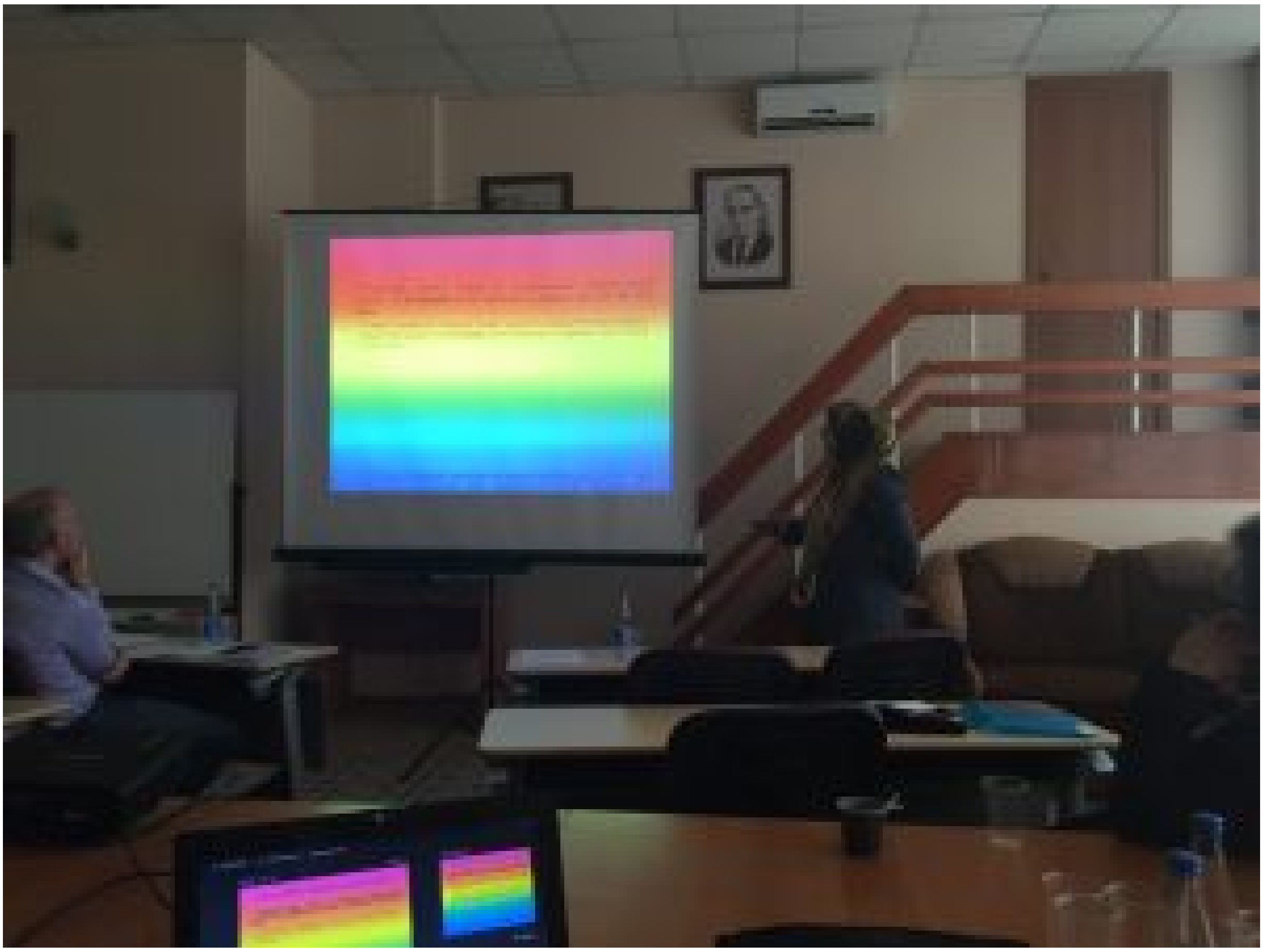
The Institute of Physics of Kazan Federal University opened a seminar on modern trends in materials science

In September 26 at the Institute of Physics of Kazan Federal University, a joint seminar was launched with researchers from Shahid Beheshti University of Tehran.

26 сентября в Институте физики КФУ начал свою работу совместный семинар с исследователями из Университета им. Шахида Бехешти из Тегерана.

Основная цель форума – прямое общение между физиками Казанского университета и участниками семинара из Ирана и установление взаимовыгодного сотрудничества. Семинар начался с устных сессий; а во вторник, 27 сентября, запланировано посещение коллегами из Ирана лабораторий Института физики.

