SCIENCE NEWS

New Hope of Detecting the Gravitational Waves: Final Piece of Einstein's Jigsaw Puzzle

Direct evidence of the existence of gravitational waves is something that has long eluded researchers, however new research has suggested that adding just one of the proposed detectors in Japan, Australia and India will drastically increase the expected rate of detection.

In a study published on May 27, 2011 in IOP Publishing's journal *Classical and Quantum Gravity*, Professor Bernard Schutz of the Albert Einstein Institute, Germany, demonstrated that an additional detector would more than double the detection rate of gravitational waves and could double the amount of sky being covered.

It was estimated last year that by 2016 the existing network of four detectors would be able to detect, on an average, 40 neutron-star merger events per year by monitoring the gravitational waves they produce. Using a computer analysis, this study showed that by performing optimal coherent data analysis, the network could theoretically detect 160 events per year.

The positioning of the current network actually makes such a large increase in detection rate unlikely; however Schutz has shown that using any of the three additional locations would change this dramatically.

The addition of all three new detectors would enable the detection of around 370 events a year, which could increase to 500 events after a few years of operation.

These detectors are most likely to encounter 'short bursts' of gravitational waves that arise from two stars or two black holes orbiting each other. The sheer acceleration of these types of events cause a distortion in space time—known as a gravitational wave—that spreads outwards like ripples moving across a lake.

Professor Schutz said, "The improvements brought about by new detectors are much bigger than the proportionate extra investment required. Even moving an existing LIGO detector to Australia brings two to four times the number of good-quality detections and also dramatically improves the direction information for the events."

"The new detector in Japan, approved last year, would add extra sensitivity and reliability and greatly improve sky coverage. Not only would we be more certain than ever of making detections, we would begin to be able to study neutron stars and gamma ray bursts with information obtainable in no other way."

Einstein's theory of general relativity describes how objects with mass bend and curve space-time. One can imagine holding out a taut bed sheet and placing a football in the centre—the bed sheet will curve around the football, readily representing how space-time gets curved by objects with mass.

Just like the ripples moving across a lake, the distortion in space-time, caused by accelerating objects, gradually decreases in strength, so by the time they finally reach Earth they are very hard to detect.

Professor Schutz continued, "In my mind, detecting gravitational waves opens up a new way of investigating the universe. We expect frequent detections of gravitational waves from merging black holes, whose waves will carry an unmistakable signature. Since gravitational waves are the only radiation emitted by black holes, we will for the first time have a direct observation of a black hole."

"Beyond that, gravitational waves have great penetrating power, so they will allow us to see directly to the centre of the systems responsible for supernova explosions, gamma-ray bursts and a wealth of other systems so far hidden from view."

At the moment, there are four detectors, currently being updated, that have the necessary sensitivity to measure gravitational waves. Three of these detectors exist as part of the LIGO project—two in Hanford, Washington, and one in Livingston, Louisiana, whilst another detector exists in Cascina, Italy, as part of the VIRGO project.

Funding has begun for an additional detector located in Japan whilst there are further proposals for developing detectors in Australia and India. It has also been proposed to move one of the Hanford detectors to Australia.

A jointly owned British-German detector, located near Hanover, Germany, called GEO 600 will begin observations for gravitational waves this summer, until the LIGO and VIRGO detectors become fully operational again.

(Source: Science Daily Online)

Physicists Explain the Long, Useful Lifetime of Carbon-14

The long, slow decay of carbon-14 allows archaeologists to accurately date the relics of history back to 60,000 years.

And while the carbon dating technique is well-known and understood (the ratio of carbon-14 to other carbon isotopes is measured to determine the age of objects containing the remnants of any

living thing), the reason for carbon-14's slow decay has not been understood. Why, exactly, does carbon-14 have a half-life of nearly 6,000 years while other light atomic nuclei have half-lives of minutes or seconds? (Half-life is the time it takes for the nuclei in a sample to decay to half of the original amount.)

"This has been a very significant puzzle to nuclear physicists for several decades," said James Vary, an Iowa State University professor of physics and astronomy. "And the underlying reason turned out to be a fairly exotic one."

The reason involves the strong three-nucleon forces (a nucleon is either a neutron or a proton) within each carbon-14 nucleus. It's all about the simultaneous interactions among any three nucleons and the resulting influence on the decay of carbon-14. And it's not an easy task to simulate those interactions.

In this case, it took about 30 million processor-hours on the Jaguar supercomputer at Oak Ridge National Laboratory in Tennessee. Jaguar has a peak performance of 2.3 quadrillion calculations per second, a speed that topped the list of the world's top 500 supercomputers when the carbon-14 simulations were run.

The research project's findings were recently published online by the journal *Physical Review Letters*.

James Vary and Pieter Maris, Iowa State research staff scientists in physics and astronomy, are the lead authors of the paper. Collaborating on the paper are Petr Navratil of TRIUMF (Canada's National Laboratory for Particle and Nuclear Physics in Vancouver) and the Lawrence Livermore National Laboratory in California; Erich Ormand of Lawrence Livermore National Lab; plus Hai Ah Nam and David Dean of Oak Ridge National Lab. The research was supported by contracts and grants from the U.S. Department of Energy Office of Science.

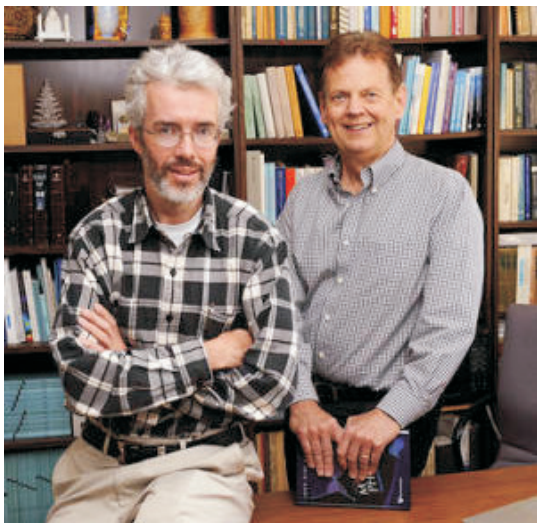
Vary, in explaining the findings, likes to remind people that two subatomic particles with different charges will attract each other. Particles with the same charges repel each other. Well, what happens when there are three particles interacting that's different from the simple addition of their interactions as pairs?

The strong three-nucleon interactions are complicated, but it turns out a lot happens to extend the decay of carbon 14 atoms.

"The whole story doesn't come together until you include the three-particle forces," said Vary. "The elusive three-nucleon forces contribute in a major way to this fact of life that carbon-14 lives so long."

Maris said the three-particle forces work together to cancel the effects of the pairwise forces governing the decay of carbon-14. As a result, the carbon-14 half-life is extended by many orders of magnitude. And that's why carbon-14 is a very useful tool for determining the age of objects.

To get that answer, Maris said researchers needed a billion-by-billion matrix and a computer capable of handling its 30 trillion non-zero elements. They also needed to develop a computer code capable of simulating the entire carbon-14 nucleus, including the roles of the three-nucleon forces. Furthermore, they needed to perform the corresponding simulations for nitrogen-14, the



Iowa State University physicists (from left to right) Pieter Maris and James Vary have used supercomputing power to solve the puzzle of the long, slow decay of carbon-14. That long half-life makes carbon-14 a useful tool to determine the ages of skeletons and other artifacts (Credit: Photo by Bob Elbert)

daughter nucleus of the carbon-14 decay. And, they needed to figure out, how the computer code could be scaled up for use on the Jaguar petascale supercomputer.

"It was six months of work pressed into three months of time," Maris said.

But it was enough for the nuclear physicists to explain the long half-life of carbon-14. And now they say there are more puzzles to solve:

"Everybody now knows about these three-nucleon forces," Vary said. "But what about four-nucleon forces? This does open the door for more study."

(Source: Science Daily Online)

Study Shows Siginificant Benefits of Yoga in People with Rheumatoid Arthritis

Individuals with rheumatoid arthritis who practice yoga showed statistically significant improvements in disease activity, according to a small study presented at the EULAR, 2011 Annual Congress.

