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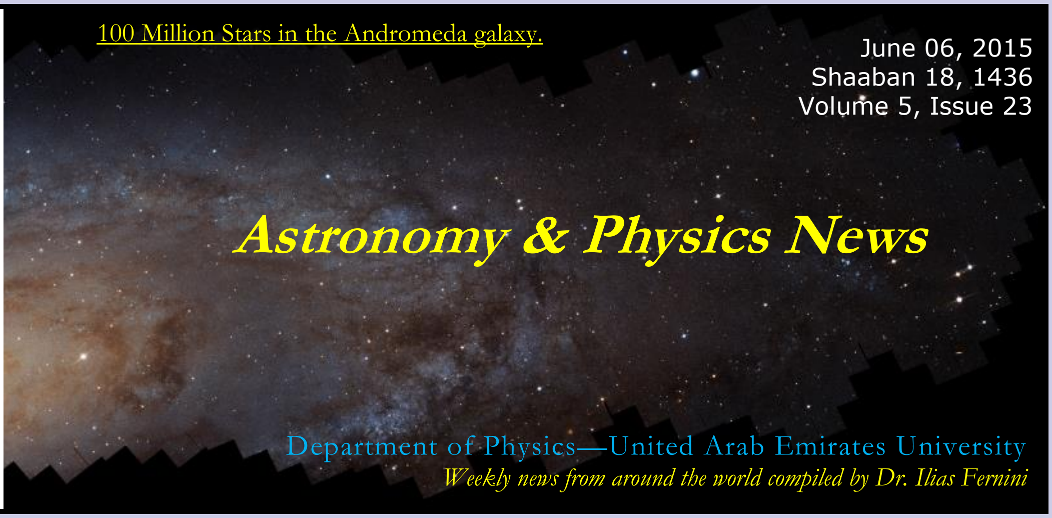
INTERNATIONAL YEAR OF LIGHT 2015



100 Million Stars in the Andromeda galaxy.

Astronomy & Physics News

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

Inside this issue:

Is this the end of particle physics as we know it?

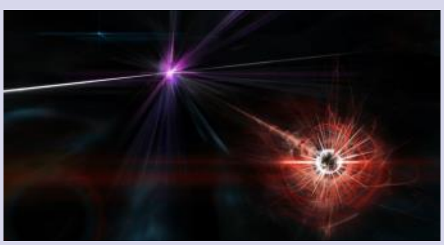
Physicists around the world are hoping that this week will mark the beginning of a new era of discovery. And not, as some fear, the end of particle physics as we know it.

After 27 months of shutdown and re-commissioning, the Large Hadron Collider has begun its much-anticipated "Season 2". Deep beneath the Franco-Swiss border, the first physics data is now being collected in CERN's freshly upgraded detector-temples at the record-breaking collision energy of 13 teraelectonvolts (TeV).

Much has been written about the upgrade to the accelerator, the experiments, and the computing infrastructure required to handle the fresh deluge of data from the new energy frontier. There has also – quite rightly – been a lot of attention paid to the crowning achievement of Run 1: the discovery of the Higgs boson.

But the "elephant in the collider" is this: we knew that Run 1 had to find the Higgs boson – or something like it, and it did. With Run 2, we don't know what we're looking for.

OK, so maybe that's bit of an over-simplification. We certainly have a good few guesses as to what's beyond the Standard Model of particle physics, our current best understanding of matter and forces at the fundamental level that was essentially completed in July 2012….***Read More***...



An artist's impression of the much-searched for magnetic monopole. Credit: Heikka Valja/MoEDAL Collaboration

How to weigh the Milky Way?

What if your doctor told you that your weight is somewhere between 100 and 400 lbs.? With any ordinary scale every patient can do better at home. Yet, one patient can't: the Milky Way.

Even though today we peer deeper into space than ever before, our home galaxy's weight is still unknown to about a factor of four. Researchers at Columbia University's Astronomy Department have now developed a new method to give the Milky Way a more precise physical checkup.

The Milky Way consists of roughly 100 billion stars that form a huge stellar disk with a diameter of 100-200 thousand light years. The Sun is part of this structure, hence, when we look into the sky, we look right into a gigantic disk of stars. The vast number of stars and the huge extent on the sky make it hard to measure fundamental quantities for the Milky Way, such as its weight.

An international team of scientists led by Columbia University researcher Andreas Kupper used stars outside this disk, which orbit around the Milky Way in a stream-like structure, to weigh the Milky Way to high precision.

