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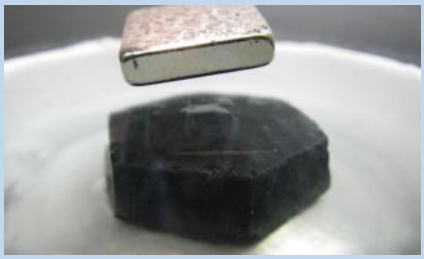
Inside this issue:

Physicists discover new properties of superconductivity

New findings from an international collaboration led by Canadian scientists may eventually lead to a theory of how superconductivity initiates at the atomic level, a key step in understanding how to harness the potential of materials that could provide lossless energy storage, levitating trains and ultra-fast supercomputers.

Professor David Hawthorn, Professor Michel Gingras, doctoral student Andrew Achkar, and post-doctoral fellow Dr. Zhihao Hao from University of Waterloo's Department of Physics and Astronomy have experimentally shown that electron clouds in superconducting materials can snap into an aligned and directional order called nematicity.

"It has become apparent in the past few years that the electrons involved in superconductivity can form patterns, stripes or checkerboards, and exhibit different symmetries - aligning preferentially along one direction," said Professor Hawthorn. "These patterns and symmetries have important consequences for superconductivity - they can compete, coexist or possibly even enhance superconductivity. "...Read More...

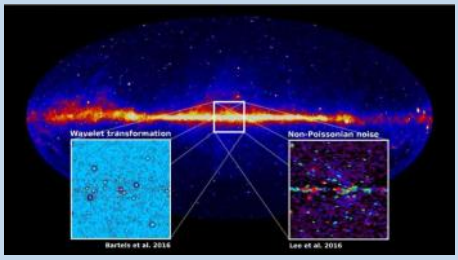


A magnet levitating above a cuprate high temperature superconductor. New findings from an international collaboration led by Canadian scientists may eventually lead to a theory of how superconductivity initiates at the atomic level, a key step in understanding how to harness the potential of materials that could provide lossless energy storage, levitating trains and ultra-fast supercomputers. Credit: Robert Hill/University of Waterloo

Galactic center's gamma rays unlikely to originate from dark matter, evidence shows

Bursts of gamma rays from the center of our galaxy are not likely to be signals of dark matter but rather other astrophysical phenomena such as fast-rotating stars called millisecond pulsars, according to two new studies, one from a team based at Princeton University and the Massachusetts Institute of Technology and another based in the Netherlands.

Previous studies suggested that gamma rays coming from the dense region of space in the inner Milky Way galaxy could be caused when invisible dark matter particles collide. But using new statistical analysis methods, the two research teams independently found that the gamma ray signals are uncharacteristic of those expected from dark matter. Both teams reported the finding in the journal Physical Review Letters this week...Read More...



Studies by two independent groups from the US and the Netherlands indicate that the observed excess of gamma rays from the inner galaxy likely comes from a new source rather than from dark matter. The best candidates are rapidly rotating neutron stars, which will be prime targets for future searches. The Princeton/MIT group and the Netherlands-based group used two different techniques, non-Poissonian noise and wavelet transformation, respectively, to independently determine that the gamma ray signals were not due to dark matter annihilation. Credit: Christoph Weniger

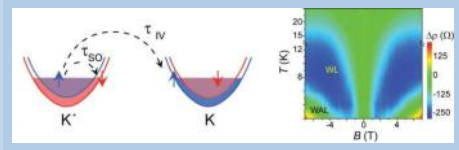
Spin dynamics in an atomically thin semi-conductor

Researchers at the National University of Singapore (NUS) and Yale-NUS College have established the mechanisms for spin motion in molybdenum disulfide, an emerging two-dimensional (2D) material. Their discovery resolves a research question on the properties of electron spin in single layers of 2D materials, and paves the way for the next generation of spintronics and low-power devices. The work was published online in the journal Physical Review Letters on 29 January 2016.

Molybdenum disulfide (MoS2), a class of transition metal dichalcogenide compounds, has attracted great attention due to wide recognition of its potential for manipulating novel quantum degrees of freedom such as spin and valley. Due to its unique material properties, a single layer of MoS2 has the potential to be used for spin transistors, where both electric current and spin current can be switched on and off independently. Despite this potential for application, there have not been any experimental studies on the mechanism for spin dynamics in MoS2.

