對外合作組織與機構動態報導

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NEW PROTOTYPES FOR SUPERCONDUCTING UNDULATORS SHOW PROMISE FOR MORE POWERFUL, VERSATILE X-RAY BEAMS

應用新超導聚頻磁鐵使同步加速器產生更高能、波頻更廣的 X 光束

June 20, 2017

Researchers at the U.S. Department of Energy's Lawrence Berkeley National Laboratory (Berkeley Lab) and Argonne National Laboratory have collaborated to design, build and test two devices that utilize different superconducting materials and could make X-ray lasers more powerful, versatile, compact and durable.

報告摘要(KEY INFORMATION)

1. 在過去數十年中，阿岡實驗室先進光子源的團隊致力進行一最具挑戰性的計畫——加速器中聚頻磁鐵的研究，該研究於自由電子雷射器的應用可望為該實驗室與全國科學研究作出更大貢獻。
2. 自從 4 月的高峰會之後，中美關係趨向穩定。5 月 17 日一帶一路國際合作高峰論壇在北京舉行，中國領導人習近平強調互利共商、中國無意干涉他國內政或強加任何意志，並表示該政策目前已有相當成果、進入全新階段。
3. 川普政權與俄羅斯疑有勾結一案已影響美俄關係。當歐洲那些倡議與俄維持和平者已失去動力，全世界轉而將焦點放在日俄關係的發展。
4. 混合水、二氧化碳，通電並加入適當的銅催化劑，以此法製造乙醇也許更加永續，但必須處理將主產物與 15 種副產物分離之耗能與昂貴成本問題。史丹佛科學家在以特定結晶銅作為催化劑時發現其催化選擇性，可望改變現狀。
5. 在科學家研究一種巨大的單細胞生物——天藍喇叭蟲——如何自癒時，遇到如何快速將細胞一分為二之問題，因此他們發明如生產線般的「細胞斷頭臺」，該工具使切分單一細胞的時間由 3 分鐘縮短至 3 秒內。

These prototype devices, called superconducting undulators (SCUs), successfully produced stronger magnetic fields than conventional permanent magnetic undulators of the same size. These fields, in turn, can produce higher-energy laser light to open up a broader range of experiments.

“For the past couple of decades, the APS engineering team has been constructing undulators for use at Argonne and across the country, and this may be the most challenging project so far.”

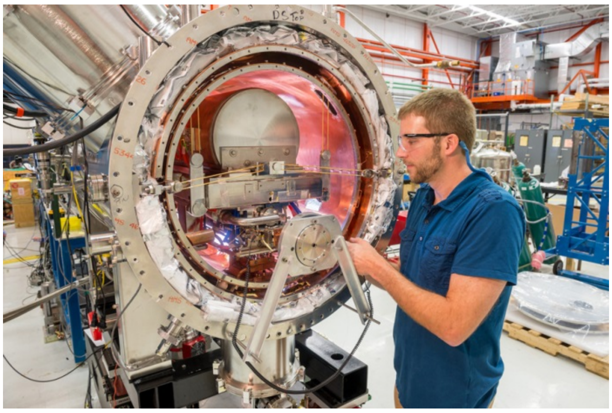
Several large-scale X-ray lasers are in the works around the globe to allow scientists to probe the properties of matter at ever smaller and faster scales, and superconducting undulators are considered among the most enabling technologies for the next generation of these and other types of light sources.

Such light sources are powerful tools for studying the microscopic structure and other properties of samples, such as proteins that are key to drug design, exotic materials relevant to electronics and energy applications, and chemistry that is central to industrial processes like fuel production.

The recent development effort was motivated by SLAC National Accelerator Laboratory’s upgrade of its Linac Coherent Light Source (LCLS), which is the nation’s only X-ray free-electron laser (FEL). The new project, now underway, is known as LCLS-II.

X-ray FELs now use permanent magnetic undulators to produce X-ray light by wiggling high-energy bunches of electrons in alternating magnetic fields produced by a sequence of permanent magnets.

But for the first time, Argonne scientists have demonstrated that a superconducting undulator could be used as a free-electron laser amplifier for the contemporary X-ray FELs.



The team at the Department of Energy’s Advanced Photon Source (APS) at Argonne successfully built and tested a 1.5-meter-long prototype SCU magnet designed to meet FEL undulator requirements. This SCU utilizes niobium-titanium superconducting wire for winding its magnetic coils.

