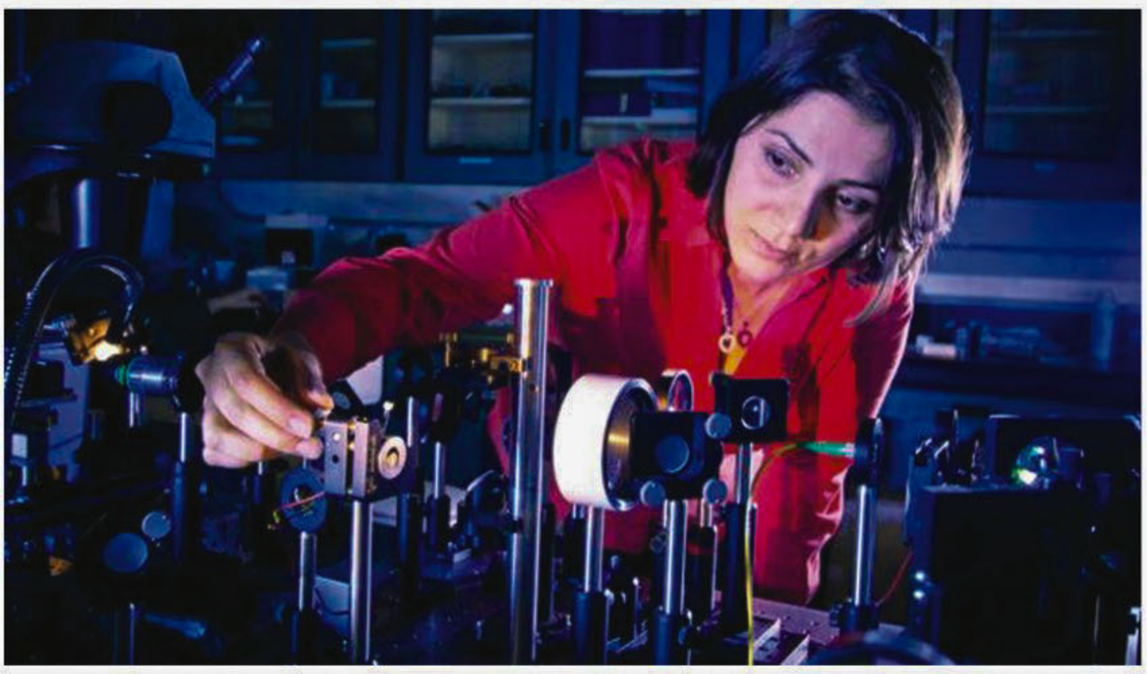
Engineers build no-waste laser



Mercedeh Khajavikhan in the lab.

A team of University of California, San Diego researchers has built the smallest room-temperature nanolaser to date, as well as an even more startling device: a highly efficient, "thresholdless" laser that funnels all its photons into lasing, without any waste.

The two new lasers require very low power to operate, an important breakthrough since lasers usually require greater and greater "pump power" to begin lasing as they shrink to nano sizes. The small size and extremely low power of these nanolasers could make them very useful components for future optical circuits packed on to tiny computer chips, Mercedeh Khajavikhan and her UC San Diego Jacobs School of Engineering colleagues report in the Feb. 9 issue of the journal Nature.

They suggest that the thresholdless laser may also help researchers as they develop new metamaterials, artificially structured materials that are already being studied for applications from super-lenses that can be used to see individual viruses or DNA molecules to "cloaking" devices that bend light around an object to make it appear invisible.

All lasers require a certain amount of "pump power" from an outside source to begin emitting a coherent beam of light or "lasing," explained Yeshaiahu (Shaya) Fainman, a professor in the Department of Electrical and Computer Engineering at UC San Diego and co-author of the new study. A laser's threshold is the point where this coherent output is greater than any spontaneous emission produced.

The smaller a laser is, the greater the pump power needed to reach the point of lasing. To overcome this problem, the UC San Diego researchers developed a design for the new lasers that uses quantum electrodynamic effects in coaxial nanocavities to alleviate the threshold constraint. Like a coaxial cable hooked up to a television (only at a much smaller scale), the laser cavity consists of a metal rod enclosed by a ring of metal-coated, quantum wells of semiconductor material. Khajavikhan and the rest of the team built the thresholdless laser by modifying the geometry of this cavity.

The new design also allowed them to build the smallest room-temperature, continuous wave laser to date. The new room-temperature nanoscale coaxial laser is more than an order of magnitude smaller than their previous record smallest nanolaser published in Nature Photonics less than two years ago. The whole device is almost half a micron in diameter -- by comparison, the period at the end of this sentence is nearly 600 microns wide.

These highly efficient lasers would be useful in augmenting future computing chips with optical communications, where the lasers are used to establish communication links between distant points on the chip. Only a small amount of pump power would be required to reach lasing, reducing the number of photons needed to transmit information, said Fainman.

