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Astronomy & Physics Weekly News

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Top News

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A universe of 2 trillion galaxies

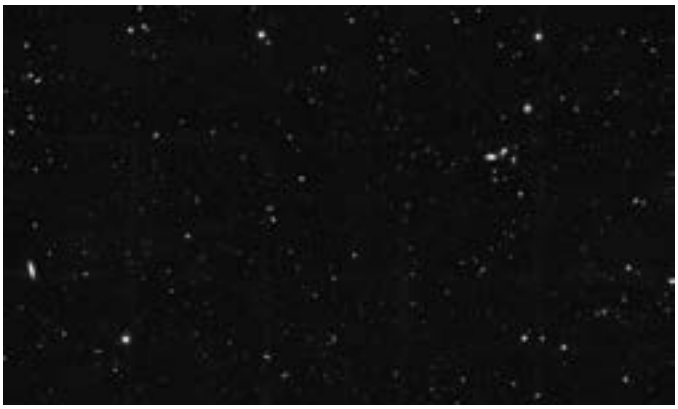


Image of the HST GOODS-South field, one of the deepest images of the sky but covering just one millionth of its total area. The new estimate for the number of galaxies is ten times higher than the number seen in this image. Credit: NASA / ESA / The GOODS Team / M. Giavalisco (UMass., Amherst)

An international team of astronomers, led by Christopher Conselice, Professor of Astrophysics at the University of Nottingham, have found that the universe contains at least 2 trillion galaxies, ten times more than previously thought. The team's work, which began with seed-corn funding from the Royal Astronomical Society, appears in the Astrophysical Journal today.

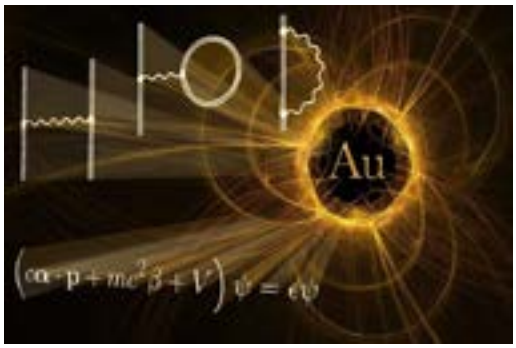
Astronomers have long sought to determine how many galaxies there are in the observable universe, the part of the cosmos where light from distant objects has had time to reach us. Over the last 20 years scientists have used images from the Hubble Space Telescope to estimate that the universe we can see contains around 100 - 200 billion galaxies. Current astronomical technology allows us to study just 10% of these galaxies, and the remaining 90% will be only seen once bigger and better telescopes are developed.

Prof Conselice's research is the culmination of 15 years' work, part-funded by a research grant from the Royal Astronomical Society awarded to Aaron Wilkinson, an undergraduate student at the time. Aaron, now a PhD student at the University of Nottingham, began by performing the initial galaxy-counting analysis, work which was crucial for establishing the feasibility of the larger-scale study.

Prof Conselice's team then converted pencil beam images of deep space from telescopes around the world, and especially from the Hubble telescope, into 3-D maps. These allowed them to calculate the density of galaxies as well as the volume of one small region of space after another. This painstaking research enabled the team to establish how many galaxies we have missed - much like an intergalactic archaeological dig.

The results of this study are based on the measurements of the number of observed galaxies at different epochs – different instances in time - through the universe's history. When Prof Conselice and his team at ...Read More...

Golden mystery solved



Unlocking the secrets of gold. Credit: Massey University

Gold is prized for its preciousness and as a conductor in electronics, but it is also important in scientific experimentation.

Ernest Rutherford utilised it when mapping the atom, in an experiment, which needed a thin metal foil made of gold. However, despite its usefulness in experimentation, scientists found gold would not always perform how they theorised it would at the atomic level.

Scientists do not like what they cannot explain, so debate grew amongst the communities best minds to explain this why gold is special, which until now remained unsolved even for the most basic atomic properties.

Acting Head of Institute of the New Zealand Institute for Advanced Study, Distinguished Professor Peter Schwerdtfeger, alongside international colleagues, solved the problem and uncovered more precise calculations for gold that will help scientists bridge the gap between theory and experiment.

