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Astronomy & Physics News

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

100 Million Stars in the Andromeda galaxy.

Inside this issue:

Revealing secrets of atomic nuclei

Individual protons and neutrons in atomic nuclei turn out not to behave according to the predictions made by existing theoretical models. This surprising conclusion, reached by an international team of physicists including staff members from the Faculty of Physics at the University of Warsaw (UW), forces us to reconsider how we have been describing large atomic nuclei for the past several decades.

Atomic nuclei shape the nature of our reality: around 99.9% of the mass of all matter is contained within them. Yet in spite of their ubiquity and significance, they still remain relatively poorly understood by contemporary physics. The main barrier to formulating a consistent theoretical description of atomic nuclei is the complexity of the interactions between their component particles, namely protons and neutrons. The situation becomes even more complicated when the nucleus contains a high number of particles. Writing in the prestigious physics journal Physical Review Letters, a team of scientists from Poland (UW Faculty of Physics), Finland and Sweden have demonstrated that we have to modify the existing model of atomic nuclei containing a significant and almost magic number of both protons and neutrons...***Read More***...

Individual proton or neutron in outermost shell of large atomic nucleus turns out not to behave according to the predictions made by existing theoretical models. This surprising conclusion was reached by an international team of physicists including staff members from the Faculty of Physics at the University of Warsaw. Credit: ©Faculty of Physics, University of Warsaw

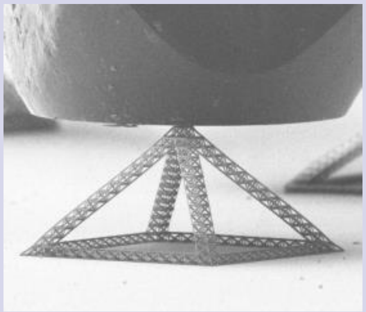
The importance of building small things

Strong materials, such as concrete, are usually heavy, and lightweight materials, such as rubber (for latex gloves) and paper, are usually weak and susceptible to tearing and damage. Julia R. Greer, professor of materials science and mechanics in Caltech's Division of Engineering and Applied Science, is helping to break that linkage.

Q: What do you do?

A: I'm a materials scientist, and I work with materials whose dimensions are at the nanoscale. A nanometer is one-billionth of a meter, or about one-hundred-thousandth the diameter of a hair. At those dimensions, ordinary materials such as metals, ceramics, and glasses take on properties quite unlike their bulk-scale counterparts. Many materials become 10 or more times stronger. Some become damage-tolerant. Glass shatters very easily in our world, for example, but at the nanoscale, some glasses become deformable and less breakable. We're trying to harness these so-called size effects to create "meta-materials" that display these properties at scales we can see.

We can fabricate essentially any structure we like with the help of a special instrument that is like a tabletop microprinter, but uses laser pulses to "write" a three-dimensional ...***Read More***...



A fractal nanotruss made in Greer's lab. Credit: Lucas Meza, Greer lab/Caltech

Reversible solid-to-liquid phase transition offers new way to synthesize crystals

The simple acts of heating and cooling affect different substances in different ways: some substances may change phase from solid to liquid to gas, while others may irreversibly break down when heat is applied. In a new study, scientists have investigated how changes in temperature affect a class of inorganic-organic hybrid crystals called coordination polymers (CPs), and show that, for some of them, the reversible solid-to-liquid phase transition can serve as an alternative way to synthesize and process these valuable materials.

The researchers, led by Satoshi Horike at Kyoto University and PRESTO (the Japan Science and Technology Agency) and Susumu Kitagawa at Kyoto University, have published their paper on reversible phase transitions in CP crystals in a recent issue of the Journal of the American Chemical Society.

The general molecular structure of CPs consists of a central metal ion surrounded by organic molecules called ligands. These units are then bonded together by the ligands to form large networks. This arrangement leads to a variety of interesting magnetic, optical, and electrical properties. As a result, CPs have many diverse applications, such as in dyes, lighting, gas storage, and catalysis.

So far, however, not much is known about the reversible solid-to-liquid phase transition of these materials, which is partly due to the fact that most CPs do not melt but irreversibly ..***Read More***...

Scientists have discovered that some coordination polymers (CPs) undergo a reversible solid-liquid phase transition as the temperature changes. Shown here are the crystalline (solid) state, the molten (liquid) state, and the glassy (supercooled) state of a CP. Credit: Umeyama, et al. ©2015 American Chemical Society

The Wild West of physics

Call it macro-micro physics: the study of the huge paired with the study of the very, very small.

In a new National Science Foundation-funded project, University at Buffalo physicists are looking to bridge the gap between two related but distinctive fields: the study of "outer space" (stars and galaxies) and "inner space" (fundamental particles and forces).

That description is from UB Professor Will Kinney, one of the three scientists involved. His partners on the research are Associate Professor Dejan Stojkovic, the principal investigator, and Professor Doreen Wackeroth.

To explain their project further: In the moments after the Big Bang, when the universe was young, it was an incredibly hot, dense soup of matter and energy.

Today, physicists can study this unique time in history by creating a similar environment inside giant machines called particle accelerators, which slam teeny-tiny protons into one another to create even smaller particles. The accelerators are like a "time machine," enabling scientists to study the conditions of the baby universe, Wackeroth says.

This is just one way in which research on the huge (cosmology) and the miniscule (subatomic particles and particle acceleration) are connected.

Taken together, the two fields could provide answers to some of the most important questions in physics today: How did our universe begin? How do gravity and quantum mechanics ...***Read More***...

The Compact Muon Solenoid (CMS) pixel detector. The CMS is used to detect particles generated by collisions at the Large Hadron Collider particle accelerator. A University at Buffalo team is working to connect findings from particle acceleration experiments to findings in cosmology. Credit: CERN

Graphene brings quantum effects to electronic circuits

Research by scientists attached to the EC's Graphene Flagship has revealed a superfluid phase in ultra-low temperature 2D materials, creating the potential for electronic devices which dissipate very little energy.

At the atomic and molecular scales, the world can be a very strange place, with everyday notions of temperature, energy and physical coherence thrown into disarray. With reality at the quantum level we must talk of statistical likelihood and probability rather than simple billiard ball cause and effect.

Take the concept of superfluidity, an ultra-cold state in which matter acts as a fluid with zero viscosity. You can think of superfluidity as a generalised thermodynamic analogue of the more commonly understood electrical superconductivity, whereby electrons move through materials without resistance and energy loss.

Superfluidity was first discovered in liquid helium, at temperatures of just a few degrees above absolute zero, but the phenomenon is evident at scales ranging from the atomic to the cosmic. It is related to the state of matter known as a Bose-Einstein condensate, in which a large fraction of the particles in bulk matter occupy the lowest quantum energy state.

The particles, which at higher temperatures move around in a random, haphazard fashion, can in this way behave as a coherent or at least quasi-coherent whole, thus bringing quantum-mechanical effects into macroscopic visibility.

Fascinating if somewhat esoteric physics it may be...***Read More***...

Andrea Gamucci at work on the Heliox system for electrical measurements. Credit: Andrea Freccioni/Scuola Normale Superiore.

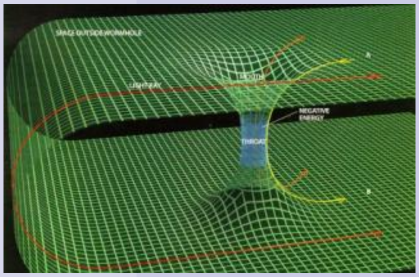
The Entire Milky Way Might Be a Huge Wormhole That's Stable and Navigable

Our very own Milky Way could be home to a giant tunnel in spacetime.

At least, that's what the authors of a new study have proposed. According to the team, a collaboration between Indian, Italian, and North American researchers at the International School for Advanced Studies (SISSA) in Italy, the central halo of our galaxy may harbor enough dark matter to support the creation and sustenance of a "stable and navigable" shortcut to a distant region of spacetime – a phenomenon known as a wormhole.

Wormholes were first conceptualized by Albert Einstein and Nathan Rosen in 1935. Far from being fodder for science fiction, the two scientists instead proposed their idea as a way to get around the idea of black hole singularities. Rather than creating a knot of infinite density, Einstein and Rosen thought, the hefty energy inherent in such a massive body would distort spacetime to such an extent that it bent over on itself, allowing a bridge to form between two distant areas of the Universe. Alas, these wormholes would be extremely unstable and would require enormous amounts of "negative energy" to remain open.

But according to the team at SISSA, large amounts of dark matter could provide this fuel. Using a model of dark matter's abundance that is based on the rotation curves of other spiral galaxies, the researchers found that the distribution of dark matter in the Milky Way produced solutions in general relativity that would, theoretically, allow a stable wormhole to arise.



A graphic of the structure of a theorized wormhole (NASA)

Paulo Salucci, an astrophysicist on the the team from SISSA, explained: "If we combine the map of the dark matter in the Milky Way with the most recent Big Bang model to explain the universe and we hypothesise the existence of space-time tunnels, what we ...***Read More***...

Peering into cosmic magnetic fields

The generation of cosmic magnetic fields has long intrigued astrophysicists. Since it was first described in 1959, a phenomenon known as Weibel filamentation instability—a plasma instability present in homogeneous or nearly homogeneous electromagnetic plasmas—has generated tremendous theoretical interest from astrophysicists and plasma physicists as a potential mechanism for seed magnetic field generation in the universe.

However, direct observation of Weibel-generated magnetic fields remained challenging for decades. In a Nature Physics paper (link is external) published this week, Lawrence Livermore National Laboratory (LLNL) researchers report for the first time well-developed, oriented magnetic filaments generated by the Weibel mechanism in counter-streaming, collision-less flows generated by high-power lasers.

"Comparison with 3D particle-in-cell simulations and a first-principles theoretical treatment proves that the magnetic field generation in such flows is real, and quite efficient," said lead author Channing Huntington, a physicist at LLNL.

The team's findings demonstrate the power of the Weibel instability to produce small-scale ...***Read More***...

Inside the Omega Laser Facility's target chamber during a shot. Experiments at this facility have provided insight into magnetic field generation. Credit: University of Rochester's Laboratory for Laser Energetics

NASA, Microsoft Collaboration Will Allow Scientists to 'Work on Mars'

NASA and Microsoft have teamed up to develop software called OnSight, a new technology that will enable scientists to work virtually on Mars using wearable technology called Microsoft HoloLens.

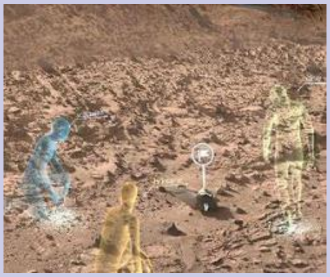
Developed by NASA's Jet Propulsion Laboratory (JPL) in Pasadena, California, OnSight will give scientists a means to plan and, along with the Mars Curiosity rover, conduct science operations on the Red Planet.

"OnSight gives our rover scientists the ability to walk around and explore Mars right from their offices," said Dave Lavery, program executive for the Mars Science Laboratory mission at NASA Headquarters in Washington. "It fundamentally changes our perception of Mars, and how we understand the Mars environment surrounding the rover."

OnSight will use real rover data and extend the Curiosity mission's existing planning tools by creating a 3-D simulation of the Martian environment where scientists around the world can meet. Program scientists will be able to examine the rover's worksite from a first-person perspective, plan new activities and preview the results of their work firsthand.

"We believe OnSight will enhance the ways in which we explore Mars and share that journey of exploration with the world," said Jeff Norris, JPL's OnSight project manager.

Until now, rover operations required scientists to examine Mars imagery on a computer screen, and make inferences about what they are seeing. But images, even 3-D stereo views, lack a natural sense of depth that human vision employs to understand spatial relationships….***Read More***...



New NASA software called OnSight will use holographic computing to overlay visual information and data from the agency's Mars Curiosity Rover into the user's field of view. Holographic computing blends a view of the physical world with computer-generated imagery to create a hybrid of real and virtual. Image courtesy NASA.

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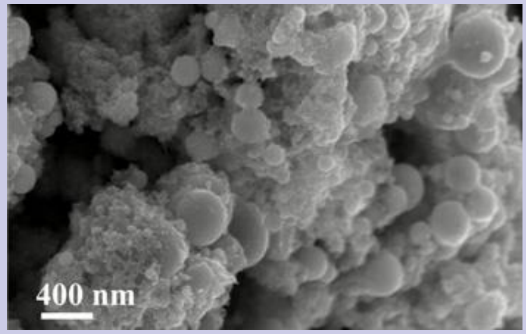


A femtosecond laser created detailed hierarchical structures in the metals, as shown in this SEM image of the platinum surface. Image: The Guo Lab/Univ. of Rochester

Laser-patterning technique turns metals into supermaterials

By zapping ordinary metals with femtosecond laser pulses researchers from the Univ. of Rochester have created extraordinary new surfaces that efficiently absorb light, repel water and clean themselves. The multifunctional materials could find use in durable, low maintenance solar collectors and sensors.

"This is the first time that a multifunctional metal surface is created by lasers that is superhydrophobic (water repelling), self-cleaning, and highly absorptive," said Chunlei Guo, a physicist at the Institute of Optics at the Univ. of Rochester who made the new surfaces with his colleague and fellow Univ. of Rochester researcher Anatoliy Vorobyev. The researchers describe the laser-patterned surfaces in an article published in the Journal of Applied Physics.

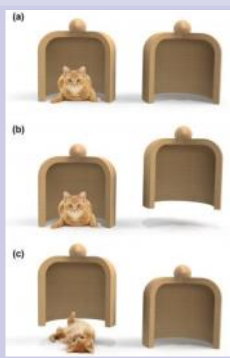
Enhanced light absorption will benefit technologies ...***Read More***...

Atoms can be in two places at the same time

Can a penalty kick simultaneously score a goal and miss? For very small objects, at least, this is possible: according to the predictions of quantum mechanics, microscopic objects can take different paths at the same time. The world of macroscopic objects follows other rules: the football always moves in a definite direction. But is this always correct? Physicists of the University of Bonn have constructed an experiment designed to possibly falsify this thesis. Their first experiment shows that Caesium atoms can indeed take two paths at the same time.

Almost 100 years ago physicists Werner Heisenberg, Max Born und Erwin Schrödinger created a new field of physics: quantum mechanics. Objects of the quantum world – according to quantum theory – no longer move along a single well-defined path. Rather, they can simultaneously take different paths and end up at different places at once. Physicists speak of quantum superposition of different paths.

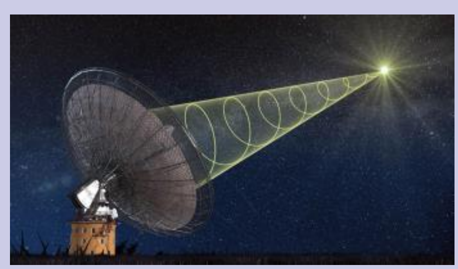
At the level of atoms, it looks as if objects indeed obey quantum mechanical laws. Over the years, many experiments have confirmed quantum mechanical ...***Read More***….



The Bonn team has developed a measurement scheme that indirectly measures the position of an atom. In essence, one looks where the Caesium atom is not. The image clarifies this procedure. Let us assume that two containers are in front of us and a cat is hidden under one of them (a). However, we do not know under which one. We tentatively lift the right jar (b) and we find it empty. We, thus, conclude that the cat must be in the left jar and yet we have not disturbed it. Had we have lifted the left jar instead, we would have disturbed the cat (c), and the measurement must be discarded. In the macro-realist's world, this measurement scheme would have absolutely no influence on the cat's state, which remains undisturbed all the time. In the quantum world, however, a negative measurement that reveals the cat's position, like in (b), is already sufficient to destroy the quantum superposition and to influence the result of the experiment. Credit: Andrea Alberti / www.warrenphotographic.co.uk

Snapshot of cosmic burst of radio waves

A strange phenomenon has been observed by astronomers right as it was happening — a "fast radio burst." The eruption is described as an extremely short, sharp flash of radio waves from an unknown source in the universe. Over the past few years, astronomers have observed a new phenomenon, a brief burst of radio waves, lasting only a few milliseconds. It was first seen by chance in 2007 when astronomers went through archival data from the Parkes Radio Telescope in Eastern Australia. Since then they have seen six more such bursts in the Parkes telescope's data, and a seventh burst was found in the data from ...***Read More***….



Parkes Radio Telescope in Eastern Australia