The results of the study conducted in the United Arab Emirates (UAE) among 47 patients (26 yoga patients and 21 controls) demonstrate that patients who completed 12 sessions of Raj yoga which is one of the gentler styles of yoga, combining exercise and breathing techniques showed significant improvements in disease activity scores (DAS28) of $p = 0.021$ and health assessment questionnaire's (HAQ†) of $p = 0.0015$. However, there was no statistically significant improvement on the quality of life scale (QoL).

"Most patients with RA do not exercise regularly despite the fact that those who do, report less pain and are therefore more physically active," said Dr Humeira Badsha, MD, Rheumatologist and founder of the Emirates Arthritis Foundation, Dubai, UAE. "While our study has been conducted in a small group of patients the results show clear benefits for patients who regularly practice Raj yoga. We believe that practising yoga longer term could infact result in further significant improvements and hope our study drives further research into the benefits of yoga in RA."

Patients were recruited by email through the Emirates Arthritis Foundation RA database (mean age of yoga group 44 years, mean age of control group 46.2 years, 80% female). Demographic data,

disease activity indices, health assessment questionnaire (HAQ) and SF-36 (a standard patient survey commonly used to calculate patient quality of life) were documented at enrolment and after completion of 12 sessions of yoga.

Results of a separate study show the positive effects of yoga on the quality of life in patients with Fibromyalgia, a long-term condition which causes extreme pain all over the body.

Results of one further study investigating the effects of yoga on the QoL of patients with fibromyalgia, demonstrated that QoL scores, after an eight session classical yoga programme which combines gentle yoga postures, breathing techniques and meditation, were better than scores obtained before the programme ($p \leftarrow 0.05$) along with a significant decrease in the anxiety levels of patients ($p \leftarrow 0.05$). As anxiety is often a key symptom in patients with this condition, this study represents a positive step in improving the lives of people suffering from fibrolmyalgia.

(Source: Science Daily Online)

Omega-3 may cut Risk of Artery Disease, Heart Attacks for Patients with Stents

Omega-3 fatty acids, combined with two blood-thinning drugs, significantly changed the blood-clotting process and may reduce the risk of heart attacks in patients with stents in their heart arteries, according to research reported in Arteriosclerosis, Thrombosis and Vascular Biology: Journal of the American Heart Association.

Foods rich in omega-3, such as salmon and other oily fish, have been previously shown in other studies to reduce the risk of heart problems in people with coronary artery disease. In this study, the participants were given the pill form of omega-3 (1,000 milligrams n-3 PUFA daily) and were encouraged to increase their consumption of oily fish.

This study sought to determine what effects omega-3 might add to those of aspirin and clopidogrel.

"There are no other studies on omega-3 effects in patients who were already being treated with optimal medical therapy after stent placement," said Grzegorz Gajos, M.D., Ph.D., lead author and assistant professor of cardiology at Jagiellonian University in Krakow, Poland. "This was a proof of concept study. We were looking for any effect and what it might be."

The Omega-PCI Study—a double-blind, placebo-controlled trial—found patients who received the omega-3 pills with aspirin and clopidogrel had blood clots more susceptible to destruction than patients who received only the two blood thinners.

The research team particularly targeted the protein fibrin and the interlaced structure it forms in coagulated blood.

Gajos and colleagues examined findings from 54 patients (41 men, 13 women, average age 62.8 years) who participated in the trial conducted at John Paul II Hospital in Krakow.

This study evaluated the effects of omega-3 in patients with stable coronary artery disease who had their clogged heart arteries opened by a catheter procedure and a stent successfully

inserted to help in keeping the vessels opened. Previously, the researchers had reported that adding omega-3 to the clopidogrel antiplatelet drug after stenting significantly lowered the platelet response in clotting.

For this study, researchers randomly selected 24 patients as controls and 30 for treatment before their heart procedures. Both groups received the same daily doses of aspirin and clopidogrel for four weeks after stenting. The treatment group received 1,000 milligrams of omega-3 daily and the controls received a placebo each day.

The study showed that, in comparison with the control group, the omega-3 treated patients:

- produced less of a clotting factor called thrombin.
- formed clots with an altered and favourable structure —including larger pores —that made them easier to disrupt. Therefore, the clot-destruction time was 14.3 per cent shorter. This might prove important in protecting patients, especially those with drug-eluting stents who occasionally develop potentially fatal late clots.
- had less oxidative stress.
- showed no significant changes in fibrinogen and clotting factor (II, XIII) levels. Fibrinogen is a protein produced by the liver. This protein helps to stop bleeding by helping in the formation of blood clots.

Fibrinogen is converted by thrombin into fibrin during blood coagulation. The implication of this finding suggests that changes in the three biomolecules had no role in reducing the treatment group's thrombin generation and altering the structure of blood clots that formed, Gajos said.

"Our study suggests that combined moderate anti-thrombotic and anti-platelet actions of omega-3, when added to those of other treatments, may improve outcomes for coronary artery disease patients," Gajos said.

Study participants experienced only mild adverse side effects and the number of events did not vary significantly between the two groups. There were not enough participants to assess clinical benefit from the changes in the clotting process.

Another limitation of the study was the inability to extrapolate the findings to healthy individuals, those with a high coronary artery disease risk, and those not taking aspirin and/or clopidogrel.

"We are planning a larger follow-up study that will include outcomes and continue indefinitely," Gajos said.

Co-authors are Jaroslaw Zalewski, M.D., Ph.D.; Pawel Rostoff, M.D.; Jadwiga Nessler, M.D., Ph.D.; Wieslawa Piwowarska, M.D., Ph.D.; and Anetta Undas, M.D., Ph.D.

(Source: Science Daily Online)

Superior Sound for Telephones, Mobiles and Related Devices

Telephone calls and video conferences with a sound quality that approaches that of direct communication are now possible with a new audio coding technology—it is almost as if the discussion participants are sitting across from one another.

MP3 for phone calls—Considering the poor sound quality of many phone calls, this is a great

idea. Videoconference phone calls in particular can be unintentionally awkward because, the participants start to speak at the same time due to the time delay in the transmission. The reasons for this are long delay times and the poor quality of today's video calls. Fraunhofer's task was therefore to improve the quality and simultaneously minimise the delay time. The technology that makes this possible is called Enhanced Low Delay Advanced Audio Coding, in short, AAC-ELD. It was developed by Manfred Lutzky, Marc Gayer, Markus Schnell and their team from the Fraunhofer Institute for Integrated Circuits IIS in Erlangen.

Fraunhofer IIS is known as the main inventor of MP3, the audio codec that made it possible to greatly reduce the size of music or other audio files without impairing the sound. To implement something similar for the telephone and other devices was easier said than done. "The algorithm requires a certain amount of time to encode the data and to decode it again at the other end of the line. The process requires data that is still in the future, as it must wait for the data to arrive. This can result in a situation where interactive communication is very difficult," explained Markus Schnell.For several years, the IIS team continued to improve the algorithm even further to shorten the delay and not impair the quality at the same time. The solution, "We attempted to further minimise the area that is forward-looking and to only process current data. We did that until we found an optimum balance between quality and delay," said Schnell.

One technology—many applications

The results are audibly good as the delay with Enhanced Low Delay AAC is only about 15 milliseconds. During this extremely short timespan, the algorithm manages to reduce the audio data to less than one-thirtieth of its original volume without major losses of sound quality. Due to its enormous performance capacity, the coding process has already prevailed in many areas.

Email With audio coding technologies, Marc Gayer, Manfred Lutzky and Markus Schnell (from left to right), were able to considerably improve the quality of communication systems. (Credit: Image courtesy of Fraunhofer-Gesellschaft)

Marc Gayer explains, "Currently, AAC Low Delay, the forerunner of AAC-ELD, is the actual standard for many video-conferencing systems. But the process is also increasingly applied in radio broadcasts, for example for live sports reports."

The advantage of improved speech transmission is also heard in mobile devices, such as the iPhone4 and in the iPad2, for example. Video telephone transmissions in particular are supported in these devices. The developers created a very special application to promote the communication between groups that are socially close to each other. A system was created that makes it possible to play games across the borders of cities or countries. "Thanks to the optimised image and sound quality, there is the impression that game partners who are far apart from each other are not in front of screens, but actually sitting across from one another," said Manfred Lutzky.