To address this gap, scientists from the Centre for Advanced 2D Materials at NUS used highly precise measurements of the classical and quantum motion of electrons to extract information on how long spins live in this new material.

The team of scientists led by Assistant Professor Goki Eda, co-leader of this study who is from the NUS Department of Physics and Department of Chemistry, thinned down a crystal of molybdenite, a mineral of MoS2, to less than one nanometer. Here, the electrons live in a ...Read More...



The sketch shows scattering in the two valleys of MoS2 close to the conduction band by spin-orbit and intervalley scattering. While the first flips the spin orientation, the second changes valley with preserved spin. Very different scattering times result in the observed transition of weak antilocalisation to weak localization as experimentally observed in the magnetoresistance as function of temperature and magnetic field (right). Credit: Hennrik Schmidt

New invention revolutionizes heat transport

Scientists at Aalto University, Finland, have made a breakthrough in physics. They succeeded in transporting heat maximally effectively ten thousand times further than ever before. The discovery may lead to a giant leap in the development of quantum computers.

Heat conduction is a fundamental physical phenomenon utilized, for example, in clothing, housing, car industry, and electronics. Thus our day-to-day life is inevitably affected by major shocks in this field. The research group, led by quantum physicist Mikko Möttönen has now made one of these groundbreaking discoveries. This new invention revolutionizes quantum-limited heat conduction which means as efficient heat transport as possible from point A to point B. This is great news especially for the developers of quantum computers.

Quantum technology is still a developing research field, but its most promising application is the super-efficient quantum computer. In the future, it can solve problems that a normal computer can never crack. The efficient operation of a quantum computer requires that it can be cooled down efficiently. At the same time, a quantum computer is prone to errors due to external noise.

Möttönen's innovation may be utilized in cooling quantum processors very efficiently and so cleverly that the operation of the computer is not disturbed. ...Read More...

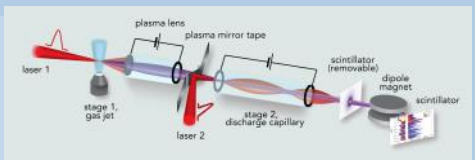
Artistic impression of quantum-limited heat conduction of photons over macroscopic distances. Credit: Heikka Valja

Coupling two 'tabletop' laser-plasma accelerators: A step toward ultrapowerful accelerators

Laser-plasma accelerators (LPAs) got the nickname "tabletop" because, as shown by the unique BELLA accelerator at the U.S. Department of Energy's Lawrence Berkeley National Laboratory (Berkeley Lab), they can boost electron beams to multibillion electron-volt energies (GeVs) in a few centimeters—a distance thousands of times shorter than conventional accelerators.

Past those few centimeters, however, the laser pulse weakens and energy gain stalls. LPAs will have to get off the tabletop if they are to rival proposed conventional colliders, such as 30-kilometer-long electron-positron linear colliders or circular proton colliders 100 kilometers in circumference, with electron-volt energies in the trillions (TeVs), not billions. Only by coupling a hundred LPAs in series, each powered by a BELLA-class laser in series, and accelerating a well-shaped beam from one stage to the next, will such high energies be achieved.

"Long before planning began for BELLA, we'd set our sights on staging as the way to achieve energies needed for compact particle colliders, free-electron lasers, and other tools of future science," says Wim Leemans, Director of Berkeley Lab's Accelerator Technology and Applied Physics Division (ATAP)and Director of the BELLA Center. But because of the daunting technical challenges, including maintaining electron ...Read More...



Schematic of the first experiment to achieve staging of laser plasma accelerators (LPAs) with independent laser pulses: a pulse from laser 1 (at left) creates a plasma wakefield in the stage 1 LPA, a gas jet. The resulting electron beam is focused by a capillary-discharge plasma lens and then penetrates a moving tape. Almost simultaneously, an incoming pulse from laser 2 strikes the tape and creates a plasma mirror, which combines the laser beam and electron beam. ….

The frigid Flying Saucer

The international team, led by Stephane Guilloteau at the Laboratoire d'Astrophysique de Bordeaux, France, measured the temperature of large dust grains around the young star 2MASS J16281370-2431391 in the spectacular Rho Ophiuchi star formation region, about 400 light-years from Earth.

