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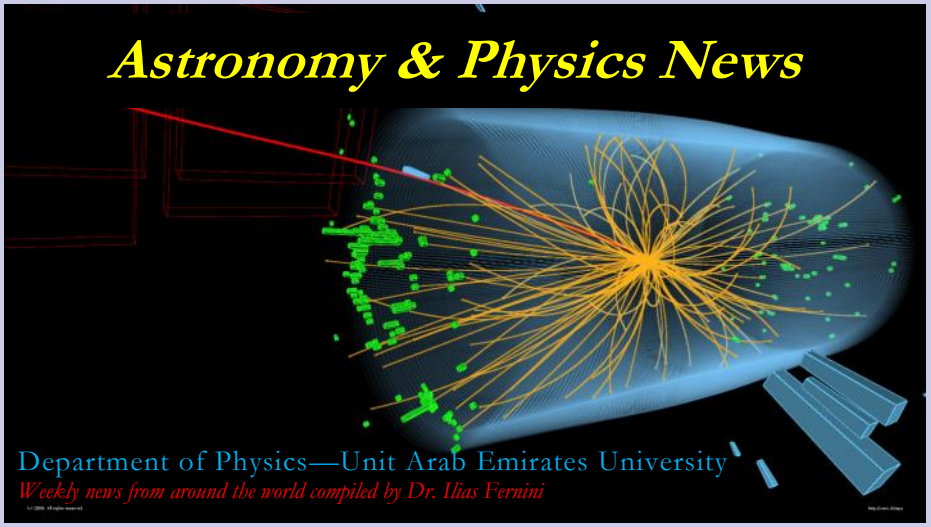


Inside this issue:

Ten of the biggest science and technology stories of 2014

This past year was an exciting time for science researchers—new discoveries and advances were made and more was learned about space, subatomic physics, speeding up computers and historical accomplishments, to name just a few. Below, we highlight what we feel were ten of the biggest stories of the year:

Superheavy element 117 was confirmed by a research team in Germany—The periodic table of elements grew bigger by one as an international team of researchers working at Germany's GSI laboratory artificially created atoms of element 117 using an accelerator. The group published its findings in Physical Review Letters, outlining how they caused the atoms to come about and describing it as 40 percent heavier than lead. The new element will get a formal name only after formal review by the International Unions of Pure and Applied Physics and Chemistry.

Engineers took a big step toward using light instead of wires inside of computers—A team working at Stanford designed and built a prism-like device able to split light into its separate colors and then to bend each of the different components at right angles. They described their "optical link" in a paper published in Scientific Reports. It is a very small slice of silicon etched with a specific pattern that looks a lot like a bar code. The team believes the device could lead to using optics rather than electricity to carry data around inside of a computer.

Superconductivity achieved without the need for cooling——a team of researchers from across the globe working at the Max Planck Institute and the SLAC National Accelerator Laboratory, succeeded for the first time in achieving superconductivity in a material without having to cool it down first. As the group explained in a paper published in the journal Nature, they used short infrared laser pulses to cause a piece of ceramic to become superconductive, if only for a few millionths of a second. Excitingly, the team ...***Read More***...

Making the Trip to Mars Cheaper and Easier: The Case for Ballistic Capture

When sending spacecraft to Mars, the current, preferred method involves shooting spacecraft towards Mars at full-speed, then performing a braking maneuver once the ship is close enough to slow it down and bring it into orbit.

Known as the "Hohmann Transfer" method, this type of maneuver is known to be effective. But it is also quite expensive and relies very heavily on timing. Hence why a new idea is being proposed which would involve sending the spacecraft out ahead of Mars' orbital path and then waiting for Mars to come on by and scoop it up.

This is what is known as "Ballistic Capture", a new technique proposed by Professor Francesco Topputo of the Polytechnic Institute of Milan and Edward Belbruno, a visiting associated researcher at Princeton University and former member of NASA's Jet Propulsion Laboratory.

In their research paper, which was published in arXiv Astrophysics in late October, they outlined the benefits of this method versus traditional ones. In addition to cutting fuel costs, ballistic capture would also provide some flexibility when it comes to launch windows….***Read More***...

A new proposal for sending craft to Mars could save money and offer more flexible launch windows. Credit: NASA

Making a Good Thing Better for Lithium Ion Batteries

The lithium-ion batteries that mobilize our electronic devices need to be improved if they are to power electric vehicles or store electrical energy for the grid. Berkeley Lab researchers looking for a better understanding of liquid electrolyte may have found a pathway forward.