"Precision in science is vital even in the most simple of experiments. For example, if you took a ball and rolled it down a slope, you could measure the gradient of the slope, the weight of the ball, wind conditions etcetera, and you could predict how fast the ball would reach the end of the slope. The more precise you made those calculations, the more likely you would find that your predictions about the speed of the ball would be closer to how fast it actually was.

"Gold is a little more mysterious and complex to measure because of its quantum nature, but even in basic experiments, such as removing and adding electrons, it remained inconsistent. Our calculations are important because more precise calculations are able to produce more reliable results," Professor Schwerdtfeger says.

The team was able to reduce the discrepancy between theory and experiment to just a few milli-electron-volts, which is a giant improvement over past results. They achieved this by using an approach, which other scientists have neglected, called Feynman's approach, which looks at the quantisation of the electromagnetic field - essentially looking at how light and matter interact.

This knowledge can be applied to further improve predictions in the research of not just ...Read More...

A tale of two pulsars' tails: Plumes offer geometry lessons to astronomers

An artist's representation of what the three unusual tails of the pulsar Geminga may look like close up. NASA's Chandra X-ray Observatory is giving astronomers a better look at pulsars and their associated pulsar wind nebulae, enabling new constraints on the geometry of pulsars and why they look the way they do from Earth. Image: Illustrations by Nahks TrEhnl

Like cosmic lighthouses sweeping the universe with bursts of energy, pulsars have fascinated and baffled astronomers since they were first discovered 50 years ago. In two studies, international teams of astronomers suggest that recent images from NASA's Chandra X-ray Observatory of two pulsars - Geminga and B0355+54 - may help shine a light on the distinctive emission signatures of pulsars, as well as their often perplexing geometry.

Pulsars are a type of neutron star that are born in supernova explosions when massive stars collapse. Discovered initially by lighthouse-like beams of radio emission, more recent research has found that energetic pulsars also produce beams of high energy gamma rays.

Interestingly, the beams rarely match up, said Bettina Posselt, senior research associate in astronomy and astrophysics, Penn State. The shapes of observed radio and gamma-ray pulses are often quite different and some of the objects show only one type of pulse or the other. These differences have generated debate about the pulsar model.

"It's not fully understood why there are variations between different pulsars," said Posselt. "One of the main ideas here is that pulse differences have a lot to do with geometry - and it also depends on how the pulsar's spin and magnetic axes are oriented with respect to line of sight whether you see certain pulsars or not, as well as how you see them."

Chandra's images are giving the astronomers a closer than ever look at the distinctive geometry of the charged particle winds radiating in X-ray and other wavelengths from the objects, according to Posselt. Pulsars rhythmically rotate as they rocket through space at speeds reaching hundreds of kilometers a second.

Pulsar wind nebulae (PWN) are produced when the energetic particles streaming from pulsars shoot along the stars' magnetic fields, form tori - donut-shaped rings - around the pulsar's equatorial plane, and jet ...Read More...

The science behind the Lunar Hydrogen Polar Mapper mission

LunaH-Map, the Lunar Hydrogen Polar Mapper, will launch in September 2018. Its task will be to find water and ice at the south pole of the moon, and map the deposits.

Arizona State University's NASA mission to visit a metal asteroid is just beginning, but the first mission that marked the school as a major player in space exploration has been under way for more than a year.

LunaH-Map, the Lunar Hydrogen Polar Mapper, will launch in September 2018. Its task will be to find water and ice at the south pole of the moon, and map the deposits.

ASU Now spoke with principal investigator Craig Hardgrove, an assistant professor in the School of Earth and Space Exploration about the science behind the mission, what will be built on its discoveries, and why there isn't a hockey rink buried on the moon.

Why look for water and ice on the moon? It can be used for fuel and drinking water in the push to Mars, saving an enormous amount of space and payload weight on spacecraft.

"That's the geologic question we're trying to answer about the moon: how much (water and ice) is there on a moderate spatial scale, so we can send a rover and really get at how much water is there," Hardgrove said.

Scientists aren't sure about how water and ice appear on the moon. It is likely deposited by two things: solar wind or passing asteroids and comets. Protons from solar wind are implanted into the lunar surface, then they combine with an electron to form a hydrogen atom. The hydrogen atom binds with oxygen and forms hydroxyl atoms.

Asteroids and comets carry water. "Those are dirty ice balls, basically," Hardgrove said, carrying 50 to 80 percent water. As they get close to the sun, they shed water.