In a new study published in The Astrophysical Journal, the team demonstrates that such streams, produced by dissolving globular clusters, can be used to measure not only the ...***Read More***...

An artist impression of the Milky Way—File image.

Physicists make first observation of the pushing pressure of light

For more than 100 years, scientists have debated the question: when light travels through a medium such as oil or water, does it pull or push on the medium? While most experiments have found that light exerts a pulling pressure, in a new paper physicists have, for the first time, found evidence that light exerts a pushing pressure.

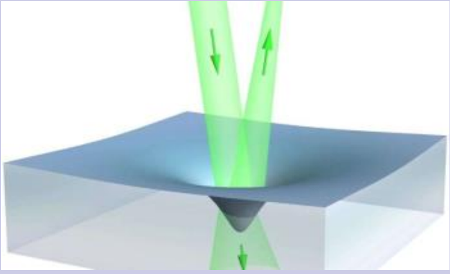
The scientists suggest that this apparent contradiction is not a fundamental one, but can be explained by the interplay between the light and the fluid medium: if the light can put the fluid in motion, it exerts a pushing force; if not, it exerts a pulling force.

The researchers, Li Zhang, Weilong She, and Nan Peng at Sun Yat-Sen University in Guangzhou, China, and Ulf Leonhardt at the Weizmann Institute of Science in Rehovot, Israel, have published a paper on the first evidence for the pushing pressure of light in a recent issue of the New Journal of Physics.

Minkowski vs. Abraham

The debate on the nature of the pressure, or momentum, of light goes back to 1908, when Hermann Minkowski (best known for developing the four-dimensional "Minkowski spacetime" used in Einstein's theory of relativity) predicted a pulling force. In 1909, physicist Max Abraham predicted the exact opposite, that light exerts a pushing force.

"Scientists have argued for more than a century about the momentum of light in materials," Leonhardt told Phys.org. ...Read More...



When light impinges on the surface of a liquid, part of the light is reflected and the remaining fraction is transmitted. The new experiments show for the first time that the liquid surface bends inward, meaning that the light is pushing on the fluid in agreement with the Abraham momentum of light. Credit: Zhang, et al.

Physicists map electron structure of superconductivity's 'doppelganger'

Physicists have painted an in-depth portrait of charge ordering—an electron self-organization regime in high-temperature superconductors that may be intrinsically intertwined with superconductivity itself.

In two complementary studies—published in Nature Materials last week and Science in March—University of British Columbia researchers confirm that charge ordering forms a predominantly one dimensional 'd-wave pattern'.

"Everything we can learn about the structure of charge ordering gets us a step closer to understanding how it's intertwined with, and potentially competes with, superconductivity," says Riccardo Comin, lead author of both papers who conducted the research while a PhD student at UBC. Comin is now a post-doctoral fellow at the University of Toronto.

Charge ordering creates instabilities in cuprate superconductors at temperatures warmer than -100 degrees Celsius. It causes some electrons to reorganize into new periodic static patterns that compete with superconductivity. The reason behind this competition has remained elusive until these studies demonstrated that charge ordering and superconductivity share the same underlying symmetry.

"Intriguingly, superconducting ...Read More...

University of British Columbia physicists Andrea Damascelli, left, and Giorgio Levy, working with liquid helium.

Are scientists finally on the brink of understanding where proton spin comes from?

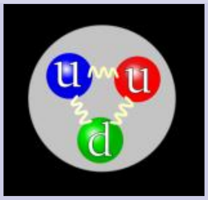
For nearly three decades, physicists have been unable to answer a seemingly simple question: where does proton spin come from?

Summing the spins of the three quarks that make up the proton seems, in principle, straightforward, however, physicists have been faced with a particularly stubborn imbalance. In 1988 the European Muon Collaboration (EMC) at CERN shocked the physics community by announcing that the sum of the spins of the three quarks that make up the proton is much less than the spin of the proton itself. This discovery questioned the fundamental idea in physics that the amount of any physical quantity on one side of an equation must equal that on the other side.

EMC researchers discovered that the net spin of the three quarks actually accounted for no more than 24% of the proton's spin and may even contribute as little as 4% – in other words, practically none.

This discovery sparked the beginning of the "spin crisis". Gerhard Mallot, a senior physicist at CERN, recalls how nervous people were and how there were conjectures that the experiment was flawed or even that the underlying theory, known as quantum chromodynamics (QCD), might not be correct.

