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Astronomy & Physics Weekly News

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Top News

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The cosmic weather report, as illustrated in this artist concept, calls for condensing clouds of cold molecular gas around the Abell 2597 Brightest Cluster Galaxy. The clouds condense out of the hot, ionized gas that suffuses the space between the galaxies in this cluster. New ALMA data show that these clouds are raining in on the galaxy, plunging toward the supermassive black hole at its center. Credit: NRAO/AUI/NSF; D. Berry / SkyWorks; ALMA (ESO/NAOJ/NRAO)

Scientists observe supermassive black hole feeding on cold gas

At the center of a galaxy cluster, 1 billion light years from Earth, a voracious, supermassive black hole is preparing for a chilly feast.

For the first time, astronomers have detected billowy clouds of cold, clumpy gas streaming toward a black hole, at the center of a massive galaxy cluster. The clouds are traveling at speeds of up to 355 kilometers per second—that's almost 800,000 miles per hour—and may be only 150 light years away from its edge, almost certain to fall into the black hole, feeding its bottomless well. The observations, which will be published in the journal Nature, represent the first direct evidence to support the hypothesis that black holes feed on clouds of cold gas.

The results also suggest that fueling a black hole—a process known as accretion—is a whole lot messier than scientists had once thought.

"The simple model of black hole accretion consists of a black hole surrounded by a sphere of hot gas, and that gas accretes smoothly onto the black hole, and everything's simple, mathematically," says Michael McDonald, assistant professor of physics in MIT's Kavli Institute for Astrophysics and Space Research. "But this is the most compelling evidence that this process is not smooth, simple, and clean, but actually quite chaotic and clumpy." ...Read More...

Cloudy days on exoplanets may hide atmospheric water

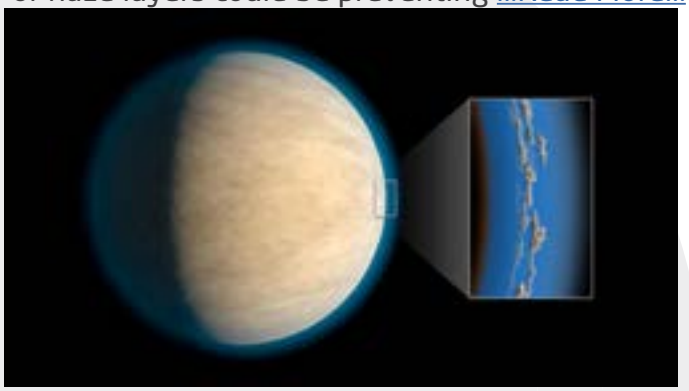
Water is a hot topic in the study of exoplanets, including "hot Jupiters," whose masses are similar to that of Jupiter, but which are much closer to their parent star than Jupiter is to the sun. They can reach a scorching 2,000 degrees Fahrenheit (1,100 degrees Celsius), meaning any water they host would take the form of water vapor.

Astronomers have found many hot Jupiters with water in their atmospheres, but others appear to have none. Scientists at NASA's Jet Propulsion Laboratory, Pasadena, California, wanted to find out what the atmospheres of these giant worlds have in common.

Researchers focused on a collection of hot Jupiters studied by NASA's Hubble Space Telescope. They found that the atmospheres of about half of the planets were blocked by clouds or haze.

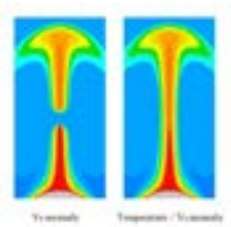
"The motivation of our study was to see what these planets would be like if they were grouped together, and to see whether they share any atmospheric properties," said Aishwarya Iyer, a JPL intern and master's degree candidate at California State University, Northridge, who led the study.

The new study, published in the June 1 issue of the Astrophysical Journal, suggests that clouds or haze layers could be preventing ...Read More...



Hot Jupiters, exoplanets around the same size as Jupiter that orbit very closely to their stars, often have cloud or haze layers in their atmospheres. This may prevent space telescopes from detecting atmospheric water that lies beneath the clouds, according to a study in the Astrophysical Journal. Credit: NASA/JPL-Caltech

Constraining the composition of Earth's interior with elasticity of minerals



The schematic plot of VP and VS anomaly caused by thermal anomaly under spin transition of iron in ferropericalse. Image courtesy Science China Press

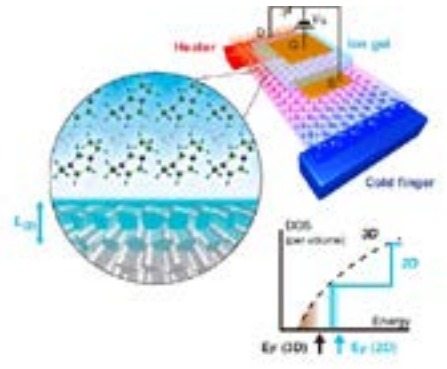
The composition and temperature of the Earth's interior are fundamental for us to understand the Earth' interior and his dynamics. Because of the impossibility to access directly most areas of the Earth's interior, the combination of the elasticity of minerals at high temperature and pressure (PT) and the seismic results becomes one of most practical ways to constrain the temperature and chemical composition of Earth's interior.