(Source: Science Daily Online)

'Sweet wheat' for Tastier and more Healthful Baking

"Sweet wheat" has the potential for joining that summertime delight among vegetables—sweet corn—as a tasty and healthful part of the diet, the scientific team that developed this mutant form of wheat concludes in a new study. The report appears in the ACS Journal of Agricultural and Food Chemistry.

Just as sweet corn arose as a mutation in field corn—being discovered and grown by Native American tribes with the Iroquois introducing European settlers to it in 1779 —Sweet wheat (SW) originated from mutations in field wheat. Toshiki Nakamura, Tomoya Shimbata and colleagues developed SW from two mutant types of wheat that each lack a different enzyme needed to make starch. Because the new wheat has much more sugar than regular wheat, they called it "sweet wheat." To see whether the flour from this new wheat could be used as an ingredient in foods, such as breads and cakes, the researchers analysed its components.

They found that SW flour tasted sweeter, and SW seeds and flour contained higher levels of sugars, lipids and dietary fiber than seeds and flours of other wheat varieties. "The specific compositional changes that occurred in SW seed suggest that SW flour may provide health benefits when used as a food ingredient," say the researchers, noting its high levels of healthful carbohydrates termed fructans.

The authors acknowledge funding from the Ministry of Agriculture, Forestry and Fisheries of Japan.

(Source: Science Daily Online)

Electron is Surprisingly Spherical, Say Scientists following 10-Year Study

Scientists at Imperial College, London have made the most accurate measurement yet of the shape of the humble electron, finding that it is almost a perfect sphere, in a study published in the journal Nature on May 25.

The experiment, which spanned more than a decade, suggests that the electron differs from being perfectly round by less than 0.0000000000000000000000000001 cm. This means that if the electron were magnified to the size of the solar system, it would still appear spherical to within the width of a human hair.

The physicists from Imperial's Centre for Cold Matter studied the electrons inside molecules called ytterbium fluoride. Using a very precise

laser, they made careful measurements of the motion of these electrons. If the electrons were not perfectly round, then like an unbalanced spinning-top, their motion would exhibit a distinctive wobble, distorting the overall shape of the molecule. The researchers saw no sign of such a wobble.

The researchers are now planning to measure the electron's shape even more closely. The results of this work are important in the study of antimatter, an elusive substance that behaves in the same way as ordinary matter, except that it has an opposite electrical charge. For example, the antimatter version of the negatively charged electron is the positively charged anti-electron (also known as a positron). Understanding the shape of the electron could help the researchers to understand how positrons behave and how antimatter and matter might differ.

Research co-author, Dr Jony Hudson, from the Department of Physics at Imperial College, London, said, "We're really pleased that we've been able to improve our knowledge of one of the basic building blocks of matter. It's been a very difficult measurement to make, but this knowledge will let us improve our theories of fundamental physics. People are often surprised to hear that our theories of physics aren't 'finished', but in truth they get constantly refined and improved by making even more accurate measurements like this one."

The currently accepted laws of physics say that the Big Bang created as much antimatter as ordinary matter. However, since antimatter was first envisaged by Nobel Prize-winning scientist Paul Dirac in 1928, it has only been found in minute amounts from sources such as cosmic rays and some radioactive substances.

Imperial's Centre for Cold Matter aims to explain this lack of antimatter by searching for tiny differences between the behaviour of matter and antimatter that no one has yet observed. Had the researchers found that electrons are not round, it would have provided proof that the behaviour of antimatter and matter differ more than physicists previously thought. This, they say, could explain how all the antimatter disappeared from the universe, leaving only ordinary matter.

New research suggests the electron is surprisingly spherical—much more spherical than, say, a common billiard ball (Credit: © Hedgehog/Fotolia)

Professor Edward Hinds, research co-author and head of the Centre for Cold Matter at Imperial College, London, said: "The whole world is made almost entirely of normal matter, with only tiny traces of antimatter. Astronomers have looked right to the edge of the visible universe and even then they see just matter, no great stashes of antimatter. Physicists just do not know what happened to all the antimatters, but this research can help us to confirm or rule out some of the possible explanations."

Antimatter is also studied in tiny quantities in the Large Hadron Collider at CERN in Switzerland, where physicists hope to understand what happened in the moments following the Big Bang and to confirm some currently unproven fundamental theories of physics, such as supersymmetry. Knowing whether the electrons are round or egg-shaped tests these same fundamental theories, as well as other theories of particle physics that even the Large Hadron Collider cannot test.

To help in improving their measurements of the electron's shape, the researchers at the Centre for Cold Matter are now developing new methods to cool their molecules to extremely low temperatures, and to control the exact motion of the molecules. This will allow them to study the behaviour of the embedded electrons in far greater detail than ever before. They say the same technology could also be used to control chemical reactions and to understand the behaviour of systems that are too complex to simulate with a computer.

(Source: Science Daily Online)

Supercapacitors: Cheaper, Greener, Alternative Energy Storage

Every year, the world consumes approximately 15 tera watts of power, according to some estimates. Since the amount of annual harvestable solar energy has been estimated at 50 tera watts, students at Stevens Institute of Technology are working on a supercapacitor that will allow us to harness more of this renewable energy through biochar electrodes for supercapacitors, resulting in a cleaner and greener planet.

Supercapacitors are common today in solar panels and hydrogen fuel cell car batteries, but the material they use to store energy, activated carbon, is unsustainable and expensive. Biochar, on the other hand, represents a cheap, green alternative. The Chemical Engineering Senior Design team of Rachel Kenion, Liana Vaccari and Katie Van Strander has designed biochar electrodes for supercapacitors, and is looking to eventually bring their solution to market. The group is advised by Dr Woo Lee, the George Meade Bond Professor of Chemical Engineering and Materials Science.

For their project, the team designed, fabricated and tested a prototype supercapacitor electrode. The group demonstrated biochar's feasibility as an alternative to activated carbon for electrodes, which can be used in hybrid electric automobile batteries or home energy storage in solar panels.

"While the team's findings are preliminary, the approach taken by us represents a small, but potentially very important step in realising sustainable energy future over the next few decades," says Dr Lee.

Biochar is viewed as a green solution to the activated carbon currently used in supercapacitor electrodes. Unlike activated carbon, biochar is the byproduct of the pyrolysis process used to produce biofuels, i.e., biochar comes from the burning of organic matter. As the use of biofuels increases, biochar production increases as well. "With our process, we are able to take that biochar and put it to good use in supercapacitors. Our supply comes from goldenrod crop, and

through an IP-protected process, most organics, metals and other impurities are removed. It is a more sustainable method of production than activated carbon," Liana says. Another significant advantage: biochar is non-toxic and will not pollute the soil when it is tossed-out. The team estimates that biochar costs almost half as much as activated carbon, and is more sustainable because it reuses the waste from biofuel product, a process with sustainable intentions to begin with.

One of the largest concerns for solar panel production today is the sheer cost of manufacturing supercapacitors. Current photovoltaic arrays rely on supercapacitors to store the energy that is harnessed from the sun. And while the growth rate of supercapacitors is advancing at 20 per cent a year, their cost is still very high, in part because, they require activated carbon. Biochar, on the other hand, is cheaper and readily available as a byproduct of a process already used in energy production.

"My favourite part of this project was seeing the creation of the prototype," Katie says. "It was cool to be able to hold it in my hand and test it and say that I made this."

"Using this technology, we can reduce the cost of manufacturing supercapacitors by lowering the cost of the electrodes," Katie says. "Our goal is eventually to manufacture these electrodes and sell them to a company that already makes supercapacitors. Once supercapacitors become cheaper, they will become more common and be integrated into more and more devices."

(Source: Science Daily Online)

Portable Hydrogen Reactor for Fuel Cells

Chemical engineering students at Stevens Institute of Technology are transforming the way that American soldiers power their battery-operated devices by making a small change: a really small change. Capitalising on the unique properties of microscale systems, the students have invented a microreactor that converts everyday fossil fuels like propane and butane into pure hydrogen for fuel cell batteries. These batteries are not only highly efficient, but also can be replenished with hydrogen again and again for years of resilient performance in the field.

With soldiers carrying up to 80 per cent of gear weight in batteries, the Army has a high interest in replacing the current paradigm of single-use batteries with a reliable, reusable power source. The Stevens-made microreactors thus have the potential to not only reduce waste from disposable batteries, but also provide American soldiers with a dependable way to recharge the batteries for the critical devices that keep them safe.