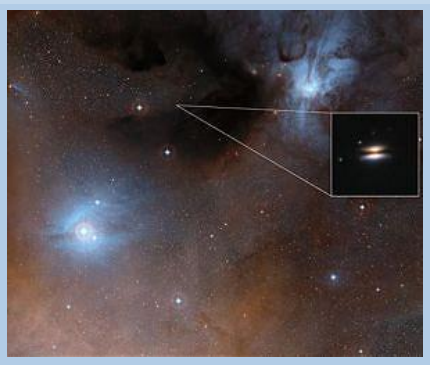
This star is surrounded by a disc of gas and dust - such discs are called protoplanetary discs as they are the early stages in the creation of planetary systems. This particular disc is seen nearly edge-on, and its appearance in visible light pictures has led to its being nicknamed the Flying Saucer.

The astronomers used the Atacama Large Millimeter/submillimeter Array (ALMA) to observe the glow coming from carbon monoxide molecules in the 2MASS J16281370-2431391 disc. They were able to create very sharp images and found something strange - in some cases they saw a negative signal! Normally a negative signal is physically impossible, but in this case there is an explanation, which leads to a surprising conclusion.

Lead author Stephane Guilloteau takes up the story: "This disc is not observed against a black and empty night sky. Instead it's seen in silhouette in front of the glow of the Rho Ophiuchi Nebula.

"This diffuse glow is too extended to be detected by ALMA, but the disc absorbs it. The resulting negative signal means that parts of the disc are colder than the background. The Earth is quite literally in the shadow of the Flying Saucer!"

The team combined the ALMA ...Read More...



The young star 2MASS J16281370-2431391 lies in the spectacular Rho Ophiuchi star formation region, about 400 light-years from Earth. It is surrounded by a disc of gas and dust -- such discs are called protoplanetary discs as they are the early stages in the creation of planetary systems. This particular disc is seen nearly edge-on, and its appearance in visible light pictures has led to its being nicknamed the Flying Saucer. The main image shows part of the Rho Ophiuchi region ...

NASA's James Webb Space Telescope Primary Mirror Fully Assembled

The 18th and final primary mirror segment is installed on what will be the biggest and most powerful space telescope ever launched. The final mirror installation Wednesday at NASA's Goddard Space Flight Center in Greenbelt, Maryland marks an important milestone in the assembly of the agency's James Webb Space Telescope.

"Scientists and engineers have been working tirelessly to install these incredible, nearly perfect mirrors that will focus light from previously hidden realms of planetary atmospheres, star forming regions and the very beginnings of the Universe," said John Grunsfeld, associate administrator for NASA's Science Mission Directorate in Washington. "With the mirrors finally complete, we are one step closer to the audacious observations that will unravel the mysteries of the Universe."

Using a robotic arm reminiscent of a claw machine, the team meticulously installed all of Webb's primary mirror segments onto the telescope structure. Each of the hexagonal-shaped mirror segments measures just over 4.2 feet (1.3 meters) across - about the size of a coffee table - and weighs approximately 88 pounds (40 kilograms). Once in space and fully ...Read More...

In this rare view, the James Webb Space Telescope's 18 mirrors are seen fully installed on the James Webb Space Telescope structure at NASA's Goddard Space Flight Center in Greenbelt, Maryland. Image courtesy NASA/Chris Gunn.

Pluto's Mysterious, Floating Hills

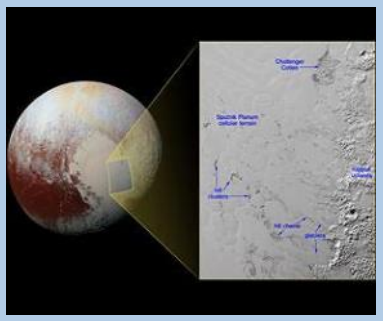
The nitrogen ice glaciers on Pluto appear to carry an intriguing cargo: numerous, isolated hills that may be fragments of water ice from Pluto's surrounding uplands. These hills individually measure one to several miles or kilometers across, according to images and data from NASA's New Horizons mission.

The hills, which are in the vast ice plain informally named Sputnik Planum within Pluto's 'heart,' are likely miniature versions of the larger, jumbled mountains on Sputnik Planum's western border. They are yet another example of Pluto's fascinating and abundant geological activity.