The nanolaser designs appear to be scalable -- meaning that they could be shrunk to even smaller sizes -- an extremely important feature that makes it possible to harvest laser light from even smaller nanoscale structures, the researchers note. This feature eventually could make them useful for creating and analyzing metamaterials with structures smaller than the wavelength of light currently emitted by the lasers.

Fainman said other applications for the new lasers could include tiny biochemical sensors or high-resolution displays, but the researchers are still working out the theory behind how these tiny lasers operate. They would also like to find a way to pump the lasers electrically instead of optically.

Co-authors for the Nature study, "Thresholdless Nanoscale Coaxial Lasers," include Mercedeh Khajavikhan, Aleksandar Simic, Michael Kats, Jin Hyoung Lee, Boris Slutsky, Amit Mizrahi, Vitaliy Lomakin, and Yeshaiahu Fainman in the Department of Electrical and Computer Engineering at the UC San Diego Jacobs School of Engineering. The nanolasers are fabricated at the university's NANO3 facility. The research was funded by the Defense Advanced Research Projects Agency, the National Science Foundation, the NSF Center for Integrated Access Networks (CIAN), the Cymer Corporation and the U.S. Army Research Office.

Source: Science Daily

ICY VOID

How cold is space?

DEBASHISH CHAKRABARTY

HAVE you ever wondered how cold space or rather the vacuum is? The actual answer to that is further nuanced than you think. If you wonder about how cold is space you need to understand certain parameters about what is space. We now define space as outer space the region beyond the atmospheres of most celestial bodies. The region is considered to be the closest thing to a natural vacuum. However it is not completely empty. It does have some gases such as hydrogen and cosmic dust. This is called the interstellar medium.

When we wonder about heat we think about a form of energy. However we stop thinking about that heat like most forms of energy such as sound needs a medium to travel through. In the case of heat it needs matter to conduct it. A piece of forged iron when quenched transfers its thermal energy to the liquid that quenches it. If you place a plate of heated food out on a table for a long period of time the process of convection transfers the heat from the food to the air molecules surrounding it. In space the rules differ. A perfect vacuum has no molecules to transfer heat to. This means it can't properly conduct heat. This principle is used to store hot liquids in storage containers such as thermoses. Essentially even though you may think of space as cold it would actually allow hot objects to retain heat longer than if they were on earth.

The issue then is how cold it is in space where there is almost no source of heat nearby. If you were to measure the temperature of space with an accurate thermometer then you could say with certainty that space is cold and very cold at that. Of course, you would first have to wait the very long time necessary for all the ambient heat in the thermometer to radiate into space before you could get an accurate reading. The resulting temperature reading would be 2.73 Kelvin this is the coldest naturally occurring temperature to absolute zero. The reason that it is not at this temperature is due to background radiation left over from the formation of the Universe.

TUNING HOME

Homesick frog

The Emei music frog.

When wooing females, a type of frog in China describes its home through songconveying the depth and entrance size of the muddy burrow with some accuracy, a study suggests.

Scientists based at the Chinese Academy of Sciences and University of California investigated the frog Babina dauchina, better known as the Emei music frog thanks to its distinctive banjo-like call.

He male frogs build burrows alongside ponds to provide a suitable place for mating, laying eggs and rearing tadpoles. The researchers noticed that they seem to make different calls from inside and outside the burrows.

By analysing the acoustic properties of the calls and examining the way female frogs react to them, the scientists found that the male frogs not only advertise whether they have a burrow or not, but also its characteristics. Female music frogs are then able to choose the male with the most desirable real estate, without having to go through the time-consuming business of waiting to be shown round.

Males inside burrows play higher-pitched notes if the entrance is wider, and longer notes if the hole is deeper, the investigators explained. Also, "Inside-nest calls consisted of notes with energy concentrated at lower frequency [pitch] ranges and longer note durations when compared with outside-nest calls," they wrote, reporting their findings in Dec. 7 in the advance online edition of the journal Biology Letters.

Source: World Science

AFTER FUKUSHIMA

Third-generation nuclear reactor designed

THE United States has approved construction of new nuclear reactors for the first time in three decades. The two new reactors approved today (Feb. 9) for Georgia would represent the first U.S. versions of next-generation reactor designs that have begun appearing in China.

These "third-generation" reactors are said to be safer, with longer-lasting batteries and passive cooling systems powered by gravity so that they can survive longer during emergencies without outside power.

The Nuclear Regulatory Commission approved construction of the two reactors at an existing nuclear power plant in Vogtle, Ga., in a 4-1 vote.

"The last plant that got to this stage of the [approval] process did so in 1978," said Harold McFarlane, manager of the nuclear science and technology directorate at Idaho National Laboratory. "We think it's a very significant step going forward. It is the first of the new generation."

The U.S. froze construction of nuclear power plants after the partial core meltdown at Three Mile Island, Pa., in 1979. Consequently, the 104 nuclear plants still operating in the country have designs dating to the 1960s and 1970s. Meanwhile, the first of the third-generation plants were designed in the 1990s and were updated throughout the new millennium.