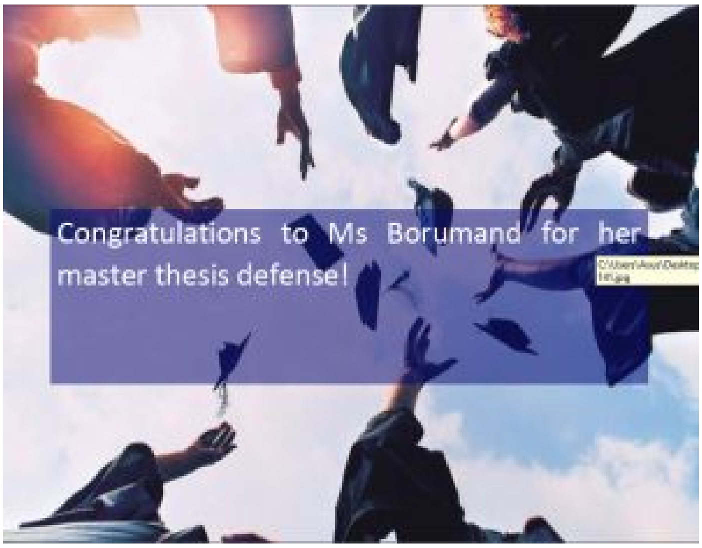
Тегеранский университет им. Шахида Бехешти готовит студентов по различным отраслям – от гуманитарных до естественнонаучных – уже 57 лет. По данным различных рейтингов, он входит в 500 известных вузов мира. Его сотрудничество с российскими вузами ведет свою двухдесятилетнюю историю. А студенты из Ирана учатся в КФУ уже 2 года. Иранские ученые приехали лично познакомиться с коллегами из Казанского университета и надеются на дальнейшее сотрудничество.



News source:http://kpfu.ru/news/irancy-247132.html

[Thesis Defense]

Congratulations to Ms Borumand for her master thesis defense!



[Thesis Defense]

Congratulations to Mr Behjati for his master thesis defense!

Thesis Defense

Congratulations to Ms Jafari for her master thesis defense!

Silicon brings more color to holograms

Silicon holograms harness the full visible spectrum to bring holographic projections one step closer.

We can’t yet send holographic videos to Obi-Wan Kenobi on our droid, but researchers at Agency for Science, Technology and Research (A*STAR), Singapore, have got us a little bit closer by creating holograms from an array of silicon structures that work throughout the visible spectrum.

Many recent advances in hologram technology use reflected light to form an image; however the hologram made by Dong Zhaogang and Joel Yang from the A*STAR Institute of Materials Research and Engineering uses transmitted light. This means the image is not muddled up with the light source.

The team demonstrated the hologram of three flat images at wavelengths ranging from blue (480 nanometers) to red (680 nanometers). The images appeared in planes 50 microns apart for red and higher spacings for shorter wavelengths.

“In principle, it can be tuned to any wavelength,” says Yang.

Holograms can record three-dimensional images, which mean they can store large amounts of information in increasingly thin layers.

Recently, holograms that are mere hundredths of the thickness of a human hair have been made from metal deposited onto materials such as silicon. The holograms are created by nanoscale patterns of metal that generate electromagnetic waves that travel at the metal-silicon interface; a field called plasmonics.

Silicon holograms are slightly thicker than the metal-based ones, but have the advantage of being broadband. Plasmonic holograms only operate in the red wavelengths because they undergo strong absorption at blue wavelengths.

A disadvantage of the silicon holograms is their poor efficiency at only three per cent; however Dong estimates this could easily be tripled.

“The losses can be lowered by optimizing the growth method to grow polycrystalline silicon instead of amorphous silicon,” he says.

The hologram is an array of tiny silicon skyscrapers, 370 nanometers tall with footprints 190 nanometers by 100 nanometers. Unlike a city grid, however, the tiny towers are not laid out in neat squares but at varying angles.

The hologram operates with circularly polarized light, and the information is encoded on to the light beam by the varied angles of the skyscrapers. These alter the phase of the transmitted light through the ‘Pancharatnam-Berry effect’.

“What’s interesting about this hologram is that it controls only the phase of the light by varying the orientation of the silicon nanostructures. The amplitude is the same everywhere; in principle you can get a lot of light transmitted,” says Yang.

The A*STAR researchers focused on nanofabrication and measurements and collaborated with Cheng-Wei Qiu from National University of Singapore, whose team specializes in hologram design.