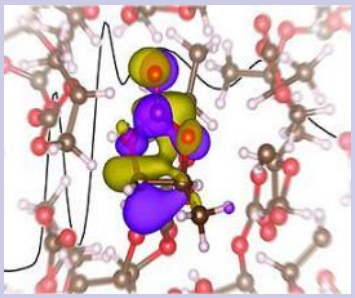
A team led by Richard Saykally, a chemist with Berkeley Lab's Chemical Sciences Division, David Prendergast, a theorist with Berkeley Lab's Molecular Foundry, and Steven Harris, a chemist with the Lab's Materials Sciences Division, found surprising results in the first X-ray absorption spectroscopy study of a model lithium electrolyte.

"A crucial process in lithium ion batteries is the transport of lithium ions between the electrodes," explains Saykally.

"Commercial lithium-ion batteries contain a liquid electrolyte comprising a lithium salt dissolved in an alkyl carbonate solvent system. There's disagreement in the battery industry on the nature of the local solvation environment of lithium ions in these solutions, a critical issue because the desolvation of the ions as they move through the negative electrode is believed to limit the electrical power that can be made available."

Most previous computational simulations have predicted a tetrahedral solvation structure for the lithium ion in the electrolyte, but the new study by Saykally, Prendergast, Harris and their collaborators show this to not be the case.

"Our results indicate a solvation ...***Read More***...



X-ray absorption spectra, interpreted using first-principles electronic structure calculations, provide insight into the solvation of the lithium ion in propylene carbonate. Image courtesy Rich Saykally, Berkeley.

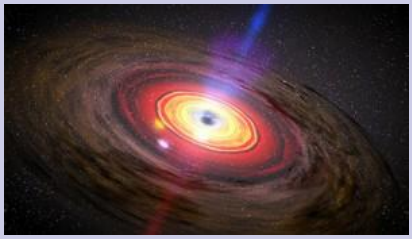
Watching a Quasar Shut Down

Most large galaxies contain a central supermassive black hole. Some — such as the one in the Milky Way's center — are dormant beasts. Others, known as quasars, outshine their host galaxies as they chow down on gas.

Black holes must transition from active to dormant status, but big changes should occur on astronomical timescales that dwarf human lifetimes. So when Stephanie LaMassa (Yale University) found two radically different spectra of an object measured just 10 years apart, she was shocked.

Most of quasars' visible-light emission comes from the hot accretion disk that feeds the black hole. Orbiting gas clouds, heated and ionized by the disk, make their contribution to the visible spectrum in the form of emission lines. These wavelength-specific spikes of emission may vary in brightness, but they don't generally change shape. Some lines are fat, spreading their emission over a wide range of wavelengths, while others are skinny. Typically, fat lines stay fat and skinny lines stay skinny.

The first spectrum, measured in 2000 with the Sloan Digital Sky Survey, resembled a classic quasar: blue in color with broad emission lines. But the second spectrum, measured in 2010 as part of the BOSS Survey, didn't exhibit those same emission lines. The broad component of one emission line, known as H-beta, had disappeared entirely, and another, known as H-alpha, had become only ...***Read More***..



An artist's conception of a quasar. NASA / Dana Berry

Study unveils new half-light half-matter quantum particles

Prospects of developing computing and communication technologies based on quantum properties of light and matter may have taken a major step forward thanks to research by City College of New York physicists led by Dr. Vinod Menon.

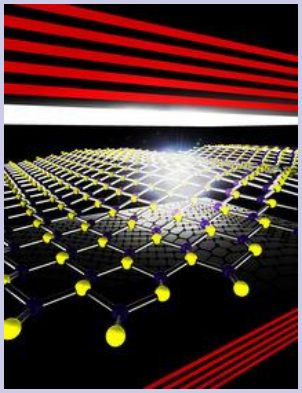
In a pioneering study, Professor Menon and his team were able to discover half-light, half-matter particles in atomically thin semiconductors (thickness ~ a millionth of a single sheet of paper) consisting of two-dimensional (2D) layer of molybdenum and sulfur atoms arranged similar to graphene. They sandwiched this 2D material in a light trapping structure to realize these composite quantum particles.

"Besides being a fundamental breakthrough, this opens up the possibility of making devices which take the benefits of both light and matter," said Professor Menon.

For example one can start envisioning logic gates and signal processors that take on best of light and matter. The discovery is also expected to contribute to developing practical platforms for quantum computing.

