INTERNATIONAL YEAR OF LIGHT 2015

100 Million Stars in the Andromeda galaxy.

June 20, 2015
Ramadhan 03, 1436
Volume 5, Issue 25

Astronomy & Physics News

Department of Physics—United Arab Emirates University
Weekly news from around the world compiled by Dr. Ilias Fernini

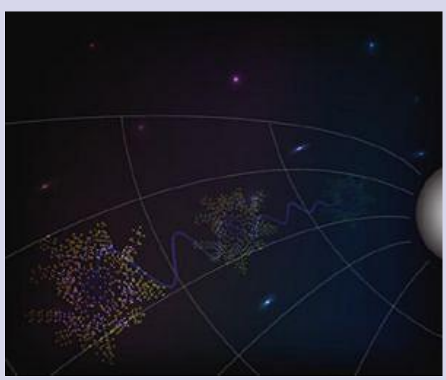
Inside this issue:

Einstein saves the quantum cat

In 1915 Albert Einstein formulated the theory of general relativity which fundamentally changed our understanding of gravity. He explained gravity as the manifestation of the curvature of space and time. Einstein's theory predicts that the flow of time is altered by mass. This effect, known as "gravitational time dilation", causes time to be slowed down near a massive object.

It affects everything and everybody; in fact, people working on the ground floor will age slower than their colleagues a floor above, by about 10 nanoseconds in one year. This tiny effect has actually been confirmed in many experiments with very precise clocks.

Now, a team of researchers from the University of Vienna, Harvard University and the University of Queensland have discovered that the slowing down of time can explain another perplexing phenomenon: the transition from ...***Read More***...



This is an illustration of a molecule in the presence of gravitational time dilation. The molecule is in a quantum superposition of being in several places at the same time, but time dilation destroys this quantum phenomenon. Image courtesy Igor Pikovski, Harvard-Smithsonian Center for Astrophysics.

What's on the surface of a black hole?

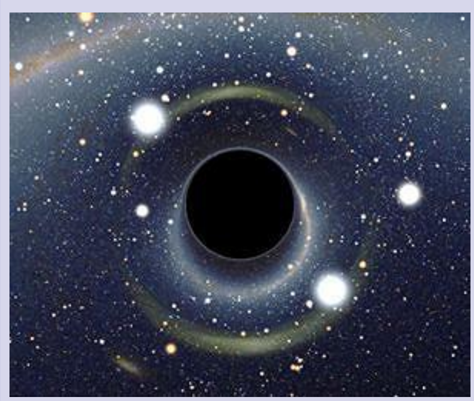
Are black holes the ruthless killers we've made them out to be? Samir Mathur says no. According to the professor of physics at The Ohio State University, the recently proposed idea that black holes have "firewalls" that destroy all they touch has a loophole.

In a paper posted online to the arXiv preprint server [arXiv:1506.04342], Mathur takes issue with the firewall theory, and proves mathematically that black holes are not necessarily arbiters of doom. In fact, he says the world could be captured by a black hole, and we wouldn't even notice.

More than a decade ago, Mathur used the principles of string theory to show that black holes are actually tangled-up balls of cosmic strings. His "fuzzball theory" helped resolve certain contradictions in how physicists think of black holes.

But when a group of researchers recently tried to build on Mathur's theory, they concluded that the surface of the fuzzball was actually a firewall.

According to the firewall theory, the surface of the fuzzball is deadly. In fact, the ...***Read More***...



Simulated view of a black hole by Alain Riazuelo of the French National Research Agency.

Nanoparticles to kill cancer cells with heat

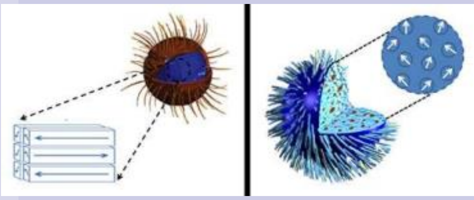
Heat may be the key to killing certain types of cancer, and new research from a team including National Institute of Standards and Technology (NIST) scientists has yielded unexpected results that should help optimize the design of magnetic nanoparticles that can be used to deliver heat directly to cancerous tumors.

When combined with other treatments such as radiotherapy or chemotherapy, heat applied directly to tumors helps increase the effectiveness of those types of treatments, and it reduces the necessary dose of chemicals or radiation.