Story Source:

The above post is reprinted from materials provided by **The Agency for Science, Technology and Research (A*STAR)**.*Note: Content may be edited for style and length.*

Journal Reference:

1. Kun Huang, Zhaogang Dong, Shengtao Mei, Lei Zhang, Yanjun Liu, Hong Liu, Haibin Zhu, Jinghua Teng, Boris Luk’yanchuk, Joel K.W. Yang, Cheng-Wei Qiu. **Silicon**

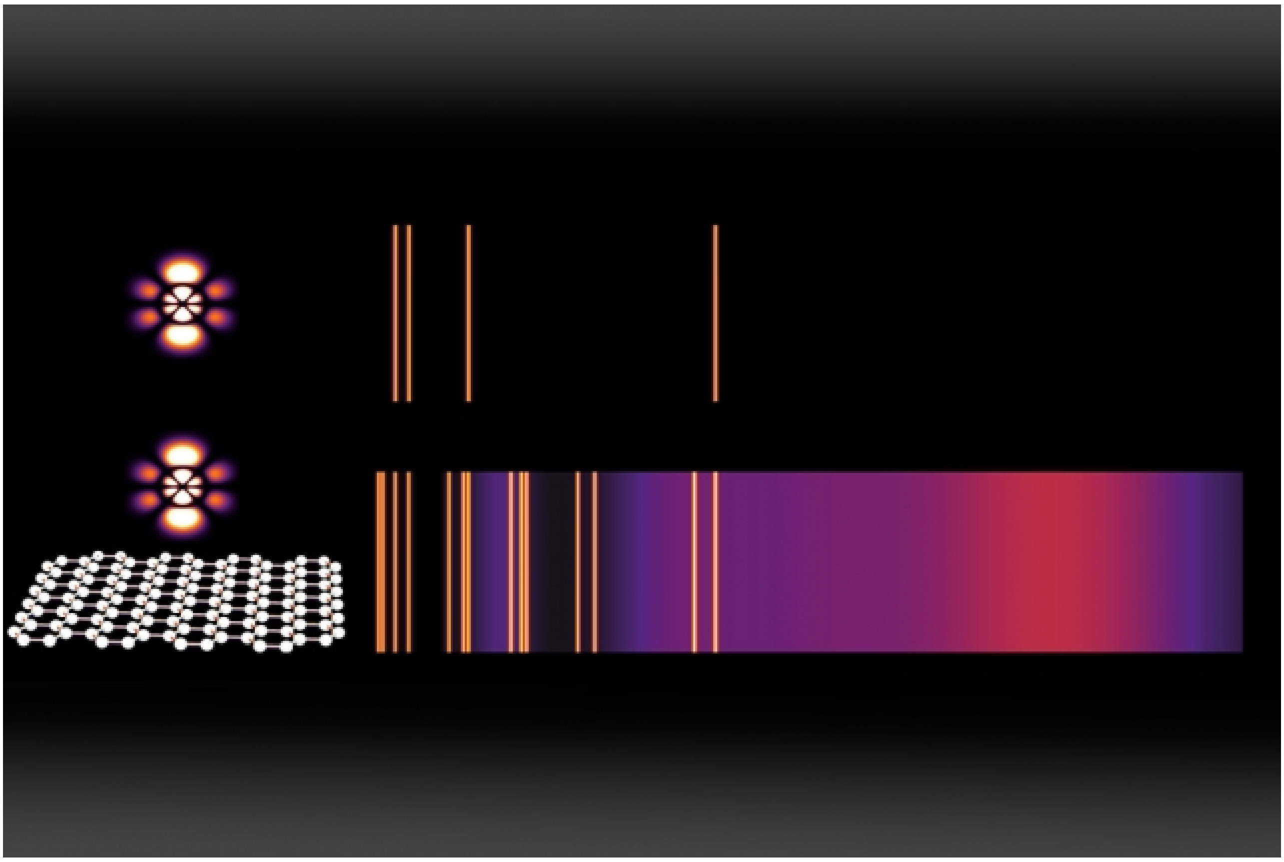
multi-meta-holograms for the broadband visible light. *Laser & Photonics Reviews*, 2016; 10 (3): 500 DOI:10.1002/lpor.201500314

News source: The Agency for Science, Technology and Research (A*STAR). "Silicon brings more color to holograms." ScienceDaily. ScienceDaily, 12 August 2016. <www.sciencedaily.com/releases/2016/08/160812190822.htm>.

Study opens new realms of light-matter interaction

Some "forbidden" light emissions are in fact possible, could enable new sensors and light-emitting devices.