Dr. Dirk Englund, a professor at MIT whose research focuses on quantum technologies based on semiconductor and optical systems, hailed the City College study.

"What is so remarkable and exciting in the work by Vinod and his team is how readily this strong coupling regime could actually be achieved. They have shown convincingly that by coupling a rather ...***Read More***...



File Image.

Universality of charge order in cuprate superconductors

The discovery of superconductivity in cuprates, a class of ceramic materials, in 1986 has boosted an impressive effort of research all around the world. These materials still hold the record for the temperature where lossless conduction of electricity can be obtained. This is why they are called high-Tc superconductors, despite the fact that high-Tc means only minus 140 degrees centigrade.

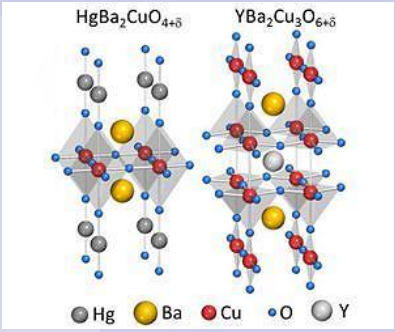
While this seems rather low, it is in fact very high compared to classical superconductors discovered at the beginning of the 20th century, where cooling close to the absolute temperature zero, minus 274 degrees, is required for the emergence of this exotic, yet very useful property.

The exciting jump of the transition temperature with the discovery of the high-Tc superconductors still nurtures hope that lossless conduction of electricity may be possible close to room temperature some day.

Still not well understood: High Tc Superconductivity

The phenomenon of superconductivity is well understood -- for the classical superconductors. When not being in the superconducting state, classical superconductors behave like metals, and superconductivity emerges from this metallic state by the pairing of electrons. Pairing of mobile charge carriers is also what is behind the superconductivity of the cuprates.

However, these ceramic superconductors are materials, where even the non-superconducting state is hardly understood, let alone the mechanism behind the pairing of the charge carriers. This is why new insights into the properties of the cuprates still keep scientists excited -- even almost 30 years after the discovery of high-Tc superconductivity...***Read More***...



These are the crystal structures of HgBa2CuO4+ and YBa2Cu3O6+. Image courtesy Nature Communications.

Student Team Wants to Terraform Mars Using Cyanobacteria

While scientists believe that at one time, billions of years ago, Mars had an atmosphere similar to Earth's and was covered with flowing water, the reality today is quite different. In fact, the surface of Mars is so hostile that a vacation in Antarctica would seem pleasant by comparison.

In addition to the extreme cold, there is little atmosphere to speak of and virtually no oxygen. However, a team of students from Germany wants to change that. Their plan is to introduce cyanobacteria into the atmosphere which would convert the ample supplies of CO_2 into oxygen gas, thus paving the way for possible settlement someday.

The team, which is composed of students and volunteer scientists from the University of Applied Science and the Technical University in Darmstadt, Germany, call their project "Cyano Knights". Basically, they plan to seed Mars' atmosphere with cyanobacteria so it can convert Mars' most abundant gas (CO_2, which accounts for 96% of the Martian atmosphere) into something breathable by humans.

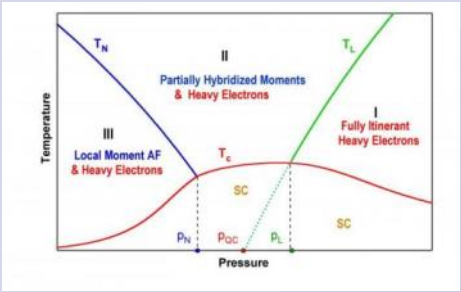
Along with teams from other universities and technical colleges taking part in the Mars One University Competition, the Cyano Knights hope that their ...***Read More***..

Artist concept of a 'Living' Mars. Credit: Kevin Gill

Simplicity will out: Novel experiment-based expression explains behavior of unconventional superconductors

Superconductivity – perhaps the leading example of emergent quantum behavior in matter – was discovered in 1911 but lacked theoretical explanation for almost five decades. In 1957, John Bardeen, Leon Cooper, and John Robert Schrieffer (BCS) developed a microscopic theory of superconductivity1 that came to be known as the BCS theory, which describes superconductivity as a microscopic effect caused by a condensation of Cooper pairs into a boson-like state. BCS theory explains the behavior of what are now known as conventional superconductors – metals for which phonons provide the recently controversial "pairing glue" that leads to the effective attractive quasiparticle interaction responsible for their superconductivity. (Phonons are quantized lattice vibrations, and quasiparticles are mobile electrons or holes in materials; both are quantized elementary excitations.)