This is where magnetic nanoparticles come in. These balls of iron oxide, just a few tens of nanometers in diameter, heat up when exposed to a powerful magnetic field. Their purpose is to bring heat directly to the tumors. Materials research, performed in part at the NIST Center for Neutron Research (NCNR), revealed magnetic behavior that proved counterintuitive to the scientific team—a finding that will affect which particles are chosen for a particular treatment.

Choosing the right kind of particles is important because, depending on their structure, they deliver a different dose of heat to the cancer. Some heat up quickly at first, while others require a stronger magnetic field to get going but ultimately deliver more heat.

"You want to design your ...***Read More***...



Iron oxide nanoparticles with a neatly-stacked internal structure (left) need a stronger magnetic field than expected to heat up, while those with a more haphazard arrangement heat up more quickly, even under a weak field. The findings, which run contrary to expectations, could affect which nanoparticles are chosen to treat certain types of cancer. Credit: NIST

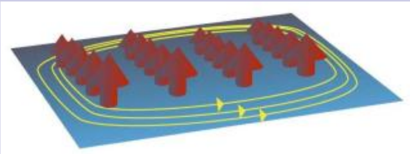
Researchers predicted existence of new quantum matter theoretically

Finland's Aalto University researchers have theorized that superconducting surfaces can become topological superconductors when magnetic iron atoms are deposited on the surface in a regular pattern. They used the latest mathematical and physical models to predict the existence of a topological superconducting state on metallic superconducting surfaces and thin films. The results were recently published in the Physical Review Letters science journal.

The work examines the properties of superconductors in low temperatures. The results are important in the search for new quantum states and possible use in future electronics applications.

'We know that in a quantum state, electric current moves without resistance on the surfaces of superconducting metals. This is an interesting phenomenon that we wanted to study in more detail. Topological superconductors differ from normal ones in that they have a current constantly moving around their edges. This current contains exotic particles called Majorana fermions. We obtained reliable signals from these particles in tests performed at the end of last year,' explains Academy Research Fellow Teemu Ojanen from the Aalto University Low Temperature Laboratory in Finland.

'The edges of a topologically superconducting surface are unidirectional, and thus the ...***Read More***...



The state of the topological superconductor predicted by researchers on the surface. The red arrows show magnetic atoms, such as iron, which form a regular structure on the surface of the superconducting metal. The topological superconducting area is surrounded by unidirectional edge states

Graphene heat-transfer riddle unraveled

Researchers have solved the long-standing conundrum of how the boundary between grains of graphene affects heat conductivity in thin films of the miracle substance, bringing developers a step closer to engineering films at a scale useful for cooling microelectronic devices and hundreds of other nanotech applications.

The study, by researchers at the Univ. of Illinois at Chicago, the Univ. of Massachusetts-Amherst and Boise State Univ., is published online in Nano Letters.

Since its discovery, graphene has attracted intense interest for its phenomenal ability to conduct heat and electricity. Virtually every nanotech device could benefit from graphene's extraordinary ability to dissipate heat and optimize electronic function, says Poya Yasaei, UIC graduate student in mechanical and industrial engineering and first author on the paper.

In a two-year, multidisciplinary investigation, the researchers developed a technique to measure heat transfer across a single grain boundary—and were surprised to find that it was an order of magnitude—a full 10 times—lower than the theoretically predicted value. They then devised computer models that can explain the surprising observations from the atomic level to the device level.

Graphene films for nanotech applications are made up of many tiny graphene crystals, says Amin Salehi-Khojin, UIC assistant professor of mechanical and industrial engineering and principal investigator on the study. Producing films .***Read More***...

Amin Salehi-Khojin, assistant professor of mechanical/industrial engineering. Photo: UIC Photo Services

Lab mimicry opens a window to the deep interiors of stars and planets

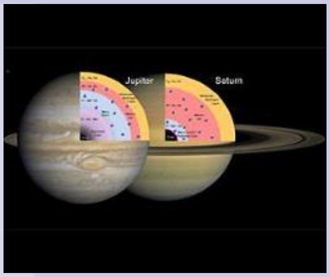
The matter that makes up distant planets and even-more-distant stars exists under extreme pressure and temperature conditions. This matter includes members of a family of seven elements called the noble gases, some of which--such as helium and neon--are household names.