This significant achievement could pave the way to expanding the X-ray energy range at existing light sources without increasing the electron beam energy. This is an important point because the construction cost of light facilities is mainly defined by the energy of the electron beam, said Efim Gluskin, an Argonne Distinguished Fellow and a physicist and interim group leader of the Magnetic Devices Group in the APS’s Accelerator Systems Division.

Gluskin said the niobium-titanium-based SCU has been designed to meet all challenging technical requirements applied to the X-ray FEL undulator, including high-precision field quality and consistency all along the magnet. In fact, it has been experimentally proven that this device has met all of these requirements. The APS SCU team has used in-house-developed cryogenic systems and magnetic measurement techniques to validate the SCU performance.

"The main challenge is to maintain the consistent wiggle motion of electrons inside of an SCU," said Gluskin, adding that the range of accepted deviation from the straight line of the beam motion across the distance of several meters is just a few microns. For comparison, an average human hair is 100 microns wide.

"That leads to very stringent requirements on the quality of the magnetic field generated by SCU magnets," Gluskin said.

SLAC's Paul Emma, the accelerator physics lead for the LCLS-II upgrade project coordinated the superconducting undulator development effort.

"With superconducting undulators," Emma said, "you don't necessarily lower the cost but you get better performance for the same stretch of undulator."

A superconducting undulator equivalent in length to a permanent magnetic undulator could produce light that is at least two to three times and perhaps up to 10 times more powerful, and could also access a wider range in X-ray wavelengths, Emma said. This produces a more efficient FEL.

Superconducting undulators have no macroscopic moving parts, so they could conceivably be tuned more quickly with high precision. Superconductors also are far less prone to damage by high-intensity radiation than permanent-magnet materials, a significant issue in high-power accelerators such as those that will be installed for LCLS-II.

There appears to be a clear path forward to developing superconducting undulators for upgrades of existing and new X-ray free-electron lasers, Emma said, and for other types of light sources.

"Superconducting undulators will be the technology we go to eventually, whether it's in the next 10 or 20 years," he said. "They are powerful enough to produce the light we are going to need – I think it's going to happen. People know it's a big enough step, and we've got to get there."

In this case, the APS team developed the technology of SCU construction to deliver a ready-to-go device right off the assembly bench.

"The SCU team found unique solutions for making this undulator performance within strict specifications of the LCLS undulator system," said Yury Ivanyushenkov, a physicist with the Argonne Accelerator Systems Division. "Over the years, the SCU team has put together a robust set of technological steps and processes to design and build state-of-the-art superconducting undulators that successfully operate at the APS. The success of this project is the direct result of the systems and facilities in place at the APS."

Geoffrey Pile, Associate Division Director of the APS Engineering Support Division at Argonne and former director of the APS LCLS-I undulator project, said the APS has a long history and expertise with designing and constructing undulators for the APS and other national labs.

One of the Argonne projects was the design and construction of the LCLS-I undulator system – 440 feet of sophisticated technical components that incorporated 33 cutting-edge undulators. The LCLS-I facility at the SLAC National Accelerator Laboratory has now been operating successfully for more than seven years.

In addition, APS scientists and engineers recently designed and built a revolutionary new Horizontal-Gap Vertically Polarizing Undulator prototype for the LCLS-II project. It was adopted and incorporated into the LCLS-II final design, and 32 production units will be constructed for SLAC by Lawrence Berkeley National Laboratory and industrial partners.

"For the past couple of decades, the APS engineering team has been constructing undulators for use at Argonne and across the country, and the SCU may be the most challenging project so far," Pile said. "It has moved the technology forward in leaps and bounds and highlights the expertise throughout the APS. Importantly, many industrial partners, people at Argonne, and our collaborators at SLAC and Berkeley contributed to the success of this project and deserve credit."

Gluskin agreed: "The development of this prototype is a culmination of more than a decade of Argonne commitments to new and innovative SCU technology that will benefit all DOE light sources."

Going forward, the APS and SLAC may collaborate on other components for the system, including beam position monitors, a phase shifter and alignment system.

The Advanced Light Source, Advanced Photon Source and Linac Coherent Light Source are DOE Office of Science User Facilities. The development of the superconducting undulator prototypes was supported by the DOE's Office of Science.

