Press Release

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Subject: *University of Electro-Communications* research: Quantum computing: Trapping single atoms in a uniform fashion

(Tokyo, 28 September 2016) *University of Electro-Communications, Tokyo* publishes the September 2016 issue of the *UEC e-Bulletin* that includes research highlights from high impact publications by UEC, Tokyo scientists on quantum computing, physiology, neurology, and space physics.

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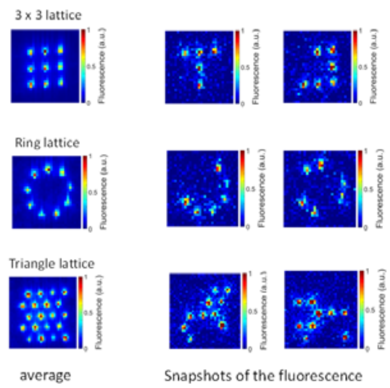
Research Highlights

Quantum computing: Trapping single atoms in a uniform fashion
http://www.ru.uec.ac.jp/e-bulletin/research-highlights/2016/quantum-computing.html



Single neutral atoms trapped individually in optical microtraps are incredibly useful tools for studying quantum physics, as the atoms then exist in complete isolation from the environment. Arrays of optical microtraps containing single atoms could enable quantum logic devices, quantum information processing, and quantum simulation.

While single atom trapping has already been achieved, there are still many challenges to overcome. One such challenge is making sure each trap holds no more than one atom at a time, and also keeping it there so it won't escape. This requires uniform optical microtraps, which have yet been fully realized.

Now, Ken'ichi Nakagawa and co-workers at the University of Electro-Communications, Tokyo, Japan, together with scientists across Japan and China, have successfully demonstrated an optimization method for ensuring the creation of uniform holographic microtrap arrays to capture single rubidium (87Rb) atoms.

The team generated holograms for red light-tuned microtraps arrays in various shapes including square, honeycomb and ring formations (see image). They combined each hologram with two phase patterns, including a grating pattern which allowed the researchers to separate out the traps from non-diffracted light. A spatial light modulator tuned the trap light to the calculated hologram pattern and ensured uniformity of depth across the microtraps.

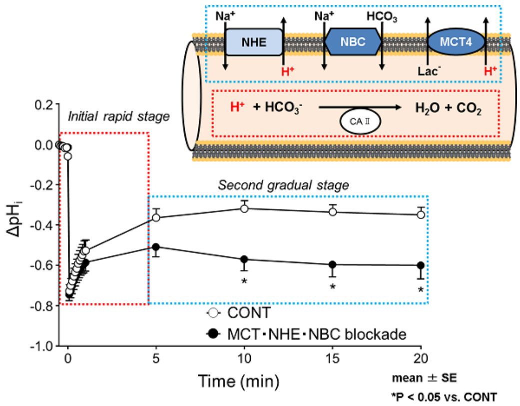
Nakagawa's team measured the diffracted light intensity with a specialized camera, and monitored the in-trap fluorescence from the Rb atoms; these two 'feedback' methods allowed them to optimize the traps and ensure uniformity. They could also verify the presence of a single atom in each trap more precisely.

Reference

Tamura, H., Unakami, T., He, J., Miyamoto, Y., Nakagawa, K. Highly uniform holographic microtrap arrays for single atom trapping using a feedback optimization of in-trap fluorescence measurements. Optics Express 8132 (2016)
doi: 10.1364/OE.24.008132

Physiology: Cell pH regulation revealed

http://www.ru.uec.ac.jp/e-bulletin/research-highlights/2016/physiology.html



Most physiological processes are pH-sensitive, and pH within individual cells in skeletal muscles (pHi) must be carefully regulated to maintain normal cellular functioning. During intensive exercise, and also in certain diseases, levels of a cationic form of hydrogen (H+) rise rapidly within cells, causing pHi levels to plummet and become more acidic. There are three membrane transporters known to be involved in regulating pHi, but their precise individual roles are unclear.

Yutaka Kano and co-workers at the University of Electro-Communications, Tokyo, together with scientists across Japan and the US, conducted experiments using in vivo bioimaging models to verify the roles of these transporters in pHi regulation.

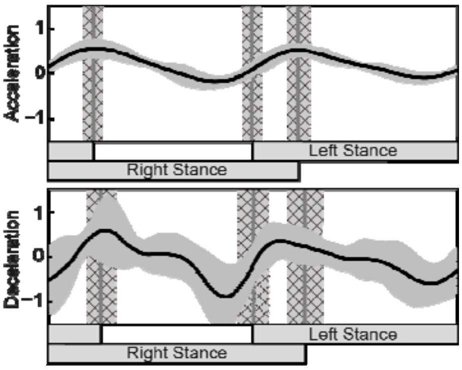
The team tested the effects of an injection of H+ into single muscle fibers in rats. They blocked each transporter involved in pHi regulation - namely, lactate/H+ cotransporter (MCT), Na+/ H+ exchange transporter (NHE) and Na+ / HCO3 cotransporter (NBC) - one at a time and then all together. They compared their results with a control group with normal transporter functioning.

Their results showed that two stages exist in pHi recovery; an initial rapid stage followed by a second, more gradual recovery stage. Kano's team discovered that the three transporters were not involved in the rapid stage. While individual transporter inhibition did not impact on pHi recovery, blocking all three transporters prevented the second stage (gradual recovery) from occurring.

The study also revealed that the pH of surrounding fibers changed following H+ injection, suggesting that they take up excess H+ to alleviate stress in affected cells.