As it is wont to do, history is now repeating itself : Unconventional superconductors, in which pairing glue and pairing ..***Read More***..



A phase diagram for heavy-electron superconductors. In region I, only itinerant heavy electrons exist below TL owing to complete hybridization of the f-moments with background conduction electrons; in region II, collective hybridization is not complete so that heavy electrons coexist with partially hybridized local moments; in region III, these residual moments order antiferromagnetically (AF) at TN and the surviving heavy electrons become superconducting (SC) at a lower temperature, Tc. The coupling of heavy electrons to the magnetic spin fluctuations emanating from the QCP is responsible for the superconductivity in all regions. Credit: Yang Y-F, Pines D (2014) Emergence of superconductivity in heavy-electron materials. Proc Natl Acad Sci USA 111(51):E18178-18182.

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What's Up in our Sky in January 2015

01- Comet C/2012 Q2 Lovejoy may reach naked eye visibility.

04- The Quadrantid meteors peak at 02:00 UT, favoring northern Europe with an expected ZHR of 120.

04- The Earth reaches perihelion at ~8:00 UT.

14- Mercury reaches greatest evening elongation 18.9° east of the Sun at ~16:00 UT.

17- The moons Io and Europa cast a double shadow on Jupiter from 3:53 to 4:58 UT.

20- Mars passes 0.2 degrees from Neptune at ~20:00 UT.

24- A triple shadow transit of Jupiter's moons occurs from 6:26 to 6:54 UT.

29- The Moon occults Aldebaran at ~17:31 UT for the Arctic, marking the first of 13 occultations of the star by the Moon in 2015.

For More About UAE Astronomy Events, check the following link: ***UAE Night Sky News***

Detecting extraterrestrial life using mechanical nanosensors

Looking for life on other planets is not straightforward. It usually relies on chemical detection, which might be limited or even completely irrelevant to alien biology. On the other hand, motion is a trait of all life, and can be used to identify microorganisms without any need of chemical foreknowledge. EPFL scientists have now developed an extremely sensitive yet simple motion detector that can be built easily by adapting already-existent technology. The system has proven accurate with detecting bacteria, yeast, and even cancer cells, and is considered for the rapid testing of drugs and even the detection of extraterrestrial life. The work is published in the Proceedings of the National Academy of Sciences (PNAS).

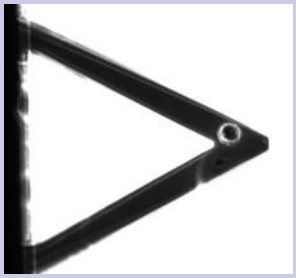
Giovanni Dietler, Sandor Kasas and Giovanni Longo at EPFL have developed a motion detector that uses a nano-sized cantilever to detect motion. A cantilever is essentially a beam that is anchored only at one end, with the other end bearing a load. The cantilever design is often used with bridges and buildings, but here it is implemented on the micrometer scale, and about 500 bacteria can be deposited on it.

The idea comes from the technology behind an existing microscope, the atomic force microscope. This powerful microscope uses a cantilever to produce pictures of the very atoms on a surface. The cantilever scans the surface like the needle of a record player and its up-and-down movement is read by a laser to produce an image.

The motion sensor the Dietler and Kasas developed works the same way, but here the sample is attached on the cantilever itself. For example, a bacterium attaches to the cantilever. If the bacterium is alive, it will inevitably move in some way, e.g. move its flagellum or simply carry out normal biological functions. That motion also moves the much smaller and sensitive cantilever and it is captured by the readout laser as series of vibrations. The signal is taken as a sign of life.

The EPFL scientists successfully tested their novel system with isolated bacteria, yeast, mouse and human cells. They even tested soil from the fields around the EPFL campus and water from the nearby Sorge river. In each case, they were able to accurately detect and isolate vibration signatures from living cells. When they used drugs to kill anything alive, the motion signals stopped.

"The system has the benefit of being completely chemistry-free," says Dietler. "That means that it can be used anywhere - in drug testing or even in the search for extraterrestrial life." The scientists envision a large array of cantilever sensors used in future space exploration probes like the Mars rover. As it relies on motion rather than chemistry, the cantilever sensor would be able to detect life forms in mediums that are native to other planets, such as the methane in the lakes of Titan….***Read More***….



Time-lapse movie of the movements of an osteoblast cell on the surface of a cantilever. Credit: PNAS 29 December 2014. doi: 10.1073/pnas.1415348112