New work from a team of scientists led by Carnegie's Alexander Goncharov used laboratory techniques to mimic stellar and planetary conditions, and observe how noble gases behave under these conditions, in order to better understand the atmospheric and internal chemistry of these celestial objects. Their work is published the week of June 15 by Proceedings of the National Academy of Sciences.

The team used a diamond-anvil cell to bring the noble gases helium, neon, argon, and xenon to more than 100,000 times the pressure of Earth's atmosphere (15-52 gigapascals), and used a laser to heat them to temperatures ranging up to 50,000 degrees Fahrenheit (about 28,000 degrees Kelvin).

The gases are called "noble" due to a kind of chemical aloofness; they normally do not combine, or "react," with other elements. Of particular interest were changes in the gases' ability to conduct electricity as the pressure and temperature changed, because this can provide important information about the ways that the noble gases do actually interact with other materials in the extreme conditions of planetary interiors and stellar atmospheres.

Insulators are materials that are unable to conduct the flow of electrons that make up an electric current. Conductors, or metals, are materials that can maintain an electrical current. Nobel gases are not normally conductive at ambient pressures, but conductivity can be induced under higher pressures….***Read More***….



Goncharov, McWilliams, and the rest of the team's work on noble gases could help solve the mystery of why Saturn emits more heat from its interior than would be expected. In Jupiter and Saturn, helium would be insulating near the surface and turn metal-like at depths close to both ...

Cosmic ray observatory to expand

Physicists plan a $6.4 million expansion of the $25 million Telescope Array observatory in Utah so they can zero in on a "hotspot" that seems to be a source of the most powerful particles in the universe: ultrahigh-energy cosmic rays. Japan will contribute $4.6 million and University of Utah scientists will seek another $1.8 million to nearly quadruple the size of the existing 300-square-mile cosmic ray observatory in the desert west of Delta, Utah. The expansion will allow the next step aimed at identifying what objects in space produce ultrahigh-energy cosmic rays - subatomic particles so energetic that just one would feel like a lead brick if it hit your foot or a fast-pitched baseball to the skull. Luckily, they don't get through Earth's atmosphere. "The question has been staring us in the face for 40 years," says Pierre Sokolsky, a University of Utah distinguished professor of physics and astronomy and principal investigator on the Telescope Array's current National Science Foundation grant.

"We know these particles exist, we know that they are coming from outside our galaxy and we really don't have a clue as to how nature pumps that much energy into them," Sokolsky adds. "In order to have a clue, we need to know where they are coming from. This hotspot is our first hint. We need to work with ...***Read More***...

This time-lapse photo shows the Middle Drum fluorescence detector station at the sprawling $25 million Telescope Array cosmic ray observatory near Delta, Utah. The current observatory includes three such telescope stations, which contain mirrors to detect faint blue flashes in the sky when an incoming cosmic ray hits gas in the atmosphere.

Brightest galaxy and first-generation stars

The newly found galaxy, labelled CR7, is three times brighter than the brightest distant galaxy known up to now. It may contain some of the first stars.

Astronomers using the Very Large Telescope of the European Southern Observatory (ESO) have discovered by far the brightest galaxy yet found in the early universe. They also say they have strong evidence that this galaxy contains some of the first generation of stars. Astronomers have been seeking these stars, which would have been massive, brilliant and the creators of the first heavy elements in history — the elements necessary to forge the stars around us today, the planets that orbit them, our human bodies and all the material things we see around us.

ESO said in a statement on June 16, 2015:

Astronomers have long theorised the existence of a first generation of stars — known as Population III stars — that were born out of the primordial material from the Big Bang. All the heavier chemical elements — such as oxygen, nitrogen, carbon and iron, which are essential to life — were forged in the bellies of stars. This means that the first stars must have formed out of the only elements to exist prior to stars: hydrogen, helium and trace amounts of lithium.

These Population III stars would have been enormous — several hundred or even a thousand times more massive than the Sun — blazing hot, and transient — exploding as supernovae after only about two million years. But until now the search for physical proof of their existence had been ..***Read More***...

Artist's concept of CR7, a very distant galaxy and by far the brightest galaxy yet found in the early universe. There is strong evidence that examples of the first generation of stars lurk within it. Image via ESO.