Reference
Tanaka, Y., Inagaki, T., Poole, D.C., & Kano, Y. pH buffering of single rat skeletal muscle fibers in the in vivo environment. American Journal of Physiology 310 (2016).
doi: 10.1152/ajpregu.00501.2015

Neurology: A closer look at walking control
http://www.ru.uec.ac.jp/e-bulletin/research-highlights/2016/neurology.html



Humans and animals tune their walking rhythms in response to their environment. If walking is disturbed in some way, the brain's neurons respond by altering the walking rhythm to maintain stability. Studying the physiological and neurological processes behind rhythm control can help scientists understand how we walk steadily and may inform future treatments for those with walking difficulties.

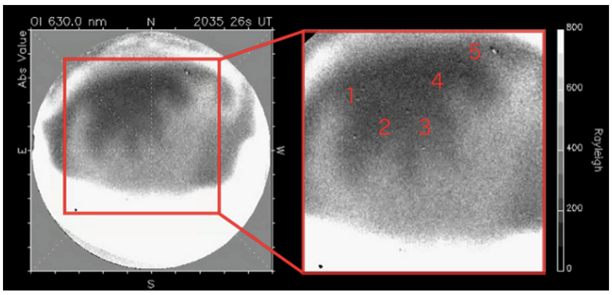
Previous research examined reactions to disturbance by pulling on the swing leg during the walking cycle. This, however, had no significant effect on the stance leg. Therefore, Tetsuro Funato at the University of Electro-Communications, Tokyo, Japan, together with scientists across Japan, decided to examine the reactions of people walking on a moving treadmill that randomly changed speed.

The team aimed to estimate the 'phase response curve', or PRC, for humans under a complete, but disturbed, walking cycle. Analysis of the PRC can reveal the behaviour of neurons and associated rhythm changes during a cycle. The researchers also assessed two methods of estimating the PRC; the conventional 'impulse method' and the newer 'weighted spike-triggered average' (WSTA) method.

Their results demonstrated that changing floor velocities affected human walking rhythm by lengthening the touch-down phase of the leading foot. The participants also extended the mid-single support phase, where only the stance leg is in contact with the floor. The researchers discovered these rhythm changes through clear, stable waveform patterns in the PRC estimated using the WSTA method. The WSTA method picked up smaller perturbations than the impulse method, and as such may prove more valuable for such investigations in future.

Reference
Funato, T., Yamamoto, Y., Aoi, S., Imai, T., Aoyagi, T., Tomita, N., & Tsuchiya, K. Evaluation of the phase-dependent rhythm control of human walking using phase response curves. PLOS Computational Biology 12 (5) (2016).
doi: 10.1371/journal.pcbi.1004950

Space physics: Confirming the structure and shape of polar cap patches
http://www.ru.uec.ac.jp/e-bulletin/research-highlights/2016/space-physics.html



Large-scale patches of enhanced electron density (plasma) are often found in the polar ionosphere - about 80 to 1000 kilometers above the Earth's surface. These 'polar cap patches' can last for hours, cover huge areas and travel quickly, and their presence can disrupt satellite communication links.

Scientists have recently begun collecting high definition, two-dimensional images of the patches using 'all-sky airglow imagers' (ASI). These specialized instruments can image emissions from excited atomic oxygen, allowing for the capture of plasma patches in greater detail.

Keisuke Hosokawa at the University of Electro-Communications in Tokyo and co-workers across Japan analyzed ASI images of ten different patches that occurred during a four-hour period over Longyearbyen in Norway in December 2013. Their observations prove for the first time that the patches exhibit specific structural qualities, as previously predicted by computer simulations1.

For example, the images allowed the team to visualize the gradients between the leading and trailing edges of the patches as they moved from day-side to night-side across the poles. The leading edge gradient was between two and three times steeper and more stable than the trailing edge.

Hosokawa's team then verified the presence of 'finger-like' structures on the trailing edge of each patch. They believe these fingers result from plasma restructuring due to disturbances moving through the plasma and mixing it. This activity makes the trailing edge more gradual in gradient and influences the shape and size of the whole patch.

Understanding patch instability, structure and shape may enable better predictions of space weather impacts on satellite communication links.

Reference
Hosokawa, K., Taguchi, S., & Ogawa, Y., Edge of polar cap patches. Journal of Geophysical Research: Space Physics 121 (2016)
DOI: 10.1002/2015JA021960

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About The University of Electro-Communications
The University of Electro-Communications (UEC) in Tokyo is a small, luminous university at the forefront of applied sciences, engineering, and technology research. Its roots go back to the Technical Institute for Wireless Commutations, which was established in 1918 by the Wireless Association to train so-called wireless engineers in maritime communications in response to the Titanic disaster in 1912. In 1949, the UEC was established as a national university by the Japanese Ministry of Education, and moved in 1957 from Meguro to its current Chofu campus Tokyo.

With approximately 4,000 students and 350 faculty, UEC is regarded as a small university, but with particular expertise in wireless communications, laser science, robotics, informatics, and material science, to name just a few areas of research.

The UEC was selected for the Ministry of Education, Culture, Sports, Science and Technology (MEXT) Program for Promoting the Enhancement of Research Universities as a result of its strengths in three main areas: optics and photonics research, where we are number one for the number of joint publications with foreign researchers; wireless communications, which reflects our roots; and materials-based research, particularly on fuel cells.
Website: http://www.uec.ac.jp/eng/