectrograph that would study the sun's corona, and more particularly, coronal mass ejections. These gigantic bubbles of charged particles speed across the solar system and can disrupt electronics on low-Earth-orbiting satellites and damage terrestrial power grids when they slam into Earth's protective magnetosphere.

In particular, Chamberlin is interested in imaging and measuring the temperature and speeds of electrons that make up these violent outbursts using a technique that has never before flown in space.

Understanding How the Corona Evolves This data would improve scientists' understanding of how the corona evolves over time and perhaps what causes the coronal mass ejections, also known as CMEs. "Currently we can't predict them. We don't know the warning signs. We're like weather forecasters 50 years ago," Chamberlin said, adding the mission also could shed light into why the ...Read More...

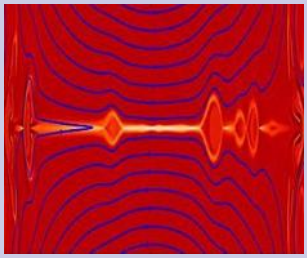
Principal Investigator Phillip Chamberlin holds a sphere coated in super-black carbon nanotubes. Image courtesy NASA/W. Hrybyk.

A new explanation for the explosive nature of magnetic reconnection

Magnetic reconnection, which occurs when magnetic lines of force break apart and reconnect with a violent burst of energy, gives rise to many beautiful and powerful phenomena in the natural world. These include solar flares, the Northern Lights, and geomagnetic storms that can disrupt cell-phone service or knock out power grids.

Scientists have long known that the Sweet-Parker model typically used to describe magnetic reconnection was unable to explain the speed at which it operates. Now, researchers have gone beyond the framework of that model to include new mechanisms that speed up reconnection, providing new insights into the process.

At the U.S. Department of Energy's Princeton Plasma Physics Laboratory (PPPL), researchers found that the Sweet-Parker model itself is flawed. To solve the problem, the researchers turned their attention to plasmoids - instabilities that occur in plasma containing the reconnecting lines of force - as the possible cause of fast reconnection (Figure 1). These instabilities take place very rapidly and change the predictions described by the Sweet-Parker model. The new model predicts a novel regime in ...Read More...



Model of a current sheet of plasma with magnetic field lines that are ready to reconnect showing plasmoid instabilities in the center of the sheet. Image courtesy of Yi-Min Huang.

Newfound Earth-size exoplanet may be an important milestone in search for alien life

Researchers have discovered an exoplanet just slightly bigger than Earth and located much closer to our Solar System than any other terrestrial, alien world. Called GJ 1132b, it orbits a tiny red, dwarf star just 39 light-years away. Though too hot for life, GJ 1132b is large relative to its close-by star, which nevertheless makes it an ideal planetary laboratory.

The exoplanet will likely be one of the first targets of the James Webb Space Telescope, Hubble's successor launching in 2018, thereby serving as a Rosetta Stone for future characterizations of small, potentially livable worlds.

"To get a really complete picture of what exo-worlds are like, we need to focus on nearby, transiting planets, such as GJ 1132b. We can measure their sizes and their masses, their orbits and their atmospheres," said Zachory Berta-Thompson, a Torres Fellow for Exoplanetary Research at the Massachusetts Institute of Technology's Kavli Institute for Astrophysics and Space Research (MKI).

Berta-Thompson is the lead author of Nature paper on GJ 1132b, published this week, and is part of the MEarth Project, which turned up GJ 1132b as it was monitoring nearby red dwarfs for exoplanet transits. He was one of three astrophysicists who spoke to The Kavli Foundation about the discovery, and what they may encounter when they get a closer look at the planet.

Although almost 2,000 exoplanets have been cataloged since astronomers found the first worlds around other stars in the ...Read More...

"GJ 1132b is three times closer to us than any other Earth-sized planet we know of, and it orbits a small red dwarf star that is just one-fifth the size of the Sun. So that's one of the reasons why this discovery is unique."

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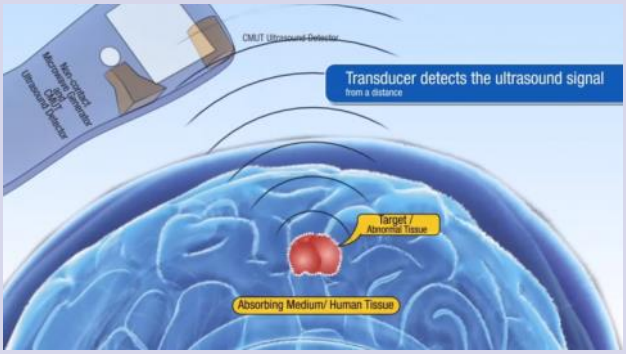
New "tricorder" technology might be able to "hear" tumors growing

When Dr. Leonard "Bones" McCoy needs to diagnose an ill member of the Starship Enterprise, he simply points his tricorder device at their body and it identifies their malady without probing or prodding. Similarly, when Capt. Kirk beams down to an alien world, his tricorder quickly analyzes if the atmosphere is safe to breathe.

Now Stanford electrical engineers have taken the latest step toward developing such a device through experiments detailed in Applied Physics Letters and presented at the International Ultrasonics Symposium in Taipei, Taiwan.

The work, led by Assistant Professor Amin Arbabian and Research Professor Pierre Khuri-Yakub, grows out of research designed to detect buried plastic explosives, but the researchers said the technology could also provide a new way to detect early stage cancers. The careful manipulation of two scientific principles drives ...Read More...



NIST team proves 'spooky action at a distance' is really real

Einstein was wrong about at least one thing: There are, in fact, "spooky actions at a distance," as now proven by researchers at the National Institute of Standards and Technology (NIST).

Einstein used that term to refer to quantum mechanics, which describes the curious behavior of the smallest particles of matter and light. He was referring, specifically, to entanglement, the idea that two physically separated particles can have correlated properties, with values that are uncertain until they are measured. Einstein was dubious, and until now, researchers have been unable to support it with near-total confidence.

As described in a paper posted online and submitted to Physical Review Letters (PRL), researchers from NIST and several other institutions created pairs of identical light particles, or photons, and sent them to two different locations to be measured. Researchers showed the measured results not only were correlated, but also—by eliminating all other known options—that these correlations cannot be caused by the locally controlled, "realistic" universe Einstein thought we lived in. This implies a different explanation such as ...Read More...

NIST physicist Krister Shalm with the photon source used in the 'Bell test' that strongly supported a key prediction of quantum mechanics: There are in fact 'spooky actions at a distance.' Credit: Burrus/NIST

UCLA professor proposes simpler way to define what makes a planet

Since the late 1980s, scientists have discovered nearly 5,000 planetary bodies orbiting stars other than the sun. But astronomers are still working on what exactly we should call them. At an American Astronomical Society meeting, UCLA professor Jean-Luc Margot described a simple test that can be used to clearly separate planets from other bodies like dwarf planets and minor planets.

The current official definition of a planet, which was issued by the International Astronomical Union in 2006, applies only to bodies in our solar system, which Margot said has created a "definitional limbo" for the newly discovered bodies. A paper by Margot that has been accepted for publication in the Astronomical Journal proposes to extend the planet definition to all planetary systems.

The new approach would require only estimates of the star's mass and the planet's mass and orbital period - all of which can be easily obtained with Earth- or space-based telescopes. ...Read More...

View of dwarf planet Ceres, based on images taken by NASA's Dawn spacecraft. Image courtesy NASA/Jet Propulsion Laboratory.