This is done by answering what kinds of aggregates of minerals have the sound velocities and densities of Earth's interior. Therefore the elasticity of minerals at high PT is crucial for us to translate the seismic sound velocity into the composition and temperature.

However, obtaining elasticity of minerals at high PT is highly challenging for experimental measurements and extremely expensive using the first-principles calculations. Wu and Wentzcovitch (2011) developed a new method, which reduces the computational loads to one-tenth of the traditional method.

he geometry and topology of electronic states in solids plays a central role in a wide range of modern condensed-matter systems including graphene or topological insulators. However, experimentally accessing this information has proven to be challenging, especially when the bands are not well-isolated from one another. As reported in last week's issue of Science, an international team of researchers has devised a straightforward method to probe the band geometry using ultracold atoms in an optical lattice. Their method, which combines ...Read More...

Converting waste heat into electricity works better in two dimensions



The enlarged illustration (in the circle) shows a 2D electron gas on the surface of a zinc oxide semiconductor. When exposed to a temperature difference, the 2D region exhibits a significantly higher thermoelectric performance compared to that of bulk zinc oxide. The bottom figure shows that the electronic density of states distribution is quantized for 2D and continuous for 3D materials. Credit: Shimizu et al. ©2016 PNAS

The large amount of waste heat produced by power plants and automobile engines can be converted into electricity due to the thermoelectric effect, a physics effect that converts temperature differences into electrical energy. Now in a new study, researchers have confirmed theoretical predictions that two-dimensional (2D) materials—those that are as thin as a single nanometer—exhibit a significantly higher thermoelectric effect than three-dimensional (3D) materials, which are typically used for these applications.

The study, which is published in a recent issue of the Proceedings of the National Academy of Sciences by Sunao Shimizu et al., could provide a way to improve the recycling of waste heat into useful energy.

Previous research has predicted that 2D materials should have better thermoelectric properties than 3D materials because the electrons in 2D materials are more tightly confined in a much smaller space. This confinement effect changes the way that the electrons can arrange themselves. In 3D materials, this arrangement (called the density of states distribution) is continuous, but in 2D materials, this distribution becomes quantized—only certain values ...Read More...

Students Experience "NASA Satellites 101"

Pi-Sat is a small satellite based on the Raspberry Pi computer. It is low-cost and easy to use, making it ideal for classroom-built satellites. Image courtesy NASA/Alan Cudmore.

Astronauts aren't the only ones who get to use NASA technology. Computer scientists and engineers at NASA's Goddard Space Flight Center in Greenbelt, Maryland, work to make flight software and satellite technology more accessible in an effort to engage the public and educate students. Students at Capitol Technology University in Laurel, Maryland, for example, use NASA technologies to develop their own computers and build their own small satellites known as CubeSats.

There has been an increasing interest in small satellite and CubeSat architecture. However, CubeSat software can often be too complex to implement into the classroom. But thanks to a novel technology known as Pi-Sat, developing flight software for satellites and other systems is more accessible than ever before. The Pi-Sat is a low-cost, easy-to-use test bed that facilitates the research and development of software for small satellite and CubeSat architectures.

"Even though the CubeSat is a compact spacecraft, it has all the complexities of a large spacecraft," said David McComas, head of the Flight Software System branch at Goddard. "Now, with Pi-Sat, we have something everyone can use. You can literally just hook up a ...Read More...

