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Inside this issue:

Engineers demo first processor that uses light for ultrafast communications

Engineers have successfully married electrons and photons within a single-chip microprocessor, a landmark development that opens the door to ultrafast, low-power data crunching.

The researchers packed two processor cores with more than 70 million transistors and 850 photonic components onto a 3-by-6-millimeter chip. They fabricated the microprocessor in a foundry that mass-produces high-performance computer chips, proving that their design can be easily and quickly scaled up for commercial production.

The new chip, described in a paper to be published Dec. 24 in the print issue of the journal Nature, marks the next step in the evolution of fiber optic communication technology by integrating into a microprocessor the photonic interconnects, or inputs and outputs (I/O), needed to talk to other chips.

"This is a milestone. It's the first processor that can use light to communicate with the external world," said Vladimir Stojanović, an associate professor of electrical engineering and computer sciences at the University of ...Read More...

This packaged electronic-photonic processor microchip under illumination reveals the chip's primary features. The light rays emanating from the chip are drawn to show that the processor talks to the outside world using light. Credit: Glenn J. Asakawa, University of Colorado

Giant comets may threaten Earth: astronomers

Planet Earth could be at higher risk of a space rock impact than widely thought, according to astronomers who suggested Tuesday keeping a closer eye on distant giant comets.

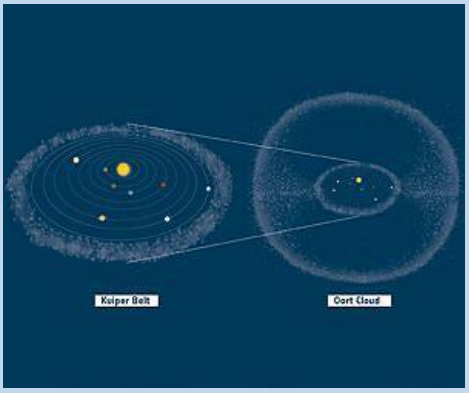
Most studies of potential Earth-smashers focus on objects in the asteroid belt roughly between Mars, Earth's outside neighbour, and Jupiter on its other flank, said the researchers.

But they noted that the discovery in the last two decades of hundreds of giant comets dubbed centaurs, albeit with much larger orbits, requires expanding the list of potential hazards.

These balls of ice and dust, typically 50-100 kilometres (31-62 miles) wide, have unstable, elliptical orbits that start way beyond Neptune, the most distant planet from the Sun.

Their paths cross those of the giant planets Jupiter, Saturn, Uranus and Neptune, whose gravity fields occasionally deflect a comet towards Earth -- once about every 40,000-100,000 years.

As they draw closer to the Sun, the comets would gradually break up, which is what causes the trademark cometary debris tail -- "making impacts on our planet inevitable". ...Read More...



File Image.

Choreographing the dance of electrons

Scientists at the National University of Singapore (NUS) have demonstrated a new way of controlling electrons by confining them in a device made out of atomically thin materials, and applying external electric and magnetic fields. This research, published on Dec. 23, 2015 in the prestigious scientific journal Nature, was led by Professor Antonio Castro Neto and his research team at the Centre for Advanced 2D Materials (CA2DM) of the NUS Faculty of Science.

Almost all modern technology like motors, light bulbs and semiconductor chips runs on electricity, harnessing the flow of electrons through devices. Explained Prof Castro Neto, "Not only are electrons small and fast, they naturally repel each other due to their electric charge. They obey the strange laws of quantum physics, making it difficult to control their motion directly."

To control electron behaviour, many semiconductor materials require chemical doping, where small amounts of a foreign material are embedded in the material to either release or absorb electrons, creating a change in the electron concentration that can in turn be used to drive currents.

However, chemical doping has limitations as a research technique, since it causes irreversible chemical change in the material being studied. The foreign atoms embedded into the material also disrupt its natural ordering, often masking important electronic states of the pure material.

The NUS research team was able ...Read More...