"Those could be passing by, depositing water on bodies like the moon," he said. "So maybe that's the explanation for why it's enriched in certain regions and not others."
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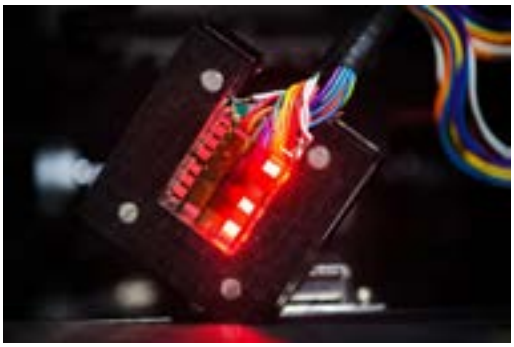
Self-assembling particles brighten future of LED lighting



A new type of LED is made with crystalline substances known as perovskites. Credit: Sameer A. Khan/Fotobuddy

Just when lighting aficionados were in a dark place, LEDs came to the rescue. Over the past decade, LED technologies—short for light-emitting diode—have swept the lighting industry by offering features such as durability, efficiency and long life.

Now, Princeton engineering researchers have illuminated another path forward for LED technologies by refining the manufacturing of light sources made with crystalline substances known as perovskites, a more efficient and potentially lower-cost alternative to materials used in LEDs found on store shelves.

The researchers developed a technique in which nanoscale perovskite particles self-assemble to produce more efficient, stable and durable perovskite-based LEDs. The advance, reported January 16 in Nature Photonics, could speed the use of perovskite technologies in commercial applications such as lighting, lasers and television and computer screens.

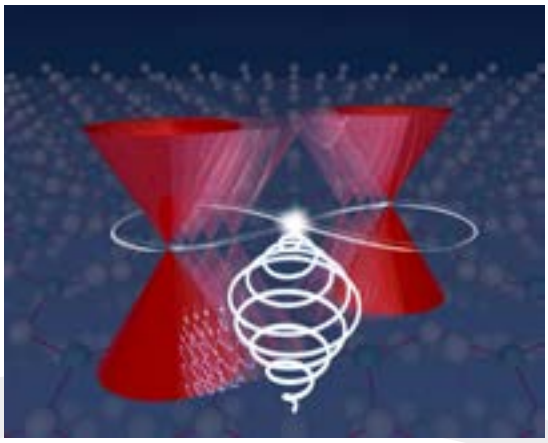
"The performance of perovskites in solar cells has really taken off in recent years, and they have properties that give them a lot of promise for LEDs, but the inability to create uniform and bright nanoparticle perovskite films has limited their potential," said Barry Rand an assistant professor of electrical engineering and the Andlinger Center for Energy and the Environment at Princeton.

"Our new technique allows these nanoparticles to self-assemble to create ultra-fine grained films, an advance in fabrication that makes perovskite LEDs look more like a viable alternative to existing technologies," Rand, the lead researcher, added.

LEDs emit light when voltage is applied across the LED. When the light is turned on, electrical current forces electrons from the negative side of the diode to the positive side. This releases energy in the form of light. LEDs operate best when this current can be strictly controlled. In Rand's devices, the thin nanoparticle-based films allowed just that.

LEDs have many advantages over incandescent bulbs, including durability, longer life, smaller size, energy efficiency and low-heat. While they are still more expensive than fluorescent lights for room illumination, they are more energy efficient, light up faster and present fewer environmental concerns related to disposal. ...Read More...

Laser-driving of semimetals allows creating novel quasi-particle states



Dancing Weyl cones: When excited by tailored laser pulses (white spiral), the cones in a Dirac fermion material dance on a path (8-shape) that can be controlled by the laser light. This turns a Dirac material into a Weyl material, changing the nature of the quasiparticles in it. One of the cones hosts right-handed Weyl fermions; the other cone hosts left-handed ones. Credit: Joerg M. Harms/MPSD

Studying properties of fundamental particles in condensed matter systems is a promising approach to quantum field theory. Quasiparticles offer the opportunity to observe particle properties that have no realization in elementary particles. In the present study, an international research team led by Angel Rubio from the Max Planck Institute for the Structure and Dynamics of Matter at CFEL in Hamburg and the University of the Basque Country in Donostia-San Sebastián predicted how laser light can be used to create Weyl fermion states in 3-D Dirac materials and to switch between Weyl semimetal, Dirac semimetal and topological insulator states on ultrafast timescales. Besides its relevance for fundamental quantum physics, the results might lead to applications in ultrafast switching of material properties. The findings are published online in the journal Nature Communications today.