Perovskite solar cells surpass 20 percent efficiency

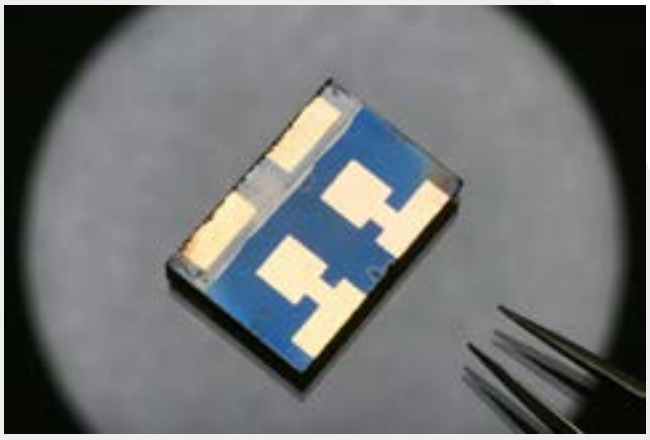
EPFL researchers are pushing the limits of perovskite solar cell performance by exploring the best way to grow these crystals.

Michael Graetzel and his team found that, by briefly reducing the pressure while fabricating perovskite crystals, they were able to achieve the highest performance ever measured for larger-size perovskite solar cells, reaching over 20% efficiency and matching the performance of conventional thin-film solar cells of similar sizes. Their results are published in Science.

This is promising news for perovskite technology that is already low cost and under industrial development.

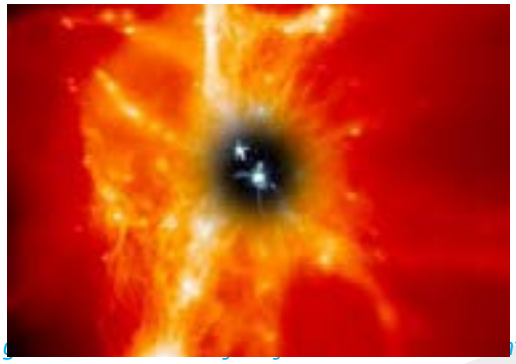
However, high performance in pervoskites does not necessarily herald the doom of silicon-based solar technology. Safety issues still need to be addressed regarding the lead content of current perovskite solar-cell prototypes in addition to determining the stability of actual devices.

Layering perovskites on top of silicon to make hybrid solar panels may actually boost the silicon solar-cell industry. Efficiency could exceed 30%, with the theoretical limit being around 44%. The improved performance would come ...Read More...



Perovskite solar cell prototype. Credit: Alain Herzog / EPFL

Wasteful galaxies launch heavy elements into surrounding halos and deep space



Spiral g… …ter, surrounded by the circumgalactic medium, which appears as black to our eyes. However, the circumgalactic medium contains very hot gas, shown in red, orange, and white that outweighs the central galaxies. The Cosmic Origins Spectrograph on the Hubble Space Telescope is an ultra-violet spectrograph that can probe these gaseous filaments and clumps. Image courtesy Adrien Thob, LJMU.

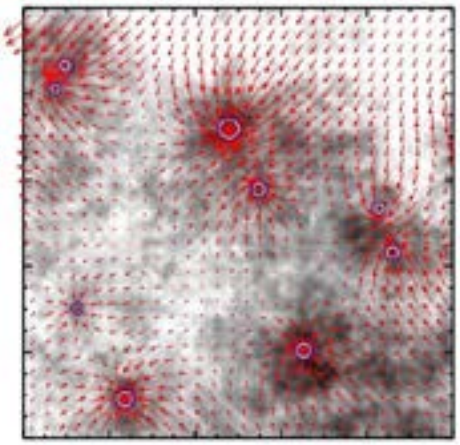
Galaxies "waste" large amounts of heavy elements generated by star formation by ejecting them up to a million light years away into their surrounding halos and deep space, according to a new study led by the University of Colorado Boulder.

The research, which was recently published online in the Monthly Notices of the Royal Astronomical Society, shows that more oxygen, carbon and iron atoms exist in the sprawling, gaseous halos outside of galaxies than exist within the galaxies themselves, leaving the galaxies deprived of raw materials needed to build stars and planets.

"Previously, we thought that these heavier elements would be recycled in to future generations of stars and contribute to building planetary systems," said Benjamin Oppenheimer, a research associate in the Center for Astrophysics and Space Astronomy (CASA) at CU-Boulder and lead author of the study. "As it turns out, galaxies aren't very good at recycling."

The near-invisible reservoir of gas that surrounds a galaxy, known as the circumgalactic medium (CGM), is thought to play a central role in cycling elements in and out of the galaxy, but the exact mechanisms of this relationship ...Read More...

The mystery of the initial mass function solved



A model … sity distribution. Dense cores where proto-stars are forming are marked and gravitational forces generated by them are shown. Image courtesy Igor Chilingarian, Andrei Klishin.