CHINA: US-CHINA RELATIONS FROM CHINA'S PERSPECTIVE AND JOINT CONSTRUCTIONOF THE BELT AND ROAD

中國觀察：從中國角度看美中關係與一帶一路之合作

By Li Zhidong

China is hoping that US-China relations have shifted toward stability since the Summit in April. President Trump has decided not to label China a currency manipulator. He declined a request from Taiwanese President Tsai Ing-wen for a telephone conference, and postponed plans to sell them weapons. Meanwhile, China has allegedly started to put pressure on North Korea, which is escalating its threats to the international community through nuclear experiments and ballistic missile launches, with a possible ban on oil exports. Further, as the first step of the 100-day plan to improve the trade imbalance, on May 11, China and the US agreed that China will restart importing beef and expand LNG imports from the US, the US will allow cooked poultry imports from China, and both countries will mutually open parts of their financial markets (China opening its card payment market to US firms, and the US applying the same supervisory regulations to Chinese financial institutions as to American ones). It is important to note the last of the 10 early achievement areas in the agreement, which states that "The United States recognizes the importance of China's Belt and Road Initiative and is to send delegates to attend the Belt and Road Forum (BRF) in Beijing May 14-15." According to Vice Finance Minister Zhu Guangyao, this item was proposed by the US.1 Hence, China is celebrating this achievement as President Trump's clear acceptance of President Xi's request for cooperation. Accordingly, the Summit is being praised as "having set the course of US-China relations in the new era," and hopes are reportedly rising for the future.

Under such circumstances, the BRF was held in Beijing on May 14 and 15, attended by representatives of more than 130 countries including the leaders of 29 countries. Representatives of more than 70 international organizations also joined the Forum, including UN Secretary-General Antonio Guterres, President Jim Yong Kim of the World Bank, and IMF Managing Director Christine Lagarde. The Belt and Road is an initiative of broad-area economic cooperation extending from China to Europe, the Mediterranean Sea, the Indian Ocean, and the South Pacific via routes on land and sea, and was announced by President Xi in the autumn of 2013. It is remarkable that support for the initiative has spread to many countries in just three years.

Meanwhile, it is also true that there has long been suspicion that the Belt and Road Initiative is a way for China "to use other countries to resolve its own overcapacity" and "to control other countries through economic aid." In response to such concerns, President Xi emphasized at the opening of the BRF that "the Initiative hopes to achieve a new model of win-win cooperation" and "China has no intention to interfere in other countries' internal affairs, export our own social system and model of development, or impose our own will on others." The joint statement adopted at the Summit also incorporated words indicating China's stance: "We uphold the spirit of peace, cooperation, openness, transparency, inclusiveness, equality, mutual learning, mutual benefit and mutual respect by strengthening cooperation on the basis of extensive consultation and the rule of law, joint construction, shared benefits and equal opportunities for all." Further, the statement also mentioned enhanced climate actions and strengthening cooperation in fully implementing the Paris Agreement, developing renewable energies, energy efficiency, and upgrading regional and international power grids.

In a press conference after the closing of the BRF, President Xi commented that the BRF has "yielded positive results" and "the Initiative has entered a new stage of full implementation." At the next BRF scheduled for 2019, the achievements of the "full implementation" will be analyzed. Developments, for which there are high expectations, must be closely monitored.

THE 'RUSSIA-GATE' CASTING DARK CLOUDS OVER RELATIONSHIP WITH THE WEST

近期俄門案使俄羅斯與歐洲的關係蒙上陰影

By Shoichi Itoh

May 9, U.S. President Trump stunned the world with the sudden dismissal of FBI Director James Comey. The dismissal has led to speculation about a possible obstruction of justice, as Director Comey was strengthening investigations of the alleged collusion between close aides of President Trump and Russia. This dismissal has been called "Russia-gate" after the Watergate scandal (August 1974) that eventually led to President Nixon's resignation, and is capturing the attention of the world.

On the day following Director Comey's dismissal, President Trump met Russia's Foreign Minister Sergei Lavrov at the White House in the latter first visit to the United States after Russia's annexation of Crimea in March 2014. While the United States officially announced that the main topics of the meeting included Syria, Iran, and Ukraine, Russia only acknowledged having discussions on Syria, Israel, and Afghanistan, and did not clarify whether Iran and Ukraine were addressed. After the meeting, Konstantin Kosachev, Chair of the Foreign Affairs Committee of the Federation Council, praised the result, saying that "U.S.-Russia relations have begun to thaw now that the administration recognizes Russia as a partner and an equal."