Because water ice is less dense than nitrogen-dominated ice, scientists believe these water ice hills are floating in a sea of frozen nitrogen and move over time like icebergs in Earth's Arctic Ocean. The hills are likely fragments of the rugged uplands that have broken away and are being carried by the nitrogen glaciers into Sputnik Planum. 'Chains' of the drifting hills are formed along the flow paths of the glaciers.

When the hills enter the cellular terrain of central Sputnik Planum, they become subject to the convective motions of the nitrogen ice, and are pushed to the edges of the cells, where the hills cluster in groups reaching up to 12 miles (20 kilometers) across.

At the northern end of the image, the feature informally named Challenger Colles - honoring the crew of the lost space shuttle Challenger - appears to be an especially large accumulation of these hills, measuring 37 by 22 miles (60 by 35 kilometers). This feature is ...Read More...



Hills of water ice on Pluto 'float' in a sea of frozen nitrogen and move over time like icebergs in Earth's Arctic Ocean-another example of Pluto's fascinating geological activity. Image courtesy NASA/JHUAPL/SwRI.

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Sharjah Center for Astronomy and Space Sciences. III - Cosmic Park

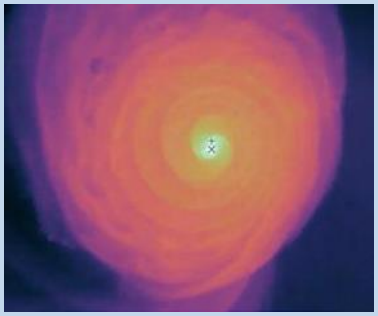
The cosmic park is a nice and beautiful representation of the Solar System as designed by his H.H. Dr. Sheikh Sultan al-Qasimi, ruler of Sharjah and President of the University of Sharjah. The large yellow dome represents the Sun. Around it, the planets are distributed to form a beautiful garden. From Mercury to Neptune, the visitor will find himself or herself sitting near any of the eight planets that make the solar system. This cosmic plunge is one of the main theme of SCASS. From the planetarium to the astronomical observatory, passing by the cosmic park, the Sharjah Center of Astronomy and Space Sciences, is the one place for everyone: to the scientist who runs the space labs and observatory, to the planetarium enthusiast who would like to be transported to the visible edges of the visible through the different digital shows, and to the lazy visitor looking for a nice green place to relax, SCASS is the one location. *(Images credit: R. Fernini)*

Turbulent times: When stars approach

When we look at the night sky, we see stars as tiny points of light eking out a solitary existence at immense distances from Earth. But appearances are deceptive. More than half the stars we know of have a companion, a second nearby star that can have a major impact on their primary companions.

The interplay within these so-called binary star systems is particularly intensive when the two stars involved are going through a phase in which they are surrounded by a common envelope consisting of hydrogen and helium.

Compared to the overall time taken by stars to evolve, this phase is extremely short, so astronomers have great difficulty observing and hence understanding it. This is where theoretical models with highly compute-intensive simulations come in. Research into this phenomenon is relevant understanding a number of stellar events such as supernovae. ...Read More...



The simulation video visualizes the evolution of the density during a time span of 105 days. As the core of the red giant and the companion draw closer together, the gravity between them releases energy that passes into the common envelope. The turbulent instabilities that occur during this phase become clearly evident. Image courtesy Sebastian Ohlmann / HITS.

Physicists investigate the structure of time, with implications for quantum mechanics and philosophy

Although in theory it may seem possible to divide time up into infinitely tiny intervals, the smallest physically meaningful interval of time is widely considered to be the Planck time, which is approximately 10^{-43} seconds. This ultimate limit means that it is not possible for two events to be separated by a time smaller than this.

But now in a new paper, physicists have proposed that the shortest physically meaningful length of time may actually be several orders of magnitude longer than the Planck time. In addition, the physicists have demonstrated that the existence of such a minimum time alters the basic equations of quantum mechanics, and as quantum mechanics describes all physical systems at a very small scale, this would change the description of all quantum mechanical systems. The researchers, Mir Faizal at the University of Waterloo and University of Lethbridge in Canada, Mohammed M. Khalil at Alexandria University in Egypt, and Saurya Das at the University of Lethbridge, have recently published a paper called "Time crystals from minimum time uncertainty" in The European Physical Journal C. ...Read More...

Credit: Vera Kratochvil/public domain