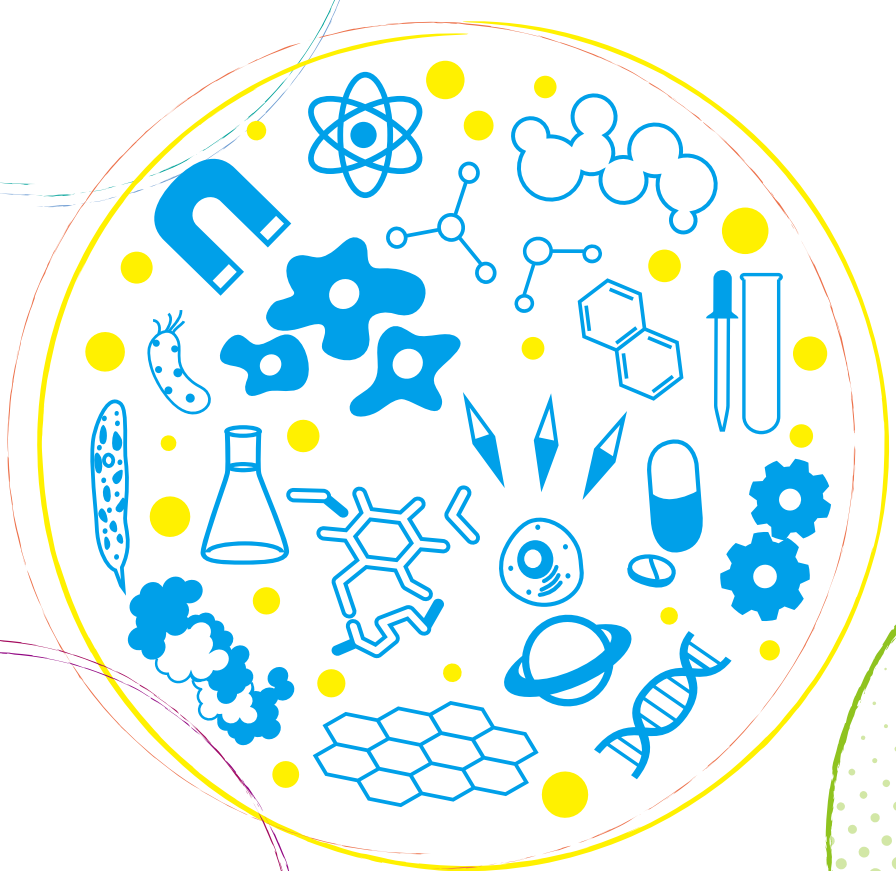