Despite President Trump's intention to mend U.S.-Russia relations, dark clouds are looming over the "Russia-gate". As criticisms mount over the dismissal even within the ruling Republican party, on May 17, the U.S. Justice Department appointed former FBI Director Robert Mueller as special prosecutor, and announced that "the investigation will include all areas including the Trump administration's connections with Russia." President Trump used Twitter to call this move "the single greatest witch hunt of a politician in American history," but the President's relationship with Russia is under increasing scrutiny in America. Due to such developments in the United States, the Russians are increasingly pessimistic about finding a way for mending relations with the US.

Despite Russia's initial expectations, Europe is moving away from a possible disunity on Russia that could lead to the lifting of economic sanctions. Besides the victory of the ruling party over the ultra-right party in the Dutch general election in March, on May 7, a centrist candidate, Emmanuel Macron, defeated Marine Le Pen, the leader of the National Front who officially promised to mend relations with Russia, in the French presidential election run-off. On the 29th, the new President Macron met President Putin in France and agreed to promote bilateral dialogue, but the former has underscored the importance of policy coordination with Germany. Meanwhile, the popularity of the ruling party led by Prime Minister Merkel is rising again in Germany. The German and Russian leaders held the first official summit in seven months on May 2 (in Sochi), but reportedly, President Putin did not respond directly to Prime Minister Merkel's demand to promptly implement the Minsk agreement.

On April 27, Prime Minister Abe had a summit meeting in Moscow, and agreed to move ahead with the Japan-Russia Agreement reached in December 2016, including efforts to conclude a peace treaty. As Russia's relationship with the West stagnates, the world is watching over developments in Japan-Russia relations.

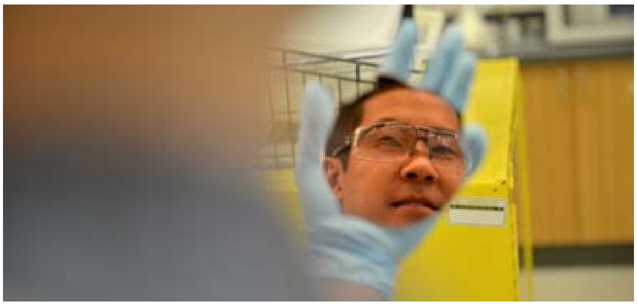
HOW DO YOU MAKE ETHANOL WITHOUT GROWING CORN?

如果不種玉米，要如何製造酒精？

By Mark Shwartz, June 20, 2017

Most cars and trucks in the United States run on a blend of 90 percent gasoline and 10 percent ethanol, a renewable fuel made primarily from fermented corn. But producing the 14 billion gallons of ethanol consumed annually by American drivers requires millions of acres of farmland.

A recent discovery by Stanford University scientists could lead to a new, more sustainable way to make ethanol without corn or other crops. This technology has three basic components: water, carbon dioxide and electricity delivered through a copper catalyst. The results are published in Proceedings of the National Academy of Sciences.



"One of our long-range goals is to produce renewable ethanol in a way that doesn't impact the global food supply," said study principal investigator Thomas Jaramillo, an associate professor of chemical engineering at Stanford and of photon science at the SLAC National Accelerator Laboratory.

"Copper is one of the few catalysts that can produce ethanol at room temperature," he said. "You just feed it electricity, water and carbon dioxide, and it makes ethanol. The problem is that it also makes 15 other compounds simultaneously, including lower-value products like methane and carbon monoxide. Separating those products would be an expensive process and require a lot of energy."

Scientists would like to design copper catalysts that selectively convert carbon dioxide into higher-value chemicals and fuels, like ethanol and propanol, with few or no byproducts. But first they need a clear understanding of how these catalysts actually work. That's where the recent findings come in.

Copper crystals

For the PNAS study, the Stanford team chose three samples of crystalline copper, known as copper (100), copper (111) and copper (751). Scientists use these numbers to describe the surface geometries of single crystals.

"Copper (100), (111) and (751) look virtually identical but have major differences in the way their atoms are arranged on the surface," said Christopher Hahn, an associate staff scientist at SLAC and co-lead lead author of the study. "The essence of our work is to understand how these different facets of copper affect electrocatalytic performance."