In the standard model of particle physics, the fundamental particles that make up all matter around us - electrons and quarks - are so-called fermions, named after the famous Italian physicist Enrico Fermi. Quantum theory predicts that elementary fermions could exist as three different kinds: Dirac, Weyl, and Majorana fermions, named after Paul Dirac, Hermann Weyl, and Ettore Majorana. However, despite being predicted almost a hundred years ago, of these three kinds of particles only Dirac fermions have been observed as elementary particles in nature so far. With the discovery of graphene in 2004, however, it was realized that the behaviour of relativistic free particles could be observed in the electronic properties of materials. This sparked the search for materials where these fundamental particles could be observed and only last year the first materials hosting Weyl fermions were discovered. While any known material only hosts one kind of these fermions in its equilibrium state, in the ...Read More...

Discovery could lead to jet engines that run hotter—and cleaner

Credit: The Ohio State University

Researchers here have made a discovery in materials science that sounds like something from the old Saturday morning cartoon Super Friends: They've found a way to deactivate "nano twins" to improve the high-temperature properties of superalloys that are used in jet engines.

The advance could speed the development of powerful and environmentally friendly turbine engines of all sorts, including those used for transportation and power generation.

The "nano twins" in question are microscopic defects that grow inside alloys and weaken them, allowing them to deform under heat and pressure. In the journal Nature Communications, engineers at The Ohio State University describe how tailoring an alloy's composition and then exposing it to high heat and pressure can not only prevent nano twins from forming, it can actually make the alloy stronger.

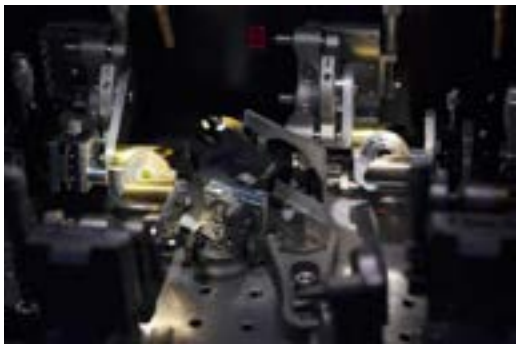
In tests, the technique, which they've dubbed "phase transformation strengthening," eliminated the formation of nano twins and decreased alloy deformation by half.

Strong, heat-resistant alloys enable turbine engines to run cleanly and efficiently, explained Michael Mills, professor of materials science and engineering and leader of the project at Ohio State. When an engine can run at very high temperatures, it consumes its fuel more thoroughly and produces lower emissions.

"We found that increasing the concentrations of certain elements in super-alloys inhibits the formation of high-temperature deformation twins, thereby significantly improving the alloys' high temperature capabilities," Mills said.

These days, the most advanced alloys are designed on computer—practically atom by atom—and Mills' team set out to address what he called a deficit in the "quantitative, comprehensive understanding" of how these exotic metal-based materials deform under high stress. ..Read More...

Studying the quantum vacuum: Traffic jam in empty space



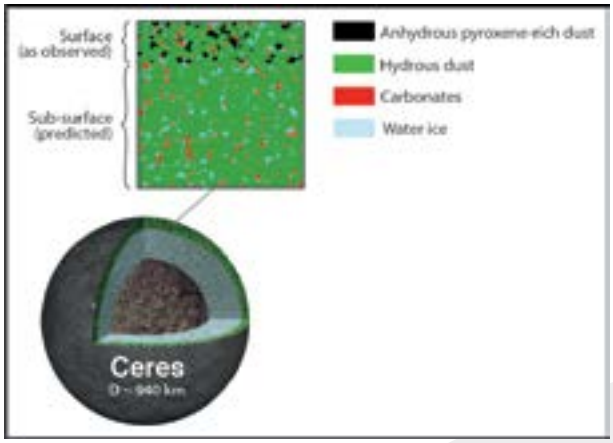
Detailed view of the central part of the experiment on subcycle quantum electrodynamics. The gallium selenide emitter crystal is seen in the bright region to the right. Here, an ultrashort laser pulse induces a local change in the velocity of light which leads to squeezing of the quantum vacuum. The nonclassical states of light propagate through the filters in the center and end up at the silver gallium sulfide detection crystal which is highlighted in the left section. The deviations from the vacuum noise are sampled there with femtosecond time resolution. Credit: University of Konstanz

An important step towards a completely new experimental access to quantum physics has been made at University of Konstanz. The team of scientists headed by Professor Alfred Leitenstorfer has now shown how to manipulate the electric vacuum field and thus generate deviations from the ground state of empty space which can only be understood in the context of the quantum theory of light.