Current methods for generating fuel cell hydrogen are both sophisticated and risky, requiring high temperatures and a vacuum to produce the necessary chemical-reaction-causing plasmas. Once in a container, hydrogen is a highly volatile substance that is dangerous and expensive to transport.

The Stevens microreactor overcomes both of these barriers by using low temperatures and

atmospheric pressure, and by producing hydrogen only as needed to avoid creating explosive targets in combat areas. These advanced reactors are created using cutting-edge microfabrication techniques, similar to those used to create plasma television screens, which use microscale physics to produce plasma under normal atmospheres.

The team has already achieved success producing hydrogen from methanol. After gasifying the methanol by suspending it in hot nitrogen gas, the mixture is drawn into a 25μm channel in the microreactor. There, it reacts with plasma to cause thermal decomposition, breaking down the methanol into its elemental components. Now the team is conducting tests to see what kinds of yields are realisable from various starter fuels. Eventually, soldiers will be able to convert everyday liquid fuels like propane or butane, commonly found on military bases, into high-potency juice for portable fuel cell batteries.

The team, made up of seniors Ali Acosta, Kyle Lazzaro, Randy Parrilla, and Andrew Robertson, are supporting Ph.D. candidate Peter Lindner in a research project sponsored by the U.S. Army. The project is overseen by Dr Ronald Besser. The team will be presenting their device prototype at Senior Projects Expo on April 27.

(Source: *Science Daily online*)

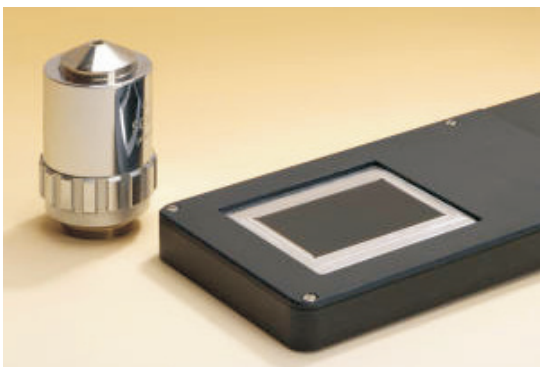
Microscope: Handy, Quick and Flat

In the future, doctors can pull out a new type of microscope to get to the bottom of suspicious changes in the skin that may indicate melanoma. The new device provides a high-resolution image of skin areas of any size—and so quickly that you can hold it in your hand without blurring the resulting picture.

Are the dark spots on a patient's skin malignant? In the future, doctors will be able to take a closer look at suspicious blemishes using a new microscope—with results in just a few fractions of a second. It examines to a resolution of five micrometers, it's also flat and lightweight, and it records images so quickly that the results are not blurred even if the doctor is holding the microscope in his or her hand. For results with comparable resolution values, a conventional microscope would either be restricted to a tiny field forced to scan the surface-conventional equipment slowly sweeps the surface, point-by-point, recording countless images before combining them to create a complete picture. The drawback of this, it takes quite a while before the image is complete. The new microscope designed by researchers at the Fraunhofer Institute for Applied Optics and Precision Engineering IOF in Jena, combines the best of both types of microscope–because it foregoes the grid, it needs to make just a single measurement, and that's what makes it very fast. Still, it records across a broad imaging area. "Essentially, we can examine a field as large as we want," remarks IOF group manager Dr Frank Wippermann. "At five micrometers, the resolution is similar to that of a scanner." There is also another benefit to the new system–with an optical length of just 5.3 millimeters, the microscope is extremely flat.

But how did researchers accomplish this feat? "Our ultrathin microscope consists of not just one but a multitude of tiny imaging channels, with lots of tiny lenses arrayed alongside one another. Each

channel records a tiny segment of the object at the same size for a 1:1 image," Wippermann explains. Each slice is roughly 300 × 300 μm^2 in size and fits seamlessly alongside the neighbouring slice; a computer programme then assembles these to generate the overall picture. The difference between this technology and a scanner microscope–all of the image slices are recorded simultaneously.



In a single pass, the ultrathin microscope can deliver high-resolution images of objects the size of a matchbox. (Credit: © Fraunhofer IOF)

The imaging system consists of three glass plates with the tiny lenses applied to them, both on top and beneath. These three glass plates are then stacked on top of one another. Each channel also contains two achromatic lenses, so the light passes through a total of eight lenses. Several steps are involved in applying the lenses to glass substrates: first, the scientists coat a glass plate with photoresistant emulsion and expose this to Ultra violet (UV) light through a mask. The portions exposed to the light become hardened. If the plate is then placed in a special solution, all that remains on the surface are lots of tiny cylinders of photoresist; the rest of the coating dissolves away. Now, the researchers heat the glass plate, the cylinders melt down, leaving spherical lenses. Working from this master tool, the researchers then generate an inverse tool that they use as a die. A die like this can then be used to launch mass production of the lenses–simply take a glass substrate, apply liquid polymer, press the die down into it and expose the polymer layer to UV light. In a process similar to the dentist's method of using UV light to harden fillings, here, too, the polymer hardens in the shape the die has printed into it. What remains are tiny lenses on the glass substrate. "Because we can mass-produce the lenses, they are really pretty low-cost," Wippermann adds.

Researchers have already produced a first prototype and will be showcasing it at the LASER World of PHOTONICS trade fair in Munich, from May 23 to 26. Boasting an image size of 36 × 24 mm^2, this microscope can capture matchbox-sized objects in a single pass. It will be at least another one to two years before the device can go into series production, according to the researcher. The spectrum of applications is diverse–with this technology, even documents can be examined for authenticity.

(Source: Science Daily Online)

Earth's Core is Melting ... and Freezing

The inner core of Earth is simultaneously melting and freezing due to circulation of heat in the overlying rocky mantle, according to new research from the University of Leeds, UC San Diego and the Indian Institute of Technology.

The findings, published on May 19, *Nature*, could help us understand how the inner core formed

and how the outer core acts as a 'geodynamo', which generates the planet's magnetic field.

"The origins of Earth's magnetic field remain a mystery to scientists," said study co-author Dr Jon Mound from the University of Leeds. "We cannot go and collect samples from the centre of Earth, so we have to rely on surface measurements and computer models to tell us what's happening in the core."

"Our new model provides a fairly simple explanation to some of the measurements that have puzzled scientists for years. It suggests that the whole dynamics of Earth's core are in some way linked to plate tectonics, which isn't at all obvious from surface observations".

"If our model is verified it's a big step towards understanding how the inner core formed, which in turn helps us to understand how the core generates the Earth's magnetic field."

Earth's inner core is a ball of solid iron about the size of our Moon. This ball is surrounded by a highly dynamic outer core of a liquid iron-nickel alloy (and some other, lighter elements), a highly viscous mantle and a solid crust that forms the surface, where we live.

Over billions of years, Earth has cooled from the inside out causing the molten iron core to partly freeze and solidify. The inner core has subsequently been growing at the rate of around 1mm a year as iron crystals freeze and form a solid mass.

The heat given off as the core cools flows from the core to the mantle to Earth's crust through a process known as convection. Like a pan of water boiling on a stove, convection currents move warm mantle to the surface and send cool mantle back to the core. This escaping heat powers the geodynamo and coupled with the spinning of Earth generates the magnetic field.

Scientists have recently begun to realise that the inner core may be melting as well as freezing, but there has been much debate about how this is possible when overall the deep Earth is cooling. Now the research team believes that they have solved the mystery.

Using a computer model of convection in the outer core, together with seismology data, they show that heat flow at the core-mantle boundary varies depending on the structure of the overlying mantle. In some regions, this variation is large enough to force heat from the mantle back into the core, causing localised melting.

The model shows that beneath the seismically active regions around the Pacific 'Ring of Fire', where tectonic plates are undergoing subduction, the cold remnants of oceanic plates at the bottom of the mantle draw a lot of heat from the core. This extra mantle cooling generates down-streams of cold material that cross the outer core and freeze onto the inner core.

Conversely, in two large regions under Africa and the Pacific where the lowermost mantle is hotter than average, less heat flows out from the core. The outer core below these regions can become warm enough that it will start melting back the solid inner core.

Co-author Dr Binod Sreenivasan from the Indian Institute of Technology said: "If Earth's inner core is melting in places, it can make the dynamics near the inner core-outer core boundcomplex than previously thought".