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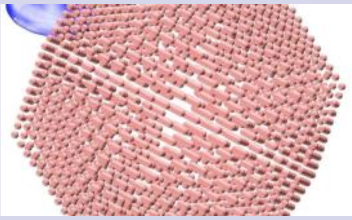
3D potential through laser annihilation

Whether in the pages of H.G. Wells, the serial adventures of Flash Gordon, or that epic science fiction saga that is Star Wars, the appearance of laser beams—or rays or phasers or blasters—ultimately meant the imminent disintegration of our hero or perhaps something a little larger, say, an entire planet.

Today we recognize the laser is reality beyond science fiction, used in targeted surgeries, precision manufacturing and in the exploration of materials at the nanoscale. Yet, harnessing the once-fabled destructive capabilities of certain lasers is proving invaluable on the path toward scientific discovery.

The x-ray electron-free laser (XFEL) is the perfect example of new technology and old perceptions converging on that narrow boundary between science and science fiction. Firing pulses of a trillion x-ray photons at molecular-sized samples in time scales on the order of million-billionths of a second (femtoseconds), researchers are aiming for the Holy Grail of ultra-fast X-ray Science – single-particle 3D imaging with atomic resolution.

Understanding the effects that these ultra-intense x-ray pulses will have on their potential targets will take the team work of Argonne National Laboratory's Advanced Photon Source ...***Read More***...



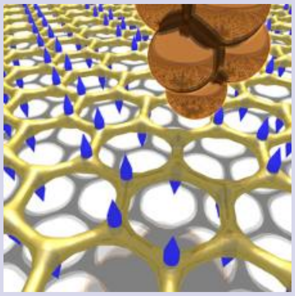
An intense Gaussian-shaped x-ray pulse (transparent blue shape) has just passed through a cluster of Argon atoms (pink spheres). Credit: Phay Ho, Chris Knight and Linda Young, Argonne National Laboratory

Hooked on phonons

An international research group led by scientists at NIST's Center for Nanoscale Science and Technology has developed a method for measuring crystal vibrations in graphene. Understanding these vibrations is a critical step toward controlling future technologies based on graphene.

They report their findings in Physical Review Letters. Carbon atoms in graphene sheets are arranged in a regularly repeating honeycomb-like lattice—a two-dimensional crystal. Like other crystals, when enough heat or other energy is applied, the forces that bond the atoms together cause the atoms to vibrate and spread the energy throughout the material, akin to how the vibration of a violin's string resonates throughout the body of the violin when played.

And just like every violin has its own unique character, each material vibrates at unique frequencies. The collective vibrations, which have frequencies in the terahertz-range (a billion billion oscillations per second), are called phonons...***Read More***...



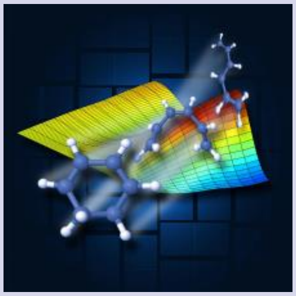
Tunneling electrons from a scanning tunneling microscope tip excites phonons in graphene. The image shows the graphene lattice with blue arrows indicating the motion direction of that carbon atoms for one of the low energy phonon modes in graphene. Image: Wyrick/NIST

New 'molecular movie' reveals ultrafast chemistry in motion

Scientists for the first time tracked ultrafast structural changes, captured in quadrillionths-of-a-second steps, as ring-shaped gas molecules burst open and unraveled. Ring-shaped molecules are abundant in biochemistry and also form the basis for many drug compounds. The study points the way to a wide range of real-time X-ray studies of gas-based chemical reactions that are vital to biological processes.

Researchers working at the Department of Energy's SLAC National Accelerator Laboratory compiled the full sequence of steps in this basic ring-opening reaction into computerized animations that provide a "molecular movie" of the structural changes.

Conducted at SLAC's Linac Coherent Light Source, a DOE Office of Science User Facility, the pioneering ...***Read More***...



Shape changes that occur in quadrillionths-of-a-second intervals in a ring-shaped molecule that was broken open by light. The molecular motion was measured using SLAC's Linac Coherent Light Source X-ray laser. The colored chart shows a theoretical model of molecular changes that syncs well with the actual results. The squares in the background represent panels in an LCLS X-ray detector. Credit: SLAC National Accelerator Laboratory