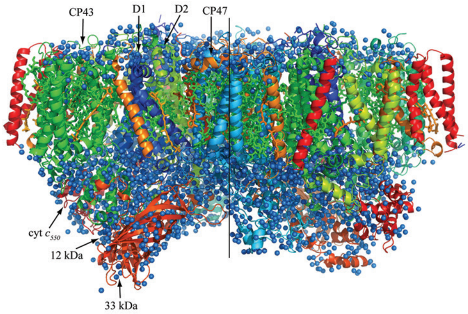
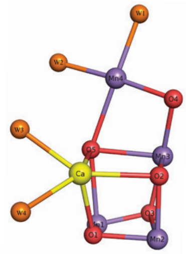
Okayama University

A Multifaceted Center for Interdisciplinary Research

Vice President
Shin-ichi Yamamoto



Protein Structure of Photosystem II



Catalyst for Water Splitting

Okayama University Library

Okayama University is a comprehensive institution with approximately 1,300 faculty and 14,000 students. It offers courses in subjects ranging from medicine and pharmacy to humanities and physical sciences and is situated approximately three hours west of Tokyo by high-speed rail. The roots of the university go back to the Medical Training Place set up in 1870 with the support of the lord of Okayama.

"An independent report compiled by the National Institute of Science and Technology Policy shows our research strengths in physics and basic life sciences," says **Shin-ichi Yamamoto,** executive director and vice president for research. "As part of the Ministry of Education, Culture, Sports, Science and Technology [MEXT] Program for Promoting the Enhancement of Research Universities, we have established the provisionally named Organization for Global Advanced Interdisciplinary Sciences, which will implement reforms that build on our strengths to create a globally competitive, research-based university."

The main pillars of the Okayama University's overall research strategy are the Center of Innovation project, enhancing translational clinical research at Okayama University Hospital (a hospital that was selected as one of the 15 core hospitals for clinical research in Japan), and the abovementioned MEXT program.

"The Organization for Global Advanced Interdisciplinary Science will coordinate our research strategy by collaborating with other institutes located near Okayama, such as RIKEN's SPring-8 synchrotron, the X-ray free electron laser (SACLA) in Harima, and the K-supercomputer in Kobe," explains Yamamoto.

Toru Numaguchi was appointed senior research administrator in 2012. "Some of the major challenges in the implementation of research reforms will be defining new areas of research over the next, say, 10 years, as well as initiating productive and high-quality international research, and estimating funding requirements over that 10-year span," says Numaguchi.

The directors of research at Okayama University have used and will continue to use powerful databases to conduct bibliometric studies in order to benchmark research, find partners for research and technology transfer, and develop future strategies.

"Data analysis and surveys will become increasingly important for devising research strategies at universities in Japan," says Yamamoto. "Data from this type of benchmarking may play a greater role in decisions for funding major projects, as in the case of the MEXT program, which was a top-down decision based on independent performance data."

Some of the centers at the university benefiting from the MEXT program are highlighted in the sidebars below.

Okayama University:
www.okayama-u.ac.jp/index_e.html

Creating New Materials for a Green Future

"The Research Center of New Functional Materials for Energy Production, Storage and Transport was launched in July 2010," says **Yoshihiro Kubozono**, director of the center. "It is the hub of an international and interdisciplinary research project based on innovative functional materials to develop science and technology for a sustainable, low-carbon society."

Research at the center covers a broad range of areas:

- High-performance and high-efficiency organic solar cell alternatives to the conventional photovoltaic devices, fabricated using inorganic materials such as amorphous silicon and other such semiconductors
- Development of novel solar cells based on new dielectric materials
- Development of low-energy consumption processes to manufacture high-performance organic field-effect transistors
- Synthesis of new nanomaterials for storing hydrogen and methane
- Development of new superconducting organic materials
- Development of high-temperature superconductors using new design approaches
- Conversion of optical energy to electrical energy using processes based on biological systems.

"We are global in our approach to pursuing our goals," explains Kubozono. "One of our colleagues from Okayama University is on a long-term stay at the University of Durham in the United Kingdom, where he is investigating new carbon-based superconductors." Funding from the MEXT program will be used to strengthen the university's global presence by inviting scientists from overseas to conduct research at the center.

Okayama University scientists are strongly encouraged to share their findings with the broader scientific community. "We regularly publish our findings in high impact journals, reflecting the high quality of our research," says Kubozono. "Notably, we have published a paper in the journal *Nature* each year since the launch of the center."