"On the one hand, we have blobs of light material being constantly released from the boundary where pure iron crystallises. On the other hand, melting would produce a layer of dense liquid above the boundary. Therefore, the blobs of light elements will rise through this layer before they stir the overlying outer core ".

"Interestingly, not all dynamo models produce heat going into the inner core. So the possibility of inner core melting can also place a powerful constraint on the regime in which the Earth's dynamo operates."

The inner core of Earth is simultaneously melting and freezing due to circulation of heat in the overlying rocky mantle, according to new research. The findings could help us to understand how the inner core formed and how the outer core acts as a 'geodynamo', which generates the planet's magnetic field. (Credit: © KristijanZontar / Fotolia)

Co-author Dr Sebastian Rost from the University of Leeds added – "The standard view has been that the inner core is freezing all over and growing out progressively, but it appears that there are regions where the core is actually melting. The net flow of heat from core to mantle ensures that there's still overall freezing of outer core material and it's still growing over time, but by no means is this a uniform process".

"Our model allows us to explain some seismic measurements which have shown that there is a dense layer of liquid surrounding the inner core. The localised melting theory could also explain other seismic observations, for example why seismic waves from earthquakes travel faster through some parts of the core than others."

(Source: Science Daily Online)

New Solar Product Captures up to 95 per cent of Light Energy

Efficiency is a problem with today's solar panels; they only collect about 20 per cent of available light. Now, a University of Missouri , engineer has developed a flexible solar sheet that captures more than 90 per cent of the availability of ` light, and he plans to make prototypes available to consumers within the next five years.

Patrick Pinhero, an associate professor in the MU Chemical Engineering Department, says "energy generated using traditional photovoltaic (PV) methods of solar collection is inefficient and

neglects much of the available solar electromagnetic (sunlight) spectrum". The device his team has developed — essentially a thin, mouldable sheet of small antennas called nantenna — can harvest the heat from industrial processes and convert it into usable electricity. Their ambition is to extend this concept to a direct solar facing nantenna device capable of collecting solar irradiation in the near infrared and optical regions of the solar spectrum.

Working with his former team at the Idaho National Laboratory and Garrett Moddel, an electrical engineering professor at the University of Colorado, Pinhero and his team have now developed a way to extract electricity from the collected heat and sunlight using special high-speed electrical circuitry. This team also partners with Dennis Slafer of Microcontinuum, Inc., of Cambridge, Mass., to immediately port laboratory bench-scale technologies into manufacturable devices that can be inexpensively mass-produced.

"Our overall goal is to collect and utilise as much solar energy as is theoretically possible and bring it to the commercial market in an inexpensive package that is accessible to everyone," Pinhero said. "If successful, this product will put us orders of magnitudes ahead of the current solar energy technologies available to us today."

As part of a rollout plan, the team is securing funding from the U.S. Department of Energy and private investors. The second phase features an energy-harvesting device for existing industrial infrastructure, including heat-process factories and solar farms.

Within five years, the research team believes they will have a product that complements conventional PV solar panels. Because it's a flexible film, Pinhero believes it could be incorporated into roof shingle products, or be custom-made to power vehicles.

Once the funding is secure, Pinhero envisions several commercial product spin-offs, including infrared (IR) detection. These include improved contraband-identifying products for airports and the military, optical computing and infrared line-of-sight telecommunications.

A study on the design and manufacturing process was published in the *Journal of Solar Energy Engineering.*

(Source: Science Daily Online)

New way to Control Conductivity: Reversible Control of Electrical and Thermal Properties could find uses in Storage systems

A team of researchers at MIT has found a way to manipulate both the thermal conductivity and the electrical conductivity of materials simply by changing the external conditions, such as the surrounding temperature. And the technique they found can change electrical conductivity by factors of well over 100, and heat conductivity by more than three-fold.

"It's a new way of changing and controlling the properties" of materials—in this case a class called percolated composite materials—by controlling their temperature", says Gang Chen, MIT's Carl Richard Soderberg, Professor of Power Engineering and Director of the

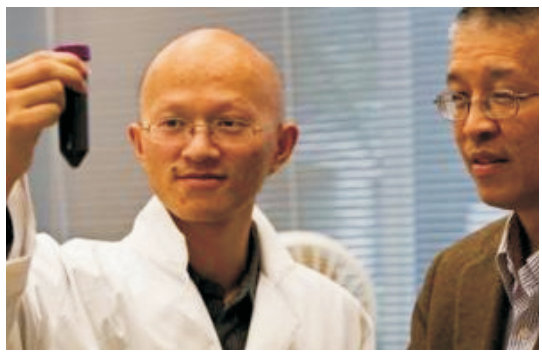
Pappalardo Micro and Nano Engineering Laboratories. Chen is the Senior author of a paper describing the process that was published online on April 19 and will appear in a forthcoming issue of *Nature Communications*. The paper's lead authors are former MIT visiting scholars Ruiting Zheng of Beijing Normal University and Jinwei Gao of South China Normal University, along with current MIT graduate student Jianjian Wang. The research was partly supported by grants from the National Science Foundation.

The system Chen and his colleagues developed could be applied to many different materials for either thermal or electrical applications. The finding is so novel, Chen says, that the researchers hope some of their peers will respond with an immediate, "I have a use for that!"

One potential use of the new system, Chen explains, is for a fuse to protect electronic circuitry. In that application, the material would conduct electricity with little resistance under normal, room-temperature conditions. But if the circuit begins to heat up, that heat would increase the material's resistance, until at some threshold temperature it essentially blocks the flow, acting like a blown fuse. But then, instead of needing to be reset, as the circuit cools down the resistance decreases and the circuit automatically resumes its function.

Another possible application is for storing heat, such as from a solar thermal collector system, later using it to heat water or homes or to generate electricity. The system's much-improved thermal conductivity in the solid state helps it to transfer heat.

Essentially, what the researchers did was suspend tiny flakes of one material in a liquid that, like water, forms crystals as it solidifies. For their initial experiments, they used flakes of graphite suspended in liquid hexadecane, but they showed the generality of their process by demonstrating the control of conductivity in other combinations of materials as well. The liquid used in this research has a melting point close to room temperature—advantageous for operations near ambient conditions—but the principle should be applicable for high-temperature use as well.



Graduate student Jianjian Wang holds a flask containing the suspension of graphite flakes in hexadecane, as Gang Chen looks on. (Credit: Photo by Melanie Gonick)

The process works because when the liquid freezes, the pressure of its forming crystal structure pushes the floating particles into closer contact, increasing their electrical and thermal conductance. When it melts, that pressure is relieved and the conductivity goes down. In their experiments, the researchers used a suspension that contained just 0.2 per cent graphite flakes by volume. Such suspensions are remarkably stable— Particles remain suspended indefinitely in the liquid, as was shown by examining a container of the mixture three months after mixing.

By selecting different fluids and different materials suspended within that liquid, the critical temperature at which the change takes place can be adjusted at will, Chen says.

"Using phase change to control the conductivity of nano composites is a very clever idea," says Li Shi, a professor of mechanical engineering at the University of Texas at Austin. Shi adds that as far as he knows "this is the first report of this novel approach" to produce such a reversible system.

"I think this is a very crucial result," says Joseph Heremans, professor of physics and of mechanical and aerospace engineering at Ohio State University. "Heat switches exist," but involve separate parts made of different materials, whereas "here we have a system with no macroscopic moving parts," he says. "This is excellent work."

(Source: Science Daily Online)

Who Knows You Best? Not You, say Psychologists

Know thyself. That was Socrates' advice, and it squares with conventional wisdom. "It's a natural tendency to think we know ourselves better than others do," says Washington University in St. Louis assistant professor Simine Vazire.

But a new article by Vazire and her colleague Erika N. Carlson reviews the research and suggests an addendum to the philosopher's edict: *Ask a friend.* "There are aspects of personality that others know about us that we don't know ourselves, and vice-versa," says Vazire. "To get a complete picture of a personality, you need both perspectives." The paper is published in *Current Directions in Psychological Science*, a journal of the Association for Psychological Science.

It's not that we know nothing about ourselves. But our understanding is obstructed by blind spots, created by our wishes, fears and unconscious motives—the greatest of which is the need to maintain a high (or if we're neurotic, low) self-image, research shows. Even watching ourselves on videotape does not substantially alter our perceptions—whereas others observing the same tape easily point out traits we're unaware of.