David L. Chandler | MIT News Office
July 14, 2016



Emission spectra are a widely used method for identifying chemical compounds; the bright lines reveal the different frequencies of light that can be emitted by an atom. Here, a normal emission spectrum for an atom in a high-energy state (top) is compared to the emission from the same atom placed just a few nanometers (billionths of a meter) away from graphene that has been doped with charge carriers (bottom). For each energy-level transition, an orange line (or purple cloud) appears if that transition is estimated to be faster than one per microsecond — making it frequent enough to be observed.

A new MIT study could open up new areas of technology based on types of light emission that had been thought to be "forbidden," or at least so unlikely as to be practically unattainable. The new approach, the researchers say, could cause certain kinds of interactions between light and matter, which would normally take billions of years to happen, to take place instead within billionths of a second, under certain special conditions.

The findings, based on a theoretical analysis, are reported today in the journal *Science* in a paper by MIT doctoral student Nicholas Rivera, Department of Physics Professor Marin Soljačić, Francis Wright Davis Professor of Physics John Joannopoulos, and postdocs Ido Kaminer and Bo Zhen.

Interactions between light and matter, described by the laws of quantum electrodynamics, are the basis of a wide range of technologies, including lasers, LEDs, and atomic clocks. But from a theoretical standpoint, "Most light-matter interaction processes are 'forbidden' by electronic selection rules, which limits the number of transitions between energy levels we have access to," Soljačić explains.

For example, spectrograms, which are used to analyze the elemental composition of materials, show a few bright lines against a mostly dark background. The bright lines represent the specific "allowed" energy level transitions in the atoms of that element that can be accompanied by the release of a photon (a particle of light). In the dark regions, which make up most of the spectrum, emission at those energy levels is "forbidden."

With this new study, Kaminer says, "we demonstrate theoretically that these constraints can be lifted" using confined waves within atomically thin, 2-D materials. "We show that some of the transitions which normally take the age of the universe to happen could be made to happen within nanoseconds. Because of this, many of the dark regions of a spectrogram become bright once an atom is placed near a 2-D material."

Electrons in an atom have discrete energy levels, and when they hop from one level to another they give off a photon of light, a process called spontaneous emission. But the atom itself is much smaller than the wavelength of the light that gets emitted — about 1/1,000 to 1/10,000 as big — substantially impairing the interactions between the two.

The trick is, in effect, to “shrink” the light so it better matches the scale of the atom, as the researchers show in their study. The key to enabling a whole range of interactions, specifically transitions in atomic states that relate to absorbing or emitting light, is the use of a two-dimensional material called graphene, in which light can interact with matter in the form of plasmons, a type of electromagnetic oscillation in the material.

These plasmons, which resemble photons but have wavelengths hundreds of times shorter, are very narrowly confined in the graphene, in a way that makes some kinds of interactions with that matter many orders of magnitude more likely than they would be in ordinary materials. This enables a variety of phenomena normally considered unattainable, such as the simultaneous emission of multiple plasmons, or two-step light-emitting transitions between energy levels, the team says.

This method can enable the simultaneous emission of two photons that are “entangled,” meaning they share the same quantum state even when separated. Such generation of entangled photons is an important element in quantum devices, such as those that might be used for cryptography.

Making use of these forbidden transitions could open up the ability to tailor the optical properties of materials in ways that had not been thought possible, Rivera says. “By altering these rules” about the relationship between light and matter, “it can open new doors to reshaping the optical properties of materials.”

Kaminer predicts that this work “will serve as a founding piece for the next generation of studies on light-matter interactions” and could lead to “further theoretical and experimental advances in many fields which rely on light-matter interactions, including atomic, molecular and optical physics, photonics, chemistry, optoelectronics, and many others.”

Beyond its scientific implications, he says, “this study has possible applications across multiple disciplines, since in principle it has potential to enable the full use of the periodic table for optical applications.” This could potentially lead to applications in spectroscopy and sensing devices, ultrathin solar cells, new kinds of materials to absorb solar energy, organic LEDs with higher efficiencies, and photon sources for possible quantum computing devices.

“From the standpoint of fundamental science, this work lays the groundwork for a subfield that just a few years ago was difficult to imagine and until now was largely unexplored,” Soljačić says.