With these results, the researchers from the field of ultrafast phenomena and photonics build on their earlier findings, published in October 2015 in the scientific journal Science, where they have demonstrated direct detection of signals from pure nothingness. This essential scientific progress might make it possible to solve problems that physicists have grappled with for a long time, ranging from a deeper understanding of the quantum nature of radiation to research on attractive material properties such as high-temperature superconductivity. The new results are published on 19 January 2017 in the current online issue of the scientific journal Nature.

A world-leading optical measurement technique, developed by Alfred Leitenstorfer's team, made this fundamental insight possible. A special laser system generates ultrashort light pulses that last only a few femtoseconds and are thus shorter than half a cycle of light in the investigated spectral range. One femtosecond corresponds to the millionth of a billionth of a second. The extreme sensitivity of the method enables detection of electromagnetic fluctuations even in the absence of intensity, that is, in complete darkness. Theoretically, the existence of these "vacuum fluctuations" follows from Heisenberg's Uncertainty Principle. Alfred Leitenstorfer and his team succeeded in directly observing these fluctuations for the first time and in the mid-infrared frequency range, where even conventional approaches to quantum ...Read More...

Observations of Ceres indicate that asteroids might be camouflaged



Ceres' surface is contaminated by a significant amount of dry material while its the area below the crust contains essentially water-bearing materials. The mid-infrared observations revealed the presence of dry pyroxene on the surface probably coming from interplanetary dust particles. The Internal structure of the Dwarf Planet Ceres was derived from the NASA Dawn spacecraft data.

The appearance of small bodies in the outer solar system could be deceiving. Asteroids and dwarf planets may be camouflaged with an outer layer of material that actually comes from somewhere else.

Using data primarily gathered by SOFIA, NASA's Stratospheric Observatory for Infrared Astronomy, a team of astronomers has detected the presence of substantial amounts of material on the surface of Ceres that appears to be fragments of other asteroids.

This is contrary to the currently accepted surface composition classification of Ceres, suggesting that the largest body in the asteroid belt between Mars and Jupiter is cloaked by material that has partially disguised its real makeup.

"We find that the outer few microns of the surface is partially coated with dry particles," says Franck Marchis, senior planetary astronomer at the SETI Institute. "But they don't come from Ceres itself. They're debris from asteroid impacts that probably occurred tens of millions of years ago."

Ceres is considered to be both an asteroid and a dwarf planet, the only dwarf planet located in the inner solar system. Astronomers have classified Ceres, as well as 75 percent of all asteroids, as belonging to composition class "C" based on their similar colors.

But the mid-infrared spectra from SOFIA show that Ceres differs substantially from C-type asteroids in nearby orbits, challenging the conventional understanding of the relationship between Ceres and smaller asteroids. "By analyzing the spectral properties of Ceres we have detected a layer of fine particles of a dry silicate called pyroxene. Models of Ceres based on data collected by ...Read More...

Astronomers search for signs of life on Wolf 1061 exoplanet

An artist's rendering of an exoplanet is shown. An exoplanet is a planet that exists outside Earth's solar system. Credit: NASA/Ames/JPL-Caltech

Is there anybody out there? The question of whether Earthlings are alone in the universe has puzzled everyone from biologists and physicists to philosophers and filmmakers. It's also the driving force behind San Francisco State University astronomer Stephen Kane's research into exoplanets—planets that exist outside Earth's solar system.

As one of the world's leading "planet hunters," Kane focuses on finding "habitable zones," areas where water could exist in a liquid state on a planet's surface if there's sufficient atmospheric pressure. Kane and his team, including former undergraduate student Miranda Waters, examined the habitable zone on a planetary system 14 light years away. Their findings will appear in the next issue of Astrophysical Journal in a paper titled "Characterization of the Wolf 1061 Planetary System."