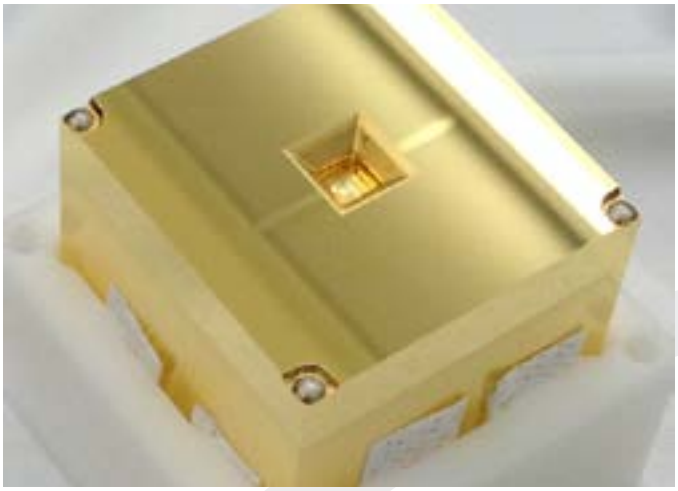
For the first time, scientists used methods of network science to solve a fundamental astrophysical problem - explaining the so-called "initial mass function", a distribution of stars by mass in galaxies and starclusters.

Andrei Klishin (an MIT graduate of 2015, currently a graduate student at the University of Michigan) under the supervision of Igor Chilingarian (researcher at Sternberg Astronomical Institute, Moscow State University and Smithsonian Astrophysical Observatory) applied methods of network science to solve a fundamental astronomical problem standing for 60 years, the origin of the Stellar Initial Mass Function.

"Such methods have been used across different research fields, from sociology and information science to molecular biology, but never before in astrophysics", Igor Chilingarian says.

The Stellar Initial Mass Function is a function that describes relative fractions of stars having different masses in a stellar system or a ratio of big and small stars in galaxies. In 1955, the theoretical physicist and astrophysicist Edwin Salpeter was the first to derive this distribution law empirically in the Solar neighborhood using star counts (presently known as the "Salpeter initial mass function"). He demonstrated that the distribution of stars by mass ...Read More...

Prototype gravitational wave spacecraft sets new free fall record



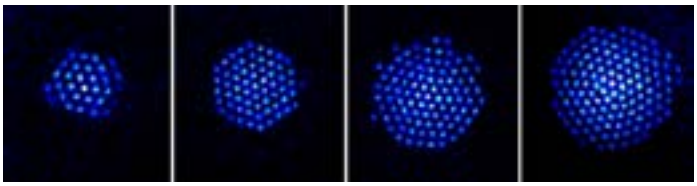
Test masses carved from blocks of high purity gold-platinum alloy, and weighing nearly 2 kilograms, are flying aboard the LISA Pathfinder spacecraft in the development of systems that will detect gravitational waves as part of the forthcoming LISA space-based gravitational wave observatory. Credit: European Space Agency, CGS SpA

A key component of a future gravitational wave observatory passed a series of tests with flying colors, while coming closer to experiencing true free fall than any other human-made object ever has. At the heart of the experiment is a two-kilogram cube of a high-purity gold and platinum alloy that is currently sailing through space almost completely free of any force other than gravity. The Laser Interferometer Space Antenna (LISA) Pathfinder mission is a European Space Agency (ESA) project that proves in principle that a formation of such cubes flown in space will be able to function as a space-based gravitational wave observatory, which will be able to detect signals from supermassive black hole collisions and other violent events that would be impossible to see on Earth.

A paper detailing the experiment will be published in the journal Physical Review Letters on June 7, 2016.

The free-falling test mass, as the gold and platinum cube is known, is nestled inside the shell-like LISA Pathfinder spacecraft, and has been orbiting a location in space called ...Read More...

Super quantum simulator 'entangles' hundreds of ions



NIST physicists have built a quantum simulator made of trapped beryllium ions (charged atoms) that are proven to be entangled, a quantum phenomenon linking the properties of all the particles. The spinning crystal, about 1 millimeter wide, can contain anywhere from 20 to several hundred ions. Credit: NIST