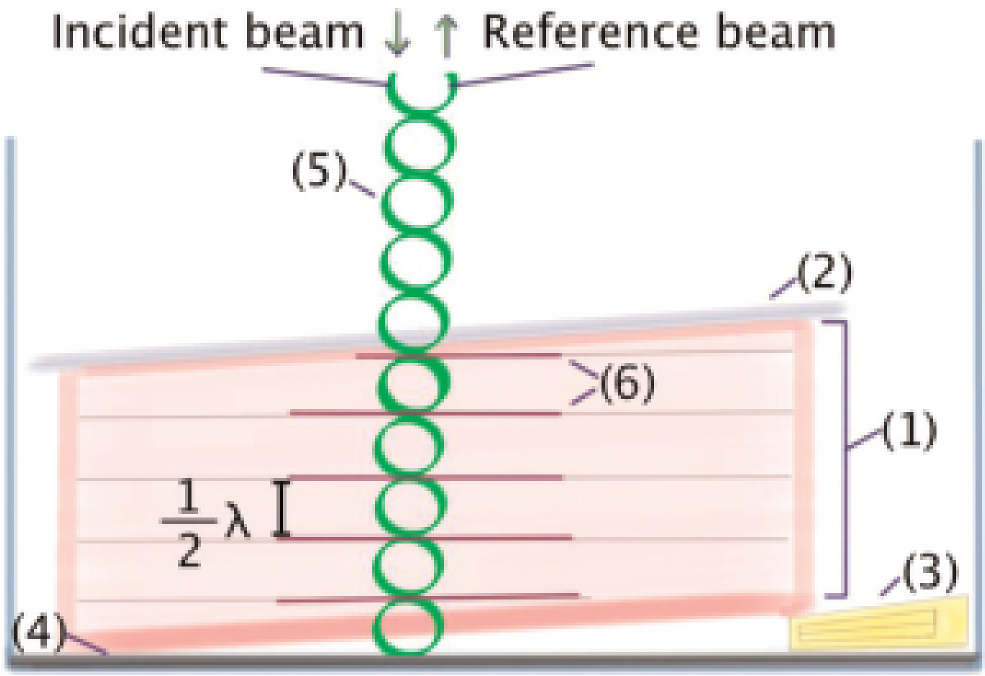
“Two-dimensional materials confine fields to a surface and motion to a plane, making possible many effects that are orders-of-magnitude too weak to appear in a bulk volume,” says Jason Fleischer, an associate professor of electrical engineering at Princeton University, who was not involved in this research. This work, he says, “systematically explores how 2-D materials improve light-matter interactions, laying a theoretical foundation for faster electronic transitions, enhanced sensing, and better emission, including the compact generation of broadband and quantum light.”

The work was partly supported by the Army Research Office through the Institute for Soldier Nanotechnologies at MIT, and by the U.S. Department of Energy.

The link was sent to us by Ms. Asghari.

[A near infrared holographic glucose sensor]

Evangelia Vezouviou et al., have reported a near infrared holographic glucose sensor. Real-time glucose monitoring has been beneficial in reducing health complications associated with diabetes as well as a decrease in mortality. This report describes a novel holographic platform, fabricated via laser ablation on chitosan hydrogel with gold nanoparticles with a replaying in visible and near IR. The sensor responded with a 12nm and 7nm shift in waveleng that glucose concentrations in the 0.70 mM range and in the visible and near IR, respectively, at pH 7.4 and an ionic strength of 154 mM. The sensor did not respond to potential interferences found in the interstitial fluid, such as fructose, vitamin C and lactate, at the irrespective normal concentrations and was stable to fluctuations in temperature, pH and ionic strength. The characteristics of this sensor suggest that it may be applicable for use as an implanted device for the real time monitoring of glucose concentrations in the interstitial fluid using near IR as the interrogating medium.



Holographic fabrication. A photosensitive emulsion (1) coated on a glass slide (2) is placed inside a tray with a 7° spacer (3) and facing towards a reflecting mirror (4).Upon exposure to the laser irradiation (5), the gold nanoparticle grains are arranged in fringes (6) align in parallel to the surface of the polymer, and are separated by half the distance of the wavelength they were exposed to. The diagram is not to scale.

Refrence:

Evangelia Vezouviou, Christopher R. Lowe – 2015 – Biosensors and Bioelectronics 68 ,371–381.

http://dx.doi.org/10.1016/j.bios.2015.01.014.