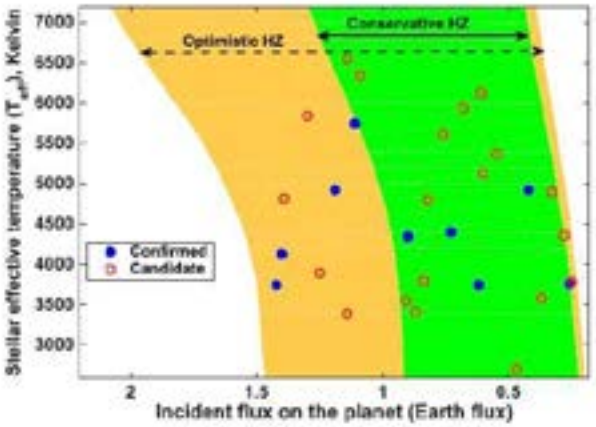
"The Wolf 1061 system is important because it is so close and that gives other opportunities to do follow-up studies to see if it does indeed have life," Kane said.

But it's not just Wolf 1061's proximity to Earth that made it an attractive subject for Kane and his team. One of the three known planets in the system, a rocky planet called Wolf 1061c, is entirely within the habitable zone. With assistance from collaborators at Tennessee State University and in Geneva, Switzerland, they were able to measure the star around which the planet orbits to gain a clearer picture of whether life could exist there.

When scientists search for planets that could sustain life, they are basically looking for a planet with nearly identical properties to Earth, Kane said. Like Earth, the planet would have to exist in a sweet spot often referred to as the "Goldilocks zone" where conditions are just right for life.

Simply put, the planet can't be too close or too far from its parent star. A planet that's too close would be too hot. If it's too far, it may be too cold and any water would freeze, which is what happens on Mars, Kane added. ..Read More...

A catalog of habitable zone exoplanets



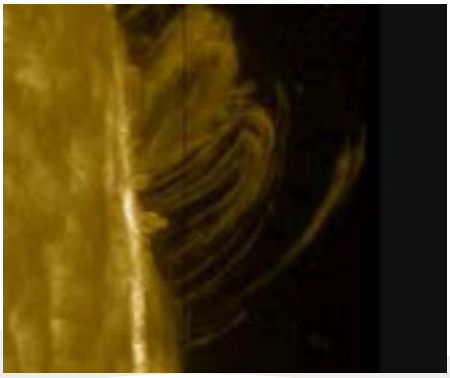
A plot of the flux incident on an exoplanet (in units of the amount on Earth) versus the host star's temperature. The plot shows two ranges for the habitable zone, conservative green area) and optimistic (yellow area); it also shows where confirmed (blue dots) and unconfirmed (red circles) exoplanets lie in the plot. There are currently twenty known exoplanet candidates smaller than two Earth-radii that fall in their optimistically-defined habitable zones. Credit: Kane et al. 2016

The last two decades have seen an explosion of detections of exoplanets, as the sensitivity to smaller planets has dramatically improved thanks especially to the Kepler mission. These discoveries have found that the frequency of planets increases to smaller sizes: terrestrial planets are more common than gas giants. The significance of a universe rich in terrestrial sized planets naturally leads to the question about the "habitable zone (HZ)" – the region around a star where a suitable planet could sustain the conditions necessary for life. In this zone, the balance between stellar radiation onto the planet and radiative cooling from the planet allows water on the surface to be a liquid. (The definition also includes consideration of the planet's atmosphere and solid surface.)

In our solar system, the Earth is cozily situated in the middle of the habitable zone which, depending on the model, extends roughly from Venus to Mars. The Kepler mission has as one of its primary goals the determination of the frequency of terrestrial planets in their habitable zones. CfA astronomer Guillermo Torres and his colleagues have now produced a complete catalog of Kepler exoplanet candidates in their habitable zones from the Kepler data releases to date. After reviewing the various criteria for determining the boundaries of the HZ, they report there are 104 candidates within an optimistic (larger) HZ definition, and twenty within a more conservative (smaller) definition of the HZ and which also have radii less than two Earth-radii, making this group in particular potential "Earth-like" candidates.

The scientists also refine the definitions for the HZ for the purpose of more useful statistical diagnostics. They define four overlapping subgroups: candidates in the conservatively defined zone with a radius less than 2 Earth-radii; those in the larger, optimistic zone with ...Read More...

Extreme space weather-induced blackouts could cost US more than $40 billion daily



The study looks at three geographical scenarios for blackouts caused by extreme space weather, depending on the latitudes affected by different types of incidents.