Not surprisingly, our intimates and those who spend the most time with us know us best. But even strangers have myriad cues to who we are—clothes, musical preferences or Facebook postings. At the same time, our nearest and dearest have reasons to distort their views. After all, a boorish spouse or bullying child says something to the other spouse or parent. "We used to collect ratings from parents—and we've mostly stopped, because they're useless," notes Vazire. What such data would show— Everyone's own child is brilliant, beautiful and charming.

Interestingly, people don't see the same things about themselves as others see. Anxiety-related traits, such as stage fright, are obvious to us, but not always to others. On the other hand, creativity, intelligence or rudeness is often best perceived by others. That's not just because they manifest themselves publicly, but also because they carry a value judgement—something that tends to affect self-judgement. But the world is not always the harsher critic. Others tend to give us higher marks for our strengths than we credit ourselves with.

Why doesn't all this information add up to better personal and mutual understanding? People are complex, social cues are many, perceptions of others are clouded by our own needs and biases, studies show. Plus, the information isn't easy to access. "It's amazing how hard it is to get direct feedback," Vazire notes, adding that she isn't advocating brutal frankness at any cost. There are good reasons for reticence.

The challenge, then, is to use such knowledge for the good. "How can we give people feedback and how can that be used to improve self-knowledge?" Vazire asks. "And how do we use self-knowledge to help people be happier and have better relationships?"

The first answer to these questions may be the most obvious, but not the easiest to practice—Listen to others. They may know more than you do—even about yourself.

(Source: *Science Daily online*)

World's Smallest Atomic Clock: Tiny Laser Reduces Power Consumption 1,000-Fold

A matchbook-sized atomic clock 100 times smaller than its commercial predecessors has been created by a team of researchers at Symmetricom Inc. Draper Laboratory and Sandia National Laboratories. The portable Chip Scale Atomic Clock (CSAC)—only about 1.5 inches on a side and less than a half-inch in depth—also requires 100 times less power than its predecessors. Instead of 10 watts, it uses only 100 milliwatts. "It's the difference between lugging around a device powered by a car battery and one powered by two AA batteries," said Sandia lead investigator Darwin Serkland.

Despite common implications of the word "atomic," the clock does not use radioactive elements as an energy source. Instead, where an old-fashioned alarm clock uses a spring-powered series of gears to tick-off seconds, a CSAC counts the frequency of electromagnetic waves emitted by cesium atoms struck by a tiny laser beam to determine the passage of time.

Still, given that the CSAC does not actually display the time of day—measured in millionths of a second, its passage would defy the ability of human eyes to read it—why would anyone want it?

The clock's uses are, indeed, specialised. Miners far underground or divers engaged in deep-sea explorations, blocked by natural barriers from GPS signals, could plan precise operations with remote colleagues who also had atomic clocks, because their timing would deviate from each other by less than one millionth of a second in a day.

A CSAC timekeeper would be invaluable to experts using electromagnetic interference to prevent telephone signals from detonating Improvised Explosive Devices, or IEDs. Though GPS signals also would be blocked, a CSAC timekeeper would still function.

On a nationwide scale, relay stations for cross-country phone and data lines, which routinely break up messages into packets of information and send them by a variety of routes before reconstituting them correctly at the end of their voyages, would continue functioning during GPS outages.

The clock's many uses, both military and commercial, are why the Defense Advanced

Research Projects Agency (DARPA) funded the work from 2001 until the CSA Clock hit the commercial market in January.

"Because few DARPA technologies make it to full industrial commercialisation for dual-use applications, this is a very big deal," said Gil Herrera, director of Sandia's Microsystems and Engineering Sciences Application (MESA) center. "CSAC now is a product with a data sheet and a price."

Cesium atoms are housed in a container the size of a grain of rice developed by Cambridge, Mass.-based Draper Lab. The cesium atoms are interrogated by a light beam from a vertical-cavity surface-emitting laser, or VCSEL, contributed by Sandia. Symmetricom, an atomic clock manufacturer, designed the electronic circuits and assembled the components into a complete functioning clock at its Beverly, Mass., location.

The reduced power consumption that was key to create the smaller unit required, in addition to a completely new architecture, a VCSEL rather than the previous tool of choice, a rubidium-based atomic vapour lamp.

"It took a few watts to excite the rubidium lamp into a plasmalike state," Serkland said. "Use of the VCSEL reduced that power consumption by more than a thousand times to just two milliwatts" (Serkland's success in attaining this huge power reduction caused some in the clock business to refer to him as "the VCSEL wizard").

The way the clock keeps time may be best imagined by considering two tuning forks. If the forks vary only slightly in size, a series of regular beats are produced when both forks vibrate. The same principle works in the new clock.

The VCSEL—in addition to being efficient, inexpensive, stable and low-power—is able to produce a very fine, single-frequency beam. The laser frequency, at 335 terahertz (894.6 nanometers), is midway between two hyperfine emission levels of the cesium atom, separated in terms of energy like the two differently sized tuning forks. One level is 4.6 gigahertz above and the other 4.6 gigahertz below the laser frequency (Hyperfine lines are the energy signatures of atoms). A tiny microwave generator sends an oscillating frequency that alternates adding and subtracting energy from the incoming laser carrier frequency. Thus, the laser's single beam

Darwin Serkland measures the wavelength of a tiny laser called a VCSEL, or vertical-cavity surface-emitting laser. The image on the monitor (left) shows a bright circle of light emitted from a VCSEL operating at the wavelength of 894 nanometers needed to drive the atomic clock. The objects that look like black baseball bats are tiny wire needles carrying milliampere currents. The round white plastic containers on Serkland's workbench each contain about 5,000 VCSELs fabricated from one-quarter of a 3-inch diameter gallium arsenide wafer. Each wafer is designed differently to yield a unique type of laser. (Credit: Image courtesy of DOE/Sandia National Laboratories)

produces two waves at both hyperfine emission energies. When they interact, the emitted waves produce (like two tuning forks of different sizes) a series of 'beats' through a process known as interference.

A photodiode monitors the slight increase in light transmission through the cesium vapour cell when the microwave oscillator is tuned to resonance. According to the international definition of the second (since 1967), the clock indicates that one second has elapsed after counting exactly 4,596,315,885 cycles (nearly 4.6 gigacycles) of the microwave oscillator signal.

Because magnetism has an influence on cesium atoms, they are shielded from Earth's magnetic field by two layers of steel sheathing.

While this sounds cumbersome, atomic clocks are simpler to maintain than timepieces of a century ago, when a pendulum clock in Paris was the source of the world's exact time. Kept in a room that was temperature- and humidity-controlled, not only would a change of one degree affect the pendulum's swing, but the difficulty of bringing accurate time to the U.S. was extreme: one synchronised a portable clock in Paris and then had to transport it across the ocean by ship, during which time the mechanical clock would inevitably drift from the time of the Paris clock.

A description of the technical details of the clock, available for approximately $1,500, can be found at Symmetricom's website at: http://www.symmetricom.com/products/frequency-references/chip-scale-atomic-clock-csac/SA.45s-CSAC/

Sandia is developing a follow-on technology for DARPA–a trapped-ion-based clock. It will improve timing accuracy at similar size, weight and power to the CSAC. Researches are working on the first compact prototype.

(Source: *Science Daily online*)

Curtains that Block Noise

Researchers at Empa, in cooperation with textile designer Annette Douglas and silk weavers Weisbrod-Zürrer AG, have developed lightweight, translucent curtain materials, which are excellent at absorbing sound. This is a combination that has been lacking until now in modern interior design. And the new "noise-quenching" curtains have just gone onto the market.

Noise is annoying. It interrupts communication, reduces productivity and tires people out—in extreme cases it can even make them ill. Sound absorbing surfaces are, therefore, needed in rooms where people work, talk to each other or are trying to relax. These decrease reverberation and so make rooms quieter. However, so called acoustically "hard" materials such as glass and concrete, which are commonly used in interior design, scarcely absorb sound at all. Heavy curtains made of material such as velvet are often used to absorb sound. On the other hand, lightweight and transparent curtains are acoustically almost useless, at least they were until now.