Further scattering experiments at the Stanford Linear Accelerator Center (SLAC), CERN and the DESY laboratory in Germany eventually confirmed that quark spin contributes 30% (+/-5%) of the total proton spin, but that still ...Read More...



The quark structure of the proton. There are two up quarks in it and one down quark. The strong force is mediated by gluons (wavey). The strong force has three types of charges, the so-called red, green and the blue. Note that the choice of green for the down quark is arbitrary; the "color charge" is thought of as circulating among the three quarks. Credit: Arpad

Isolating sunlight scattering could help illuminate Universe's birth

Astrophysicists have developed a new method for calculating the effect of Rayleigh scattering on photons, potentially allowing researchers to better understand the formation of the Universe.

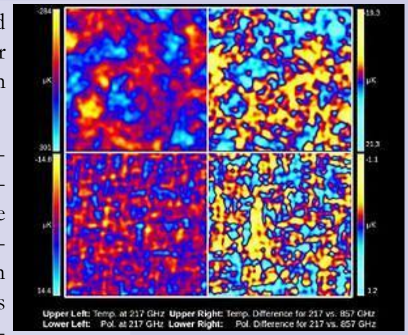
UBC theoretical cosmology graduate student Elham Alipour, UBC physicist Kris Sigurdson and Ohio State University astrophysicist Christopher Hirata probed the effect of Rayleigh scattering - the process that makes the sky appear blue when the Sun's photons are scattered by molecules in the atmosphere - on the cosmic microwave background (CMB).

The CMB is the oldest light in the universe, which originated when electrons combined with protons to form the first atoms. These primordial atoms were also the first to Rayleigh scatter light.

"Detecting the Rayleigh signal is challenging because the frequency range where Rayleigh scattering has the biggest effect is contaminated by 'noise' and foregrounds, such as galactic dust," lead author Elham Alipour said.

By using different high-frequency channels to observe the CMB and combining this information, researchers may be able to better isolate the Rayleigh signal. This calculation of the effects of Rayleigh scattering on cosmology might help us better understand the formation of our Universe 13.6 billion years ago.

"The CMB sky is a snapshot of the early Universe, it is a single frame in the movie of the Universe, and we have shown that Rayleigh signal gives us another fainter snapshot of the same scene at a slightly different time," co-author Kris Sigurdson explained…. **Read More**...



By using different high-frequency channels to observe the CMB and combining this information, researchers may be able to better

Herschel's hunt for filaments in the Milky Way

Observations with ESA's Herschel space observatory have revealed that our Galaxy is threaded with filamentary structures on every length scale. From nearby clouds hosting tangles of filaments a few light-years long to gigantic structures stretching hundreds of light-years across the Milky Way's spiral arms, they appear to be truly ubiquitous. The Herschel data have rekindled the interest of astronomers in studying filaments, emphasising the crucial role of these structures in the process of star formation.

Stars are born in the densest pockets of the interstellar medium, a diffuse mixture of gas and dust that pervades galaxies, including our Milky Way. One of the most intriguing questions in astrophysics concerns understanding how this material, which is typically characterised by very low density, can come together, creating denser concentrations that later evolve into compact cores and, finally, give birth to stars.

In the search for answers, astronomers observe giant molecular clouds, the cosmic incubators where gas and dust are transformed into stars. While these studies are performed using a variety of techniques, one crucial approach is the observation of infrared light, since the interstellar material shines brightly at ...***Read More***...

The Aquila Rift. Image courtesy ESA/Herschel/SPIRE/PACS/Ph. Andre for the 'Gould Belt survey' Key Programme Consortium.

How do galaxies die?

Everything eventually dies, even galaxies. So how does that happen?

Time to come to grips with our galactic mortality. Not as puny flesh beings, or as a speck of rock, or even the relatively unassuming ball of plasma we orbit.

Today we're going to ponder the lifespan of the galaxy we inhabit, the Milky Way. If we look at a galaxy as a collection of stars, some are like our Sun, and others aren't.

The Sun consumes fuel, converting hydrogen into helium through fusion. It's been around for 5 billion years, and will probably last for another 5 before it bloats up as a red giant, sheds its outer layers and compresses down into a white dwarf, cooling down until it's the background temperature of the universe.

So if a galaxy like the Milky Way is just a collection of stars, isn't that it? Doesn't a galaxy die when its last star dies?