Kubozono was recently in the spotlight following the generation of potassium-doped picene, a semiconducting solid hydrocarbon. The material exhibits superconductivity properties at relatively high temperatures (up to 18 Kelvin, or -255.2°C). "Superconductivity in carbon materials may be a new way to produce superconducting circuits for ultra-low power electronics," says Kubozono. "This is an excellent example of our focus on interdisciplinary science, with chemists contributing to physics."


Yoshihiro Kubozono

Kubozono Laboratory:
interfa.rlss.okayama-u.ac.jp/index.html

Research Center of New Functional Materials for Energy Production, Storage and Transport:
www.science.okayama-u.ac.jp/RCNFM/indexeng.html

Photosynthesis Research Center

The Photosynthesis Research Center was launched in April 2013. "Our goals are to clarify the biochemical mechanisms of photosynthesis, in particular reactions related to light-induced water-splitting," explains **Jian-Ren Shen**, director of the center. "Our findings may enable the synthesis of catalysts for artificial photosynthesis—for a potentially unlimited source of clean energy."

The importance of Shen's research into the mechanisms of light-induced water-splitting led to its selection as one of the 10 Breakthroughs of the Year in 2011 published by *Science*. It was also awarded the prestigious 2012 Asahi Prize for outstanding accomplishments in the fields of academics and arts.

"The results are described in a 2011 *Nature* paper and are the culmination of 21 years of my research on photosynthesis resulting in the synthesis of ultra-pure, single-crystals of the so-called Photosystem II membrane protein complex, or PS II," explains Shen.

Ultrahigh resolution X-ray diffraction experiments on the PS II crystals conducted at the SPring-8 facility showed that it has a cubic-core of four manganese atoms, five oxygen atoms, and a calcium atom. This cluster of Mn_4CaO_5 catalyzes the light-induced splitting of water. "The distorted chair-like structure of the cluster proved to be difficult to synthesize artificially," says Shen. "But there is considerable industrial interest in doing so. Success may yield a means of extracting clean energy from the sun."

Okayama University Photosynthesis Research Center:
www.okayama-u.ac.jp/en/tp/news/news_id2402.html


Jian-Ren Shen

Research Core for the Extreme Quantum World

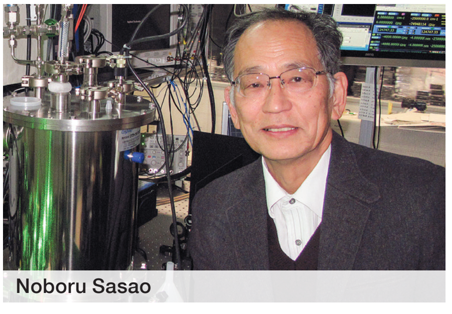
Photons are the most abundant particles in the universe at about 410 particles per cubic centimeter, while the second most abundant are neutrinos (330 particles per cm^3). The physics of photons (light) is well established, but quantitative information about neutrinos, such as their absolute mass, is lacking despite their importance for explaining the structure and origins of the universe.

The physical properties of neutrinos are not well understood in large part because they are extremely difficult to detect. Current state-of-the-art research on neutrinos is expensive, time-consuming, and requires the use of massive particle accelerators and/or detectors buried deep in the Earth.

Now, **Noboru Sasao** and colleagues at the Okayama University Research Core for the Extreme Quantum World are proposing to conduct research in ordinary, inexpensive university labs in an attempt to demystify the world of neutrinos and the origins of the universe through the Spectroscopy with the Atomic Neutrino (SPAN) project.

"In SPAN, we are investigating the properties of neutrinos by analyzing the response of target atoms to incident laser light," says Sasao, leader of the SPAN project. "Our approach offers a relatively inexpensive and systematic method for obtaining preliminary data about neutrinos that could be used as the basis for more advanced and quantitative research on the origins of matter in the universe."

In these experiments, the researchers excite atoms or molecules coherently with laser light and detect and measure the energies of photons emitted due to the de-excitation, a process called radiative emission of a neutrino pair (RENP). Neutrinos are impossible to detect directly but information about their absolute mass can be ascertained by analysis of the photon spectra. However, the rate of emission of light in the RENP process is extremely small, which in turn limits the probability of finding information about neutrinos in the emission spectra. "We intend to overcome this problem by using lasers to amplify the optical signal from samples," explains Sasao. "We refer to this amplification mechanism as macro-coherent amplification, and it manifests itself as two photons being emitted in the de-excitation process, which we have called paired super-radiance." Initial proof-of-principle experiments using a solid sample of parahydrogen are promising, showing a coherence time of longer than 20 ns. This is very long for solid materials, which typically have coherence times of less than 1 ns.


Noboru Sasao

Research Core for the Extreme Quantum World:
www.xqw.okayama-u.ac.jp/index.php