Following the devastating earthquake and tsunami that led to the meltdown at Japan's Fukushima Plant last March, Germany, Switzerland and Spain halted construction of any new nuclear power plants. However, energy-hungry China has pressed ahead with adding new, third-generation nuclear reactors.

A view of the Vogtle 4 nuclear island for the new third-generation plant, as well as the Vogtle 1 and 2 reactors already operating.

The newly approved AP1000 reactors for the Vogtle plant to be made by Westinghouse have safety features that would give people "days instead of hours" to restore electric power in a Fukushima scenario, McFarlane told InnovationNewsDaily. The Fukushima reactors suffered a meltdown after the lack of electricity knocked out their cooling systems.

In the new models, which Westinghouse already has built for China, "the water needed to cool the reactors is stored inside the containment building rather than outside of containment," explained Robert Buell, a risk analyst at Idaho National Laboratory. "You use physics and natural circulation along the containment walls to cool the reactors instead of relying on mechanical systems."

The Fukushima disaster did not go unmentioned during the Nuclear Regulatory Commission vote. According to the news service Reuters, NRC chairman Gregory Jaczko cast the lone vote against the new reactors, arguing that the commission should delay approval until it requires all nuclear plant operators to include "Fukushima enhancements" safety and operational lessons learned from the meltdown.

Source: Live Science

EVOLVED IN POLLUTION

Sooty-moth tale stands test

A recently criticized textbook example of evolutionary forces in action, the dark forms of peppered moths that spread with industrialization in Britain, may be on its way back.

Results of an ambitious experiment on the moths (Biston betularia) support the original hypothesis that their dark-colored forms spread in soot-coated landscapes because they are more difficult for hungry birds to spot, says evolutionary biologist James Mallet of Harvard University. He and three colleagues have published the final peppered moth experiment of Michael Majerus, who spent six years monitoring the fates of a total of 4,864 moths, presented his conclusions at a conference but died before publishing them. The study appears online February 8 in Biology Letters.

The moth story not only makes "a compelling example of evolution in action," but it's "a terrific case history of how science works," says evolutionary biologist Scott Freeman of the University of Washington in Seattle. "Majerus raised questions; he and his colleagues did the hard work required to answer them."

The moths, which usually have salt-white wings sprinkled with pepper-black, have long played a role in evolutionary biology. In the early years of genetics, breeding experiments established that a single gene can create a black form. It showed up in Manchester, England, in 1848, and by 1895, 98 percent of the region's moths were dark. Moths went dark in similarly industrializing areas, and when clean-air regulations began to clear the pollution, dark forms went into decline.

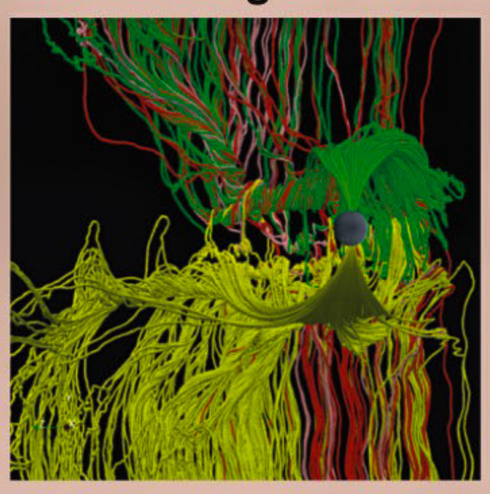
Experiments in the mid-20th century supported the idea that industrial grime provided better camouflage for dark wings, but that work drew escalating challenges starting in the 1990s. Majerus and other scientists raised questions about those studies' methods, such as whether the high densities of moths released had altered the results and whether the tree trunks where moths were placed were a normal resting place.

Source: Science News

Experiment support the much-debated original hypothesis that industrialization favored a dark form (left) of the peppered moth over the lighter one (right).

TANGLED FIELDS

Earth's magnet dances to the Sun



Source: Live Science

This image, released this week, shows a computer simulation of the complex and crazy magnetic fields that make up Earth's magnetosphere. The magnetosphere is the result of the interaction of charged particles from the sun and the magnetic field that surrounds the planet. When solar storms send particles flowing toward Earth, the result can be stunning space weather the kind that creates beautiful auroras but also can disrupt satellites, telecommunications and electrical power grids. Researchers at Oak Ridge National Laboratory in Tennessee are trying to understand how these storms work in order to better predict how storms on the sun will influence life on our planet.

DID YOU KNOW?

How fast can a hippo run?

A hippopotamus may seem huge but it can still run faster than a man.

Hippos are the second-largest land animal -- second only to elephants. Male hippos can weigh more than 6,000 pounds. Females are more "delicate," topping out around 3,000 pounds. Despite their massive bulk, hippos can run faster than humans -- up to 30 miles per hour!