In previous studies, scientists had created single-crystal copper electrodes just 1-square millimeter in size. For this study, Hahn and his co-workers at SLAC developed a novel way to grow single crystal-like copper on top of large wafers of silicon and sapphire. This approach resulted in films of each form of copper with a 6-square centimeter surface, 600 times bigger than typical single crystals.

Catalytic performance

To compare electrocatalytic performance, the researchers placed the three large electrodes in water, exposed them to carbon dioxide gas and applied a potential to generate an electric current.

The results were clear. When the team applied a specific voltage, the electrodes made of copper (751) were far more selective to liquid products, such as ethanol and propanol, than those made of copper (100) or (111).

Ultimately, the Stanford team would like to develop a technology capable of selectively producing carbon-neutral fuels and chemicals at an industrial scale.

“The eye on the prize is to create better catalysts that have game-changing potential by taking carbon dioxide as a feedstock and converting it into much more valuable products using renewable electricity or sunlight directly,” Jaramillo said. “We plan to use this method on nickel and other metals to further understand the chemistry at the surface. We think this study is an important piece of the puzzle and will open up whole new avenues of research for the community.”

A MICROSCOPIC GUILLOTINE CUTS CELLS IN TWO

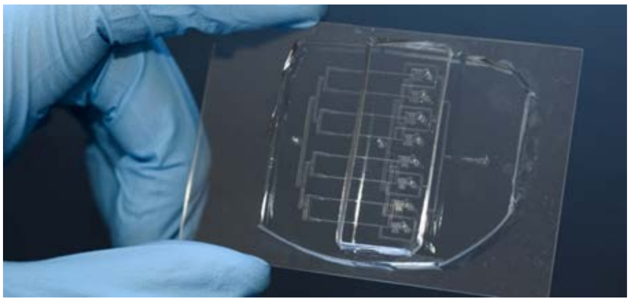
顯微鏡斷頭臺：將細胞切半

By Taylor Kubota, June 29, 2017

While doing research at the Woods Hole Marine Biological Laboratory in Massachusetts, Sindy Tang learned of a remarkable organism: *Stentor coeruleus*. It’s a single-celled, free-living freshwater organism, shaped like a trumpet and big enough to see with the naked eye. And, to Tang’s amazement, if cut in half it can heal itself into two healthy cells.

Tang, who is an assistant professor of mechanical engineering at Stanford University, knew right away that she had to study this incredible ability. “It is one of the Holy Grails of engineering to make self-healing materials and machines,” she said. “A single cell is analogous to a spacecraft – both have to figure out how to repair damage without anyone’s help from the outside.”

But before they could pursue that Holy Grail, Tang and fellow researchers needed a way to efficiently slice the cell in two – traditional methods take three minutes per cell and they needed hundreds for their experiments. To that end, they developed a new tool that is essentially an assembly line guillotine for cells. (See video here.) This device, detailed in the June 27 issue of the *Proceedings of the National Academy of Sciences*, pushes a row of cells down a tight channel onto a pointed knife blade, which cuts the cells evenly in half. This guillotine cuts *Stentor* cells 200 times faster than the previous method with similar survival rates.



In addition to spurring the development of self-healing materials, being able to efficiently study cell healing could eventually help scientists study and treat a variety of human diseases related to cell regeneration, such as cancer and neurodegenerative diseases, said Lucas Blauch, a graduate student in the Tang lab and lead author of the study.

Prior to Tang's cellular guillotine, scientists hoping to study *Stentor* had to slice the cells by hand under a microscope, using a glass needle.

"Cutting a single cell by hand takes about 3 minutes if you're good at it, and even if you're good at it, you can't always cut the cell equally in half. This method has not changed for over 100 years," said Blauch. "We knew that our lab's expertise in microfluidics would allow us to create a device to do that much faster."

Using the century-old cutting method, it would take a researcher five hours to cut 100 cells, and by the time they were done, the cells they cut first would be well on their way to healing. Tang's guillotine could cut 150 cells in just over 2 minutes, and the cuts were much more standardized and synchronized in the stage of their repair process. They achieved this rate by creating a scaled-up version of their tool with eight identical parallel channels that run simultaneously.

Now, Tang said, her group is ready to study how the cells heal. "From the engineering perspective, we hope to be able to extract basic principles from our studies, and apply them to engineering design to make self-healing materials and machines," she said.