Together with industrial partner Weisbrod-Zürrer AG, a silk weaving company, and the textile designer Annette Douglas, Empa researchers have developed a new curtain fabric that is lightweight but still absorbs sound.

"Acousticians are pretty astonished when they see the readings we are achieving with the new

Researchers at Empa, in cooperation with textile designer Annette Douglas and silk weavers Weisbrod-Zürrer AG, have developed lightweight, translucent curtain materials, which are excellent at absorbing sound. (Credit: Image courtesy of Swiss Federal Laboratories for Materials Science and Technology (EMPA))

curtains in the reverberation room. The weighted sound absorption coefficient is between 0.5 and 0.6," commented Kurt Eggenschwiler, Head of Empa's Acoustics/Noise Control Division. In other words, the new textiles "quench" five times more sound than conventional translucent curtains. Eggenschwiler continued, "The new curtain genuinely absorbs sound, noticeably improving the room acoustics—and its design is also of very high quality."

A real gap in the market

Another advantage is that because the new curtains are translucent, they can be used in a variety of places such as offices, living rooms, restaurants, hotel lobbies, seminar rooms and even multi-purpose auditoriums. They are often the deciding factor in satisfying the acoustic requirements and regulations that apply to these rooms. Just shortly after their launch, it became apparent that the new textiles are really filling a gap in the market, as interest in them is "massive" according to Eggenschwiler.

The idea of a curtain that absorbs noise while, at the same time, being lightweight and translucent, came from the textile designer Annette Douglas, who has worked with the interaction between sound and textiles for many years and received the Swiss Textile Design Award in 2005 for the project "Acoustic walls for open plan offices." In cooperation with researchers from Empa's Acoustics/Noise Control Division and silk weavers Weisbrod-Zürrer AG, and with support from researchers from Empa's Advanced Fibres Division, she submitted an associated project to the Commission for Technology and Innovation (CTI) in 2010. Not a simple task, because thin and, therefore, translucent fabrics are normally poor sound absorbers.

Successful combination of computer modelling, acoustic measurement and specialised textile knowledge

The first acoustically optimised lightweight textile came into being on a computer. The Empa acousticians wanted to use the characteristics of this virtual textile in order to prepare a kind of "recipe" for material experts, which would enable them to specifically manufacture a fabric that could absorb sound. In addition, they first developed a mathematical model to illustrate both the microscopic structure of the fabric as well as its macroscopic composition. On the basis of numerous acoustic measurements made on

various samples, specifically woven by Weisbrod-Zürrer, they were able to gradually optimise the acoustic properties of the fabric. Annette Douglas then succeeded in translating the new findings into weaving techniques. She chose yarns that gave the materials the necessary characteristics in terms of flammability and translucence and determined the weave structure, i.e., how the threads should be woven in and out of each other. Weisbrod-Zürrer then adjusted the sophisticated manufacturing process so that the industrially-made curtains actually displayed the required acoustic characteristics.

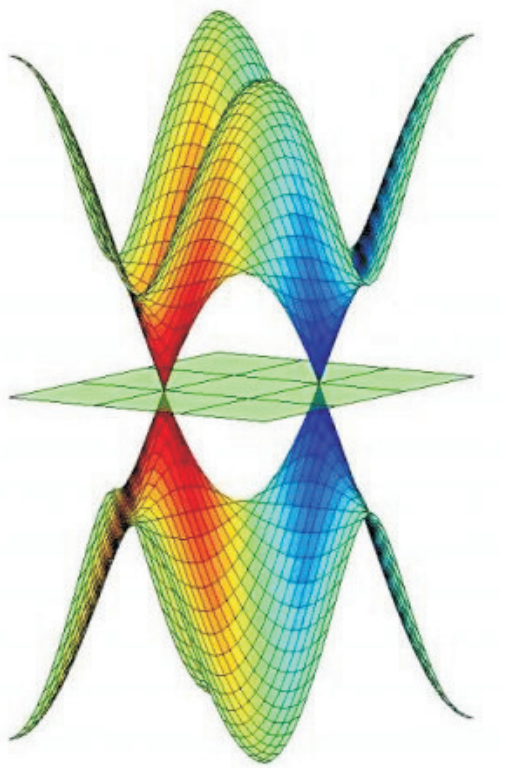
(Source: Science Daily Online)

Electronics: A Step Toward Valleytronics

Valley-based electronics, also known as valleytronics, is one step closer to reality. Two researchers at the Naval Research Laboratory (NRL) have shown that the valley degree of freedom in graphene can be polarised through scattering off a line defect. Unlike previously proposed valley filters in graphene, which rely on confined structures that have proven hard to achieve experimentally, the present work is based on a naturally occurring line defect that has already been observed.

The discovery was published in *Physical Review Letters* on March 28, 2011 and was also the subject of a separate viewpoint article in *Physics*.

Information in solid-state, either classical or quantum, is generally carried by electrons and holes. The information can be encoded in various degrees of freedom such as charge or spin. Charge representations, for example the absence or presence of an electron in a quantum dot, are attractive as they are easily manipulated and interrogated through electric fields. The advantage of spin representations, used in the field of spintronics, is their superior shielding from undesired electric fluctuations in the environment, making the information in these latter representations more robust. In the future, there might be a third middle-ground alternative



The band structure of graphene with its two valleys is shown in blue and red. (Credit: Naval Research Laboratory)

in the valley degree of freedom that exists in certain crystals, including graphene.

The valley degree of freedom in graphene gained attention in 2007, when it was proposed that electrons and holes could be filtered according to which valley they occupy. Unfortunately, the structures required for this and subsequent valley filters are difficult to fabricate, and as a result a valley filter has yet to be demonstrated experimentally. The present study from NRL shows that an extended line defect in graphene acts as a natural valley filter. "As the structure is already available, we are hopeful that valley-polarised currents could be generated in the near future" said Dr Daniel Gunlycke who made the discovery together with Dr Carter White. Both work in NRL's Chemistry Division.

Valley refers to energy depressions in the band structure, which describes the energies of electron waves allowed by the symmetry of the crystal. For graphene, these regions form two pairs of cones that determine its low-bias response. As a large crystal momentum separates the two valleys, the valley degree of freedom is robust against slowly varying potentials, including scattering caused by low-energy acoustic phonons that often require low-bias electronic devices to operate at low temperatures typically only accessible in laboratories.

Valley polarisation is achieved when electrons and holes in one valley are separated spatially from those in the other valley, but this is difficult to do as the two valleys have the same energies. It was found, however, that this spatial separation can be obtained in connected graphene structures that possess reflection symmetry along a particular crystallographic direction with no bonds crossing the reflection plane. This property turns out to be present in a recently observed line defect in graphene. The reflection symmetry only permits electron waves that are symmetric to pass through the line defect. Anti-symmetric waves are reflected. By projecting an arbitrary low-energy wave in graphene onto its symmetric component, one gets the transmission amplitude through this defect, which is strongly dependent on the valley. Electron and hole waves approaching the line defect at a high angle of incidence results in a polarisation near 100 per cent.

"There is a long way to go before valleytronics can become a viable technology", explains Gunlycke. The recent advance, however, provides a realistic way to reach a crucial milestone in its development. This research was supported by the Office of Naval Research, both directly and through the Naval Research Laboratory.

(Source: Science Daily Online)

Research Shows that Music Changes Perception

Music is not only able to affect your mood—listening to particularly happy or sad music can even change the way we perceive the world, according to researchers from the University of Groningen.

Music and mood are closely inter-related—listening to a sad or happy song on the radio can make you feel more sad or happy. However, such mood changes not only affect how you feel, they

also change your perception. For example, people will recognise happy faces, if they are feeling happy themselves.

A new study by researcher Jacob Jolij and student Maaike Meurs of the Psychology Department of the University of Groningen shows that music has an even more dramatic effect on perception—even if there is nothing to see, people sometimes still see happy faces when they are listening to happy music and sad faces when they are listening to sad music.

Smileys

Jolij and Meurs had their test subjects perform a task in which they had to identify happy and sad smileys while listening to happy or sad music. Music turned out to have a great influence on what the subjects saw—smileys that matched the music were identified much more accurately. And even when no smiley at all was shown, the subjects often thought they recognised a happy smiley when listening to happy music and a sad one when listening to sad music.