The daily U.S. economic cost from solar storm-induced electricity blackouts could be in the tens of billions of dollars, with more than half the loss from indirect costs outside the blackout zone, according to a new study.

Previous studies have focused on direct economic costs within the blackout zone, failing to take into account indirect domestic and international supply chain loss from extreme space weather.

"On average the direct economic cost incurred from disruption to electricity represents only 49 percent of the total potential macroeconomic cost," says the paper published in Space Weather, a journal of the American Geophysical Union. The paper was co-authored by researchers from the Cambridge Centre for Risk Studies at University of Cambridge Judge Business School; British Antarctic Survey; British Geological Survey and University of Cape Town.

Under the study's most extreme blackout scenario, affecting 66 percent of the U.S. population, the daily domestic economic loss could total $41.5 billion plus an additional $7 billion loss through the international supply chain.

Electrical engineering experts are divided on the possible severity of blackouts caused by "Coronal Mass Ejections," or magnetic solar fields ejected during solar flares and other eruptions. Some believe that outages would last only hours or a few days because electrical collapse of the transmission system would protect electricity generating facilities, while others fear blackouts could last weeks or months because those transmission networks could in fact be knocked out and need replacement.

Extreme space weather events occur often, but only sometimes affecting Earth. The best-known geomagnetic storm affected Quebec in 1989, sparking ...Read More...

This Week's Sky at a Glance, Jan. 21-28

Jan. 22	Moon at apogee 04:14 (404913 km)
Jan. 26	Mercury 3.7o S of Moon (04:46)
Jan. 28	New Moon (04:07)

UoS Students in Japan (Jan. 01 - 12, 2017)
AGI Workshop at SCASS (Jan. 16, 2017)

To enhance the capabilities of the CubeSat Laboratory at SCASS, his HE Prof. Hamid Al Naimiy has kindly accepted to send three Emirati students (Ali Nasir Salim Khalfan Al-hammadi, Rasheed Abdulla Saeed Al-Hamdy Al-Yammahi, and Eman Yousif Mohamed Ali Al-Ali) from the University of Sharjah to Japan (Chiba Institute of Technology) during the period Jan. 01-12, 2017. The UoS Emirati students were able to follow a rich program on the CanSat technology and the different technologies related to rockets launches. The program was organized under the supervision of the UAE Space Agency as part of a large program to initiate the young Emirati students to the CubeSat technology.

In the same Cubesat program atr SCASS, the Sharjah Center for Astronomy and Space Sciences and Analytical Graphics, Inc. (AGI) have organized a special one-day workshop on Monday, Jan. 16, 2017 under the theme "Space Mission design and Operation." The workshop was worked out as a training program for the members (students and faculty members) of the CubeSat Laboratory program at the University of Sharjah and the Sharjah Center for Astronomy and Space Sciences. The participants had a chance to analyze existing space missions and even create their space mission from scratch.

AGI is one of the leading companies that provides commercial software for designing, developing and operating missions within the space and national defense communities. Its best application STK is a 2D and 3D modeling environment used by engineers, mission analysts, operators and decision-makers from more than 700 global organizations to model complex systems (such as aircraft, satellites, ground vehicles and their sensors) to evaluate their performance in real or simulated time. Built on a time-dynamic, physics-based geometry engine, AGI software answers fundamental questions essential to solving dynamic analysis problems.

The fifteen students (half of them are Emirati students) that attended the workshop come from two main colleges of the University of Sharjah: Engineering and Sciences. These students are the ones that will be responsible for building the first CubeSat for the University of Sharjah with the help and guidance of eight faculty members.

Under the wise vision of His Highness Dr. Sheikh Sultan Bin Mohammed Al Qasimi, Supreme Council Member of Ruler of Sharjah and President of the University of Sharjah, the Sharjah Center of Astronomy and Space Sciences is moving forward in the pursuit of introducing space technologies to the University of Sharjah through the Sharjah Center of Astronomy and Space Sciences, and one of them is the CubeSat technology. Under the guidance of HE Prof. Hamid Al Naimiy, Chancellor of the University of Sharjah and Director of the Sharjah Center for Astronomy and Space Sciences, five laboratories related to astronomy and space sciences are being established at the center. The UAE as a whole and Sharjah, in particular, is quickly building a bright future in space-related programs. The UAE Mars Hope that will be launched in 2020 is one notable example.


OPENING CEREMONY