Without an electric field applied, the electrons (represented by the black figures) avoid each other (left). When an electric field is applied (represented by the jazz band), the electrons (represented by the black figures) pair up in a superconducting state and dance in harmony. Credit: National University of Singapore

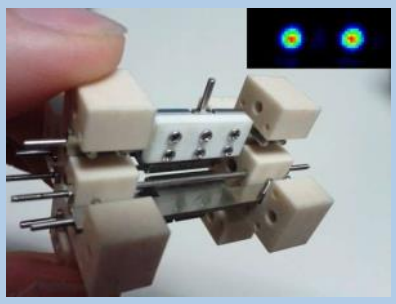
Team succeeds in observing a two-phonon quantum interference, a world first

A research group at Osaka University has succeeded in observing at the intended timing two -phonon quantum interference by using two cold calcium ions in ion traps, which spatially confine charged particles. A phonon is a unit of vibrational energy that arises from oscillating particles within crystals. Two-particle quantum interference experiments using two photons or atoms have been previously reported, but this group's achievement is the world's first observation using two phonons.

This group demonstrated that the phonon, a quantum mechanical description of an elementary vibrational motion in matter, and the photon, an elementary particle of light, share common properties. This group's research results will contribute to quantum information processing research, including quantum simulation using phonons and quantum interface research.

Ion traps are an important technique in physically achieving quantum information processing including quantum computation, and research on ion traps is being carried out all over the world, with Dr. David J. Wineland of the United States, a leading expert in the field, winning the Nobel Prize in Physics in 2012.

For this research, a team from Osaka University led by Shinji Urabe, Professor Emeritus, Kenji Toyoda, Assistant Professor, and Atsushi Noguchi (currently at the Research Center for Advanced Science and Technology, The University of Tokyo) used a laser to irradiate...Read More...

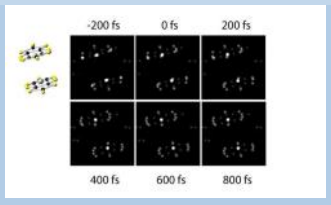


Ion trap and 2 ions (top right)

Short electron pulses make it possible to observe a structural change in a complex molecule as if watching a film

Chemistry is now ready for the movies: an international team which includes researchers from the Max Planck Institute for the Structure and Dynamics of Matter in Hamburg has used a type of molecular camera to follow a fast-moving ballet performed by atoms in molecules as they change their structure. The researchers use a comparatively compact, efficient and low-cost technology for the detailed and slow-motion observation of how the miniscule atoms move at a molecular transition in a complex material. As is the case with all chemical reactions where atoms change position, such structural transformations take place in a few 100 femtoseconds or even faster – a femtosecond is a millionth of a billionth of a second. Although femtochemistry is already using recording technology for chemical processes, this has so far only been possible with large and expensive installations in which only selected research projects can be undertaken.

"Just imagine you could observe how atoms move during a chemical process," says chemistry professor Dwayne Miller enthusiastically. The Director, who hails from Canada, and his team at the Max Planck Institute for the Structure and Dynamics of Matter have been working on ...Read More...



A molecular movie: the individual frames show how each individual atom in Pt(dmit)2 molecules moves within a few 100 femtoseconds (fs) while Me4P[Pt(dmit)2]2 is switched from the insulating state to the metallic, conducting state with the aid of laser light. The illustration on the left shows the original structure: grey - platinum, black - carbon, yellow - sulphur. Credit: Science 2015/MPI for the Structure and Dynamics of Matter

Auroral mystery solved: Sudden bursts caused by swirling charged particles

Auroras are dimly present throughout the night in polar regions, but sometimes these lights explode in brightness. Now Japanese scientists have unlocked the mystery behind this spectacle, known as auroral breakup.

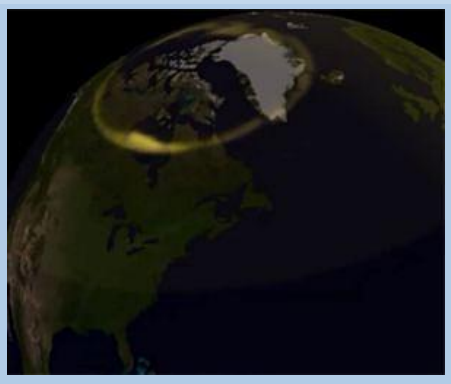
For years, scientists have contemplated what triggers the formation of auroral substorms and the sudden bursts of brightness. Appearing in the Journal of Geophysical Research, the current study overthrows existing theories about the mechanism behind this phenomenon.