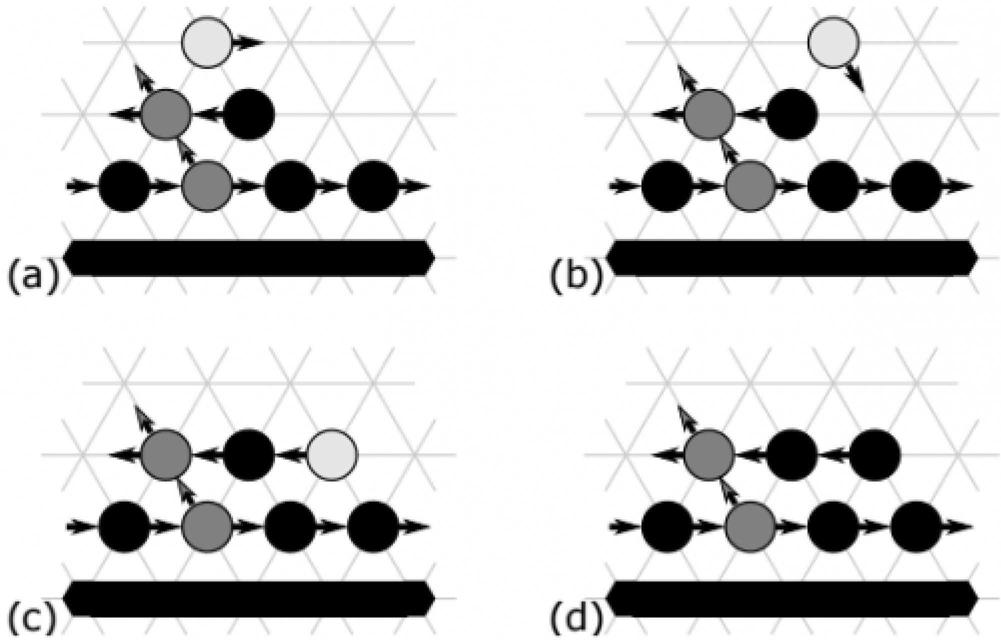
News sent to our group by Ms. Khajemiri

[Programmable Material Algorithm Solves Universal Coating Problem]

If you want to measure the temperature at any point on an object's surface, a thin coating of programmable material can do the job, say computer scientists.

- January 11, 2016

The world is full of complex structures such as bridges, roads, wind turbines, power stations, and so on, that have to be carefully monitored to ensure their integrity.



Today, much of this work has to be done by engineers on the spot. That's not so easy for objects that span hundreds, or even thousands, of kilometers, such as roads, or remote structures such as offshore wind turbines.

So a way of doing this remotely would be hugely valuable. Clearly it requires some kind of independent sensor that can measure the required property such as temperature or acidity, or cracking, and so on.

And indeed there are numerous gadgets for doing this. For example, optical fibers attached to or embedded in objects can measure the forces acting on it and sensors attached to these fibers can monitor temperature, acidity, and so on.

But these kinds of sensors do not provide global coverage—they cannot tell you the temperature at any point on the object. For that you need something more ambitious.

The dream would be to have a smart coating that does this job. This would be a “programmable material” that entirely coats an object in a thin layer. It would contain tiny particulate sensors that gather information about the surface, such as its temperature, and communicate it to their nearest neighbors.

While mathematicians have long pondered the properties of programmable materials, one question has stumped them. Is it possible to use a smart coating to determine the temperature at any point on an arbitrary object, even though the sensors have no knowledge of its overall geometry?

Today, we get an answer to this question thanks to the work of Zahra Derakhshandeh at Arizona State University in Tempe and a few pals. They’ve developed a series of algorithms that provide the mathematical framework that allows these particles to solve this problem.

To make this work, the particulate sensors and the coating must have certain properties. Derakhshandeh and co say the sensors must be able to move within the surface and to make, and break, communication bonds with their nearest neighbors. The object must have a geometry that allows a uniform coating.

Under those conditions, Derakhshandeh and co say that their framework functions as a universal coating algorithm for programmable matter. The particles need only have limited memory and communicate only over short distances and are entirely anonymous—in other words they are all equivalent.

That’s curious work that could one day lead to some useful applications in remote monitoring.

There is still work to be done, however. Given the task of measuring some property of the material at a specific point, one important problem is how quickly the algorithm can do this. To find out, the team suggests testing the algorithm in a simulation or with real programmable matter. It will be interesting to see how they get on.

Another important problem will be the energy efficiency of this kind of programmable matter. What kind of communications overhead does the coating problem impose and could the energy for this conceivably be harvested from the environment?