But you already know a galaxy is more than just stars. There's also vast clouds of gas and dust. Some of it is primordial hydrogen left from the formation of the universe 13.8 billion years ago.

All stars in the Milky Way formed from this primordial hydrogen. It and other similar sized galaxies produce 7 bouncing baby stars every year. Sadly, ours has used up 90% of its hydrogen, and star formation will slow down until it both figuratively, and literally, runs out of gas.

The Milky Way will die after it's used all its star-forming gas, when all of the stars we have, and all those stars yet to be born have died. Stars like our Sun can only last for ...***Read More***...

Artist's conception of the Milky Way galaxy. Credit: Nick Risinger

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Keeping astronauts in space longer with better air and water

As astronauts embark on increasingly ambitious space missions, scientists have to figure out how to keep them healthy for longer periods far from Earth. That entails assuring the air they breathe and the water they drink are safe - not an easy task given their isolated locations.

But scientists are now reporting in the ACS journal Analytical Chemistry a new method to monitor the quality of both in real time with one system.

Current options for testing air and water for contaminants, including microbes and radiation, require collecting samples and sending them back to Earth for analysis. But for long missions - aboard the International Space Station (ISS), for example - this approach could take six months before the astronauts have their results.

The ISS is also equipped with some real-time hardware for detecting unwanted substances, but it has limitations. Facundo M. Fernandez, William T. Wallace and colleagues wanted to come up with a system to conduct real-time, sensitive monitoring.

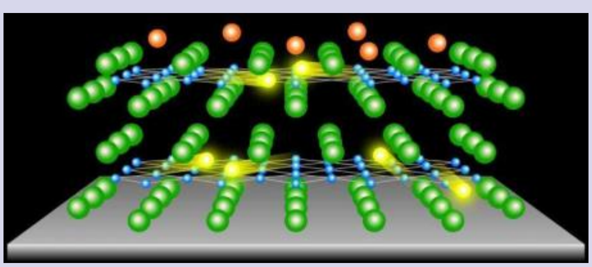
The researchers outfitted a kind of air quality monitor (AQM) already used aboard space missions with a device that can vaporize water samples, turning its contents and any contaminants, into a gas.

The gas can then enter the AQM for analysis. Astronauts could also use the same equipment, with a modification, for testing the air. The team says the system could be used in space or for remote locations right here on Earth….***Read More***...

High-temperature superconductivity in atomically thin films

A research group at Tohoku University has succeeded in fabricating an atomically thin, high-temperature superconductor film with a superconducting transition temperature (Tc) of up to 60 K (-213°C). The team, led by Prof. Takashi Takahashi (WPI-AIMR) and Asst. Prof. Kosuke Nakayama (Dept. of Physics), also established the method to control/tune the Tc.

This finding not only provides an ideal platform for investigating the mechanism of superconductivity in the two-dimensional system, but also paves the way for the development of next-generation nano-scale superconducting devices….***Read More***...



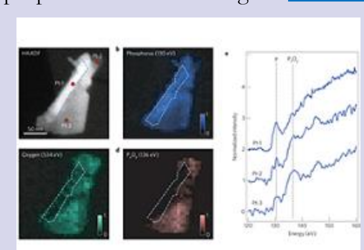
Blue and green circles indicate iron (Fe) and selenium (Se) atoms, respectively. The superconducting transition temperature is tuned by introducing electrons by depositing potassium atoms (orange circles) on the surface. Yellow circles represent a pair of superconducting electrons (Cooper pair). Credit: Takashi Takahashi

Mastering extraordinary properties of an emerging semiconductor

A team of researchers from Université de Montréal,Polytechnique Montréal and the Centre national de la recherche scientifique (CNRS) in France is the first to succeed in preventing two-dimensional layers of black phosphorus from oxidating. In so doing, they have opened the doors to exploiting their striking properties in a number of electronic and optoelectronic devices. The study's results were published in the journal Nature Materials.

Black phosphorus: future key player in new technologies

Black phosphorus, a stable allotrope of phosphorus that presents a lamellar structure similar to that of graphite, has recently begun to capture the attention of physicists and materials researchers. It is possible to obtain single atomic layers from it, which researchers call 2D phosphane. A cousin of the widely publicized graphene, 2D phosphane brings together two very sought-after properties for device design. ...***Read More***...



Chemical analysis by hyperspectral TEM-EELS spectroscopy of a multilayer 2D-phosphane exfoliated under ambient light in air.