The Kyoto-Kyushu research team has revealed that hot charged particles, or plasmas, gather in near-Earth space - just above the upper atmosphere of the polar region - when magnetic field lines reconnect in space. This makes the plasma rotate, creating a sudden electrical current above the polar regions.

Furthermore, an electric current overflows near the bright aurora in the upper atmosphere, making the plasma rotate and discharge the extra electricity. This gives rise to the "surge", the very bright sparks of light that characterize substorms.

"This isn't like anything that us space physicists had in mind," said study author Yusuke Ebihara of Kyoto University. Ebihara based the study on a supercomputer simulation program developed by Takashi Tanaka, professor emeritus at Kyushu University.

Auroras originate from plasma from the sun, known as the solar wind. In the 1970s, scientists discovered that when this plasma approaches the Earth together with magnetic fields, it triggers a change in the Earth's magnetic field lines on the dayside ...Read More...



A Japanese research team has solved how auroral breakups occur. Hot charged particles, or plasmas, gather in near-Earth space -- just above the upper atmosphere of the polar region -- when magnetic field lines reconnect in space. This makes the plasma rotate, creating a sudden electrical current above the polar regions. Furthermore, an electric current overflows near the bright aurora in the upper atmosphere, making …..

NASA suspends March launch of InSight mission to Mars

NASA has suspended the March 2016 launch of its InSight mission to Mars because of problems with a key scientific component, the US space agency said Tuesday.

The next launch window will not occur until around May 2018 and NASA said it does not yet know if it will be able to continue with the mission given budget constraints.

The InSight lander was set to delve deep beneath the Red Planet's surface in order to discover how the solar system's rocky planets formed.

"Learning about the interior structure of Mars has been a high priority objective for planetary scientists since the Viking era," said John Grunsfeld, associate administrator for NASA's Science Mission Directorate in Washington.

"We push the boundaries of space technology with our missions to enable science, but space exploration is unforgiving, and the bottom line is that we're not ready to launch in the 2016 window," he said in a statement.

The problematic instrument is a seismometer provided by France's Centre National d'Etudes Spatiales (CNES), designed to measure ground movements as small as the diameter of an atom.

"It's a hard blow," CNES president Jean-Yves Le Gall told AFP. ...Read More...

File photo of Insight being assembled.

Chandra Finds Remarkable Galactic Ribbon Unfurled

An extraordinary ribbon of hot gas trailing behind a galaxy like a tail has been discovered using data from NASA's Chandra X-ray Observatory. This ribbon, or X-ray tail, is likely due to gas stripped from the galaxy as it moves through a vast cloud of hot intergalactic gas. With a length of at least 250,000 light years, it is likely the largest of such a tail ever detected.

The tail is located in the galaxy cluster Zwicky 8338, which is almost 700 million light years from Earth. The length of the tail is more than twice the diameter of the entire Milky Way galaxy. The tail contains gas at temperatures of about ten million degrees, about twenty million degrees cooler than the intergalactic gas, but still hot enough to glow brightly in X-rays that Chandra can detect.

The researchers think the tail was created as a galaxy known as CGCG254-021, or perhaps a group of galaxies dominated by this large galaxy, plowed through the hot gas in Zwicky 8338. The pressure exerted by this rapid motion caused gas to be stripped away from the galaxy.

Galaxy clusters are the largest structures in the Universe held together by gravity. They consist of hundreds, or even thousands, of galaxies, enormous pools of hot gas, and vast amounts of unseen dark matter.

"Since galaxy clusters are so enormous, they play a critical role in understanding how our Universe evolves," said Gerrit Schellenberger of the University of Bonn in Germany, who led the study. "To understand galaxy clusters we need to understand how their ...Read More...