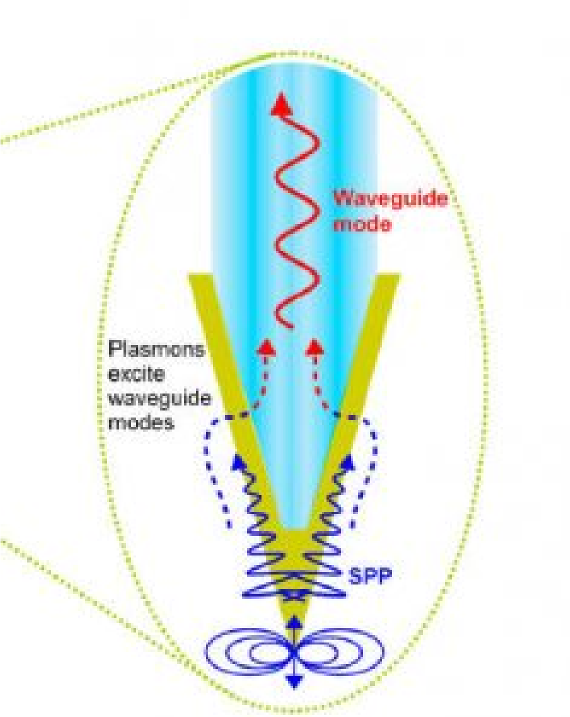
It’s still early days for programmable matter and for a universal coating. But the savings that Derakhshandeh and co’s algorithms might allow are considerable, given the cost of monitoring and maintaining off shore wind turbines, for example. That alone should guarantee further interest in this topic for the future.

Ref: http://arxiv.org/abs/1601.01008 : Universal Coating for Programmable Matter

https://www.technologyreview.com/s/545346/programmable-material-algorithm-solves-universal-coating-problem/

News sent to our group by Ms. Asghari

[Plasmonic Tip Based on Excitation of Radially Polarized Conical Surface Plasmon Polariton for Detecting Longitudinal and Transversal Fields]



Tugchin et al., study experimentally the excitation of the radially polarized conical surface plasmon polariton (SPP) in a fully metal-coated conically tapered M-profile fiber which works as a “plasmonic tip” for the scanning near-field optical microscope (SNOM). This structure extends the Kretschmann configuration to the conical geometry. In this plasmonic tip, the radially polarized waveguide mode, propagating inside the fiber, resonantly excites the radially polarized SPP on the metal surface, which consequently gets confined at the apex where the field oscillates longitudinally along the tip axis. We also demonstrate the reverse process, where a longitudinal field excites the radially polarized SPP mode which then resonantly excites the radially polarized waveguide mode. This plasmonic tip combines the advantageous properties of near-field optical probes. Though, it has the shape of an apertureless SNOM tip, it can simplify the detection/excitation procedure and suppresses the background signal by its fiber-based design. Unlike the sharp apertureless SNOM tips that detects only the longitudinal field component or aperture SNOM tips that detect mostly the transversal component, the plasmonic tip detects both longitudinal and transversal field in collection mode and backward-scattering mode, respectively. The plasmonic tip, with further improvements, can become an advanced tool in SNOM due to its ability for background-free near-field detection, ease of operation, and higher conversion efficiency from far-field to near-field than conventional tips.

The link of published paper can be found here:

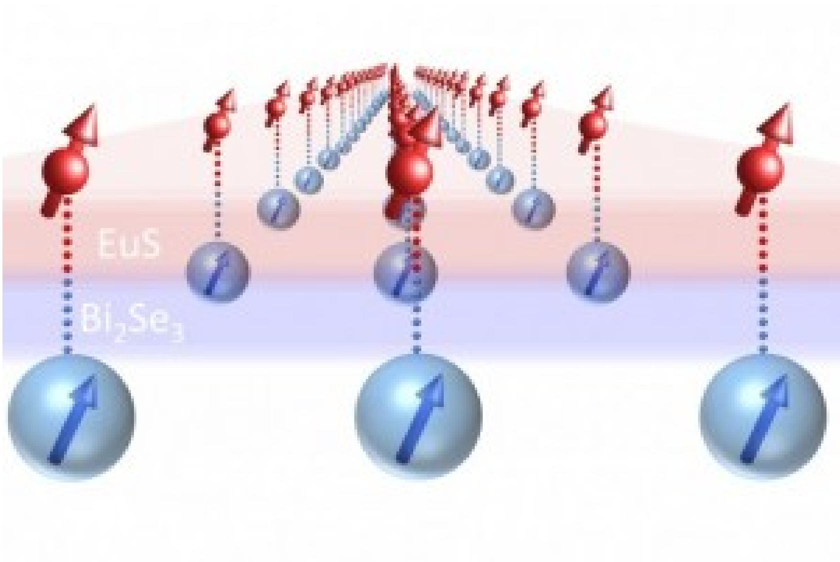
http://pubs.acs.org/doi/abs/10.1021/acsphotonics.5b00339?journalCode=apchd5

[Researchers find unexpected magnetic effect]()

Combining two thin-film materials yields surprising room-temperature magnetism.