Expectation

The latter finding is particularly interesting according to the researchers. Jolij: 'Seeing things that are not there is the result of top-down processes in the brain. Conscious perception is largely based on these top-down processes—your brain continuously compares the information that comes in through your eyes with what it expects on the basis of what you know about the world. The final result of this comparison process is what we eventually experience as reality. Our research results suggest that the brain builds up expectations not just on the basis of experience but on your mood as well.'

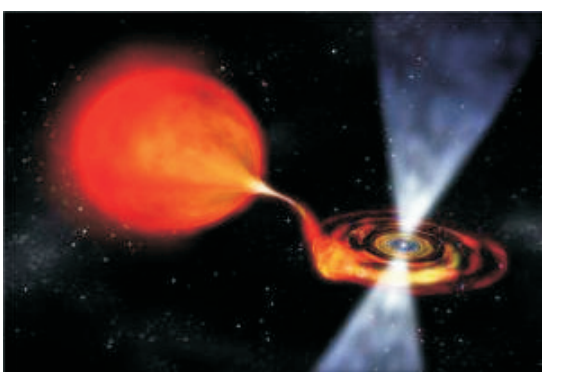
The research was published in the open access journal *PLoS ONE* on 21 April.

(Source: Science Daily Online)

School Students Help Astronomers to Study Mysterious X-Ray Source

Astronomers from Wales and the Netherlands, in collaboration with five schools, have used eight telescopes simultaneously to study the strange behaviour of an X-ray binary star system. Results were presented by postgraduate student Fraser Lewis at the RAS National Astronomy Meeting in Llandudno, Wales, on April 18.

IGR J00291 + 5934 ('00291') is a rare X-ray binary system containing a pulsar—a neutron star spinning several hundred times per second—and a normal star. Only 12 such systems are known. In September 2008, 00291 increased in brightness at X-ray wavelengths by



Artist's impression of IGR J00291+5934. The strong gravity from the dense pulsar attracts material from the companion. The flow of gas from the companion to the pulsar is energetic and glows in X-ray light. (Credit: NASA/Dana Berry)

a factor of at least a thousand times and in visible wavelengths by a factor of around a hundred times. While such type of outburst is not uncommon for this type of system, the timescale is usually months to years. However, 00291, having been in outburst for 20 days, faded away to its normal faint state but then re-brightened within 30 days.

"We had never seen this rapid a turnaround in a system of this type before" said Lewis, of the Faulkes Telescope Project at the University of Glamorgan. "To try to understand what was driving this unique behaviour, we gathered data from several telescopes, at different wavelengths, to create a dataset of unprecedented detail."

The group, led by Lewis and Dr David Russell, of the University of Amsterdam, used data from Faulkes Telescope North, the Isaac Newton Telescope and the Keck Telescope (optical wavelengths), PAIRITEL (infrared), the Westerbork Synthesis Radio Telescope (radio), the Swift GRB mission (UV and X-ray), and the XMM-Newton and RXTE satellites (X-ray). Five schools, including St. Brigid's School, Denbigh and St. Davids College, Cardiff, were involved in collecting the data using Faulkes Telescope North.

In X-ray binary systems, material from the star spirals in towards the pulsar, forming an accretion disc. Friction and gravity heat this material up until it reaches temperature of millions of degrees and emits X-rays.

"The behaviour of 00291 is baffling. Outbursts are thought to be driven by the 'emptying' of the accretion disc, which means that the time between outbursts indicates the time that it takes to fill the disc, and the size of the disc itself. However, for a system as compact as 00291, it's unlikely that it could replenish its supply within 30 days," said Lewis.

To find a solution to this mystery, Lewis and Russell have turned to a group at the Naval Research Laboratory in Washington led by Dr Jacob Hartman. Hartman's group suggests that the outburst is all one event that was interrupted halfway through by a propeller effect.

"The idea is that when the 'propeller' switches on, the material that was spiralling inwards becomes ejected from the system, stopping the outburst. Then the propeller switches off again, the outburst restores itself. However, there are still many things that we don't understand," said Lewis.

These results are presented within the wider context of an extensive optical monitoring programme of 32 low-mass X-ray binaries using the 2-metre Faulkes Telescopes in Hawaii and Australia.

(Source: Science Daily Online)

Optical Microscope without Lenses Produces High-Resolution 3-D Images on a Chip

UCLA researchers have redefined the concept of a microscope by removing the lens to create a system that is small enough to fit in the palm of a hand but powerful enough to create three-dimensional tomographic images of miniscule samples.

The advance, featured in the early online edition of the journal *Proceedings of the National Academy of*

Sciences, represents the first demonstration of lens-free optical tomographic imaging on a chip, a technique capable of producing high-resolution 3-D images of large volumes of microscopic objects.

"This research clearly shows the potential of lens-free computational microscopy," said Aydogan Ozcan, senior author of the research and an associate professor of electrical engineering at UCLA's Henry Samueli School of Engineering and Applied Science. "Wonderful progress has been made in recent years to miniaturise life-sciences tools with microfluidic and lab-on-a-chip technologies, but until now optical microscopy has not kept pace with the miniaturisation trend."

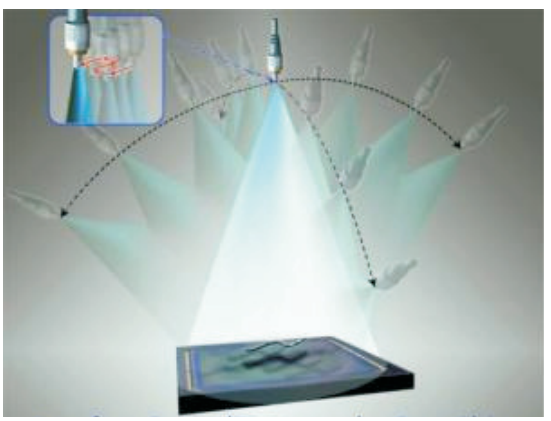
An optical imaging system small enough to fit onto an opto-electronic chip provides a variety of benefits. Because of the automation involved in on-chip systems, scientific work could be sped up significantly, which might have a great impact in the fields of cell and developmental biology. In addition, the small size not only has great potential for miniaturising systems but also leads to cost savings on equipment.

The optical microscope, invented more than 400 years ago, has tended to grow larger and more complex as it has been modified to image ever-smaller objects with better resolution. To address this lack of progress in miniaturisation, Ozcan's research group—with graduate student Serhan Isikman and postdoctoral scholar Waheb Bishara as lead researchers—developed the new tomographic microscopy platform through the next evolution of a lens-free imaging technology the group created and has been improving for years.

Ozcan, a researcher at the California Nano Systems Institute at UCLA, makes the analogy that a traditional optical microscope is like a huge set of pipes delivering content, in the form of images, to the user. Over years of development, bottlenecks occur that impede further improvement. Even if one part of the system—that is, one bottleneck—is improved, other bottlenecks keep that improvement from being fully realised. Not so with the lens-free system, according to Ozcan.

"Lens-free imaging removes the pipes altogether by utilising an entirely new design," he said.

The system takes advantage of the fact that organic structures, such as cells, are partially



Lens-free tomographic imaging: Schematic diagram of the lens-free tomography set-up showing the angles of rotation for the light source to illuminate a sample. (Credit: Image courtesy of UCLA)

transparent. So by shining a light on a sample of cells, the shadows created reveal not only the cells' outlines but details about their sub-cellular structures as well.

"These details can be captured and analysed if the shadow is directed onto a digital sensor array," Isikman said. "The end result of this process is an image taken without using a lens."

Ozcan envisions this lens-free imaging system as one component in a lab-on-a-chip platform. It could potentially fit beneath a microfluidic chip, a tool for the precise control and manipulation of sub-millimeter biological samples and fluids, and the two tools would operate in tandem, with the microfluidic chip depositing and subsequently removing a sample from the lens-free imager in an automated, or high-throughput, process.

The platform's 3-D images are created by rotating the light source to illuminate the samples from multiple angles. These multiple angles also allow the system to utilise tomography, a powerful imaging technique. Through the use of tomography, the system is able to produce 3-D images without sacrificing resolution.

"The field of view of lens-based microscopes is limited because the lens focuses on a narrow area of a sample," Bishara said. "A lens-free microscope has both a much larger field of view and depth of field because the imaging is done by the digital sensor array and is not constrained by a lens."

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