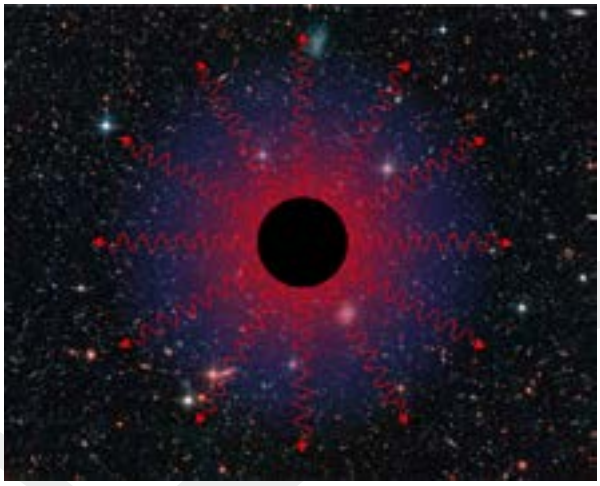
Physicists at the National Institute of Standards and Technology (NIST) have "entangled" or linked together the properties of up to 219 beryllium ions (charged atoms) to create a quantum simulator. The simulator is designed to model and mimic complex physics phenomena in a way that is impossible with conventional machines, even supercomputers. The techniques could also help improve atomic clocks.

The new NIST system can generate quantum entanglement in about 10 times as many ions as any previous simulators based on ions, a scale-up that is crucial for practical applications. The behavior of the entangled ions rotating in a flat crystal just 1 millimeter in diameter can also be tailored or controlled to a greater degree than before.

Described in the June 10, 2016, issue of Science, NIST's latest simulator improves on the same research group's 2012 version by removing most of the earlier system's errors and instabilities, which can destroy fragile quantum effects.

"Here we get clear, indisputable proof the ions are entangled," NIST postdoctoral researcher Justin Bohnet said. "What entanglement represents in this case is a useful resource for something else, like quantum simulation or to enhance a measurement in an atomic clock." ... Read More...

Hawking team updates soft hair theory to help solve black hole information paradox



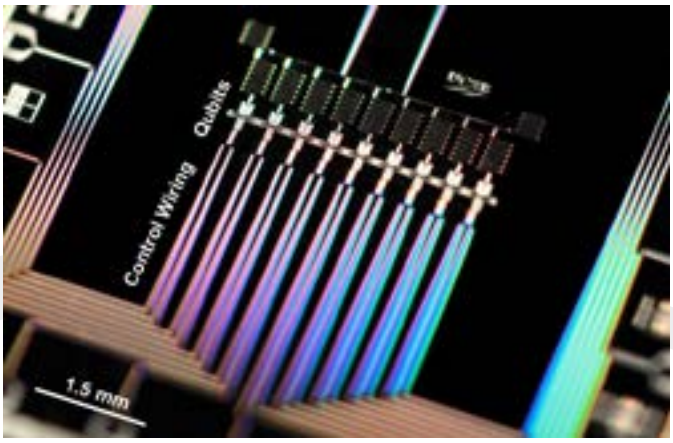
Hawking, Perry, and Strominger suggest that black holes might have "soft hair," low-energy quantum excitations that release information when the black hole evaporates. Credit: APS/Alan Stonebraker

Stephen Hawking, along with Malcolm Perry and Andrew Strominger has updated his ideas regarding solving the black hole information paradox. In their new paper published in the journal Physical Review Letters, the trio outlines their ideas regarding soft hair and black holes and why they believe it may hold the key to resolving a problem that has been causing issues for physicists for over forty years.

The black hole information paradox is relatively easy to understand—black holes theoretically suck in everything around them, including light, causing information to be lost, forever. But back in the 70's Hawking and colleagues discovered that some information escapes—it is now known as Hawking radiation—but the information that escapes is not enough to describe everything that was eaten by a given black hole, so, the question remains, what happens to the rest of the information when the black hole dies?

Trying to solve this paradox has proven to be much more difficult. But, this past January, progress was made, Hawking, Perry and Strominger proposed a possible solution to ....Read More...

Google combines two main quantum computing ideas in one computer



Quantum computer operating on 9 quantum bits. Credit: Julian Kelly

A team of researchers from Google, the University of the Basque Country, the University of California and IKERBASQUE, Basque Foundation for Science has devised a means for combining the two leading ideas for creating a quantum computer in one machine, offering a possible means for learning more about how to create a true quantum computer sometime in the future. They have published the details in the journal Nature.

Computer scientists would really like to figure out how to build a true quantum computer—doing so would allow for solving problems that are simply unsolvable on conventional machines. But, unfortunately, the idea behind such a computer is still mostly theoretical. To move some of the ideas from theory to reality, the researchers with this new effort have built an actual machine that is based on two of the strongest approaches to building a quantum computer.

The first approach is based on the gate model, where qubits are linked together to form primitive circuits that together form quantum logic gates. In such an arrangement, each logic gate is capable of performing one specific type of operation. Thus, to make use of such a computer, each of the logic gates must be programmed ahead of time to carry out ....Read More...

Dept. of Applied Physics & Astronomy

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