David L. Chandler | MIT News Office

May 9, 2016



A new and unexpected magnetic effect has taken researchers by surprise, and could open up a new pathway to advanced electronic devices and even robust quantum computer architecture.

The finding is based on a family of materials called topological insulators (TIs) that has drawn much interest in recent years. The novel electronic properties of TIs might ultimately lead to new generations of electronic, spintronic, or quantum computing devices. The materials behave like ordinary insulators throughout their interiors, blocking electrons from flowing, but their outermost surfaces are nearly perfect conductors, allowing electrons to move freely. The confinement of electrons to this vanishingly thin surface makes then behave in unique ways.

But harnessing the materials' promise still faces numerous obstacles, one of which is to find a way of combining a TI with a material that has controllable magnetic properties. Now, researchers at MIT and elsewhere say they have found a way to overcome that hurdle.

The team at MIT, led by Jagadeesh Moodera of the Department of Physics and postdoc Ferhat Katmis, was able to bond together several molecular layers of a topological insulator material called bismuth selenide (Bi_2Se_3) with an ultrathin layer of a magnetic material, europium sulfide (EuS). The resulting bilayer material retains all the exotic electronic properties of a TI and the full magnetization capabilities of the EuS.

But the big surprise was the stability of that effect. While EuS itself is known to retain its ability to hold a magnetic state only at extremely low temperatures, just 17 degrees above absolute zero (17 Kelvin), the combined material keeps those characteristics all the way up to ordinary room temperature. That could make all the difference for developing devices that are practical to operate, and could open up new avenues of device design as well as research into a new area of basic physical phenomena.

The findings are being reported in the journal Nature, in a paper by Katmis, Moodera, and 10 others at MIT, and a multinational, multidisciplinary team from Oak Ridge, Argonne National Laboratories, and institutions in Germany, France, and India.

The room-temperature magnetic effect seen in this work, Moodera says, was something that “wasn’t in anybody’s wildest expectations. This is what astonished us.” Research like this, he says, is still so near the frontiers of scientific knowledge that the phenomena are impossible to predict. “You can’t tell what you’re going to see next week or what’s going to happen” in the next experiment, he says.

In particular, novel combinations of two materials with very different properties “is an area with very little depth of research.” And getting clear and repeatable results depends on a high degree of precision in the preparation of the surfaces and joining of the two materials; any contamination or imperfections at the interface between the two — even down to the level of individual atomic layer — can throw off the results, Moodera says. “What happens, happens where they meet,” he says, and the careful and persistent effort of

Katmis in making these materials was key to the new discovery.

The finding could be a step toward new kinds of magnetic interactions at the interfaces between materials, with stability that could result in magnetic memory devices which could store information at the level of individual molecules, the team says.

The effect, which the researchers call proximity-induced magnetism, could also enable a new variety of "spintronic" devices based on a property of electrons called spin, rather than on their electrical charge. It might also provide the first practical way of producing a kind of particle called Majorana fermions, predicted by physicists but not yet observed convincingly. That in turn could help in the development of quantum computers, they say.

"A nice thing about this is that it shows both very fundamental physics and also takes us forward to many possible applications," Katmis says. He says the effect is somewhat similar to unexpected findings a decade ago in the interfaces between some oxide materials, which has triggered a decade of intensive research.

This new finding, coupled with other recent quantum behavior observed in TIs, can lead to many possibilities for future electronics and spintronics, the team says.

"This beautiful work from Moodera's group is a very exciting demonstration that the whole is greater than the sum of its parts," says Philip Kim, a professor of physics at Harvard University, who was not involved in this work. "Topological insulators and magnetic insulators are two completely dissimilar materials. Yet they produce very unusual emergent effects at their atomically clean interface," he adds. "The enhanced interfacial magnetism shown in this work can be very relevant to building up novel spintronics devices that can process information with low energy consumption."

The team also included associate professor of physics Pablo Jarillo-Herrero and postdoc Peng Wei at MIT, and researchers at the Institute for Theoretical Physics in Bochum and the Institute for Theoretical Solid State Physics in Dresden, both in Germany; the Ecole Normale Superieure in Paris; and the Institute of Nuclear Physics, in Kolkata, India. The work was supported by the National Science Foundation, Office of Naval Research, and the U.S. Department of Energy.

The news was sent to us by Mr. Mosleh.