The researchers think the tail was created as a galaxy known as CGCG254-021, or perhaps a group of galaxies dominated by this large galaxy, plowed through the hot gas in Zwicky 8338. Image courtesy X-ray: NASA/CXC/University of Bonn/G. Schellenberger et al; Optical: INT.

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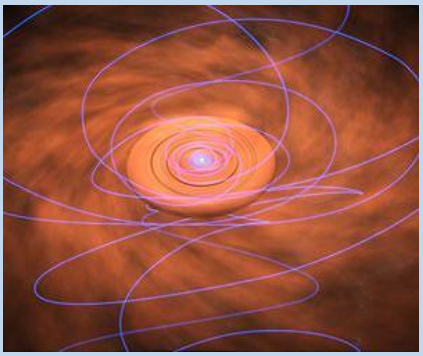
Twisted magnetic fields give new insights on star formation

Using new images that show unprecedented detail, scientists have found that material rotating around a very young protostar probably has dragged in and twisted magnetic fields from the larger area surrounding the star.

The discovery, made with the National Science Foundation's Karl G. Jansky Very Large Array (VLA) radio telescope, has important implications for how dusty disks - the raw material for planet formation - grow around young stars.

The scientists studied a young protostar about 750 light-years from Earth in the constellation Perseus. Their observations, made in 2013 and 2014, measured the alignment, or polarization, of radio waves emitted by material, mostly dust, falling into a burgeoning disk orbiting the young star. ...Read More...



Magnetic field lines (purple) are twisted as they are dragged inward toward a swirling, dusty disk surrounding a young star in this artist's conception. Image courtesy Bill Saxton, NRAO/AUI/NSF.

Physicists continue to investigate why the universe did not collapse

According to the best current physics models, the universe should have collapsed shortly after inflation—the period that lasted for a fraction of a second immediately after the Big Bang.

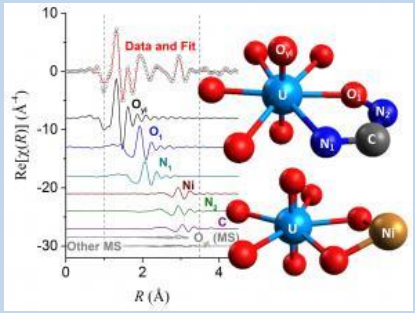
The problem lies in part with Higgs bosons, which were produced during inflation and which explain why other particles have the masses that they do. Previous research has shown that, in the early universe, the Higgs field may have acquired large enough fluctuations to overcome an energy barrier that caused the universe to transition from its standard vacuum state to a negative energy vacuum state, which would have caused the universe to quickly collapse in on itself. In a new paper published in Physical Review Letters, Matti Herranen at the University of Copenhagen and coauthors may have come a step closer to solving the problem by constraining the strength of the coupling between the Higgs field and gravity, which is the last unknown parameter of the standard model.

As the physicists explain, the stronger the Higgs field ...Read More...

This is the "South Pillar" region of the star-forming region called the Carina Nebula. Like cracking open a watermelon and finding its seeds, the infrared telescope "busted open" this murky cloud to reveal star embryos tucked inside finger-like pillars of thick dust. Credit: NASA

Technique could set new course for extracting uranium from seawater

An ultra-high-resolution technique used for the first time to study polymer fibers that trap uranium in seawater may cause researchers to rethink the best methods to harvest this potential fuel for nuclear reactors.
The work of a team led by Carter Abney, a Wigner Fellow at the Department of Energy's Oak Ridge National Laboratory, shows that the polymeric adsorbent materials that bind uranium behave nothing like scientists had believed. The results, gained through collaboration with the University of Chicago and detailed in a paper published in Energy & Environmental Science, highlight data made possible with X-ray Absorption Fine Structure spectroscopy performed at the Advanced Photon Source. The APS is a DOE Office of Science User Facility at Argonne National Laboratory.
"Despite the low concentration of uranium and the presence of many other metals extracted from seawater, we were able to investigate the local atomic environment around uranium and better ...Read More...



Using high-energy X-rays, researchers discovered uranium is bound by adsorbent fibers in an unanticipated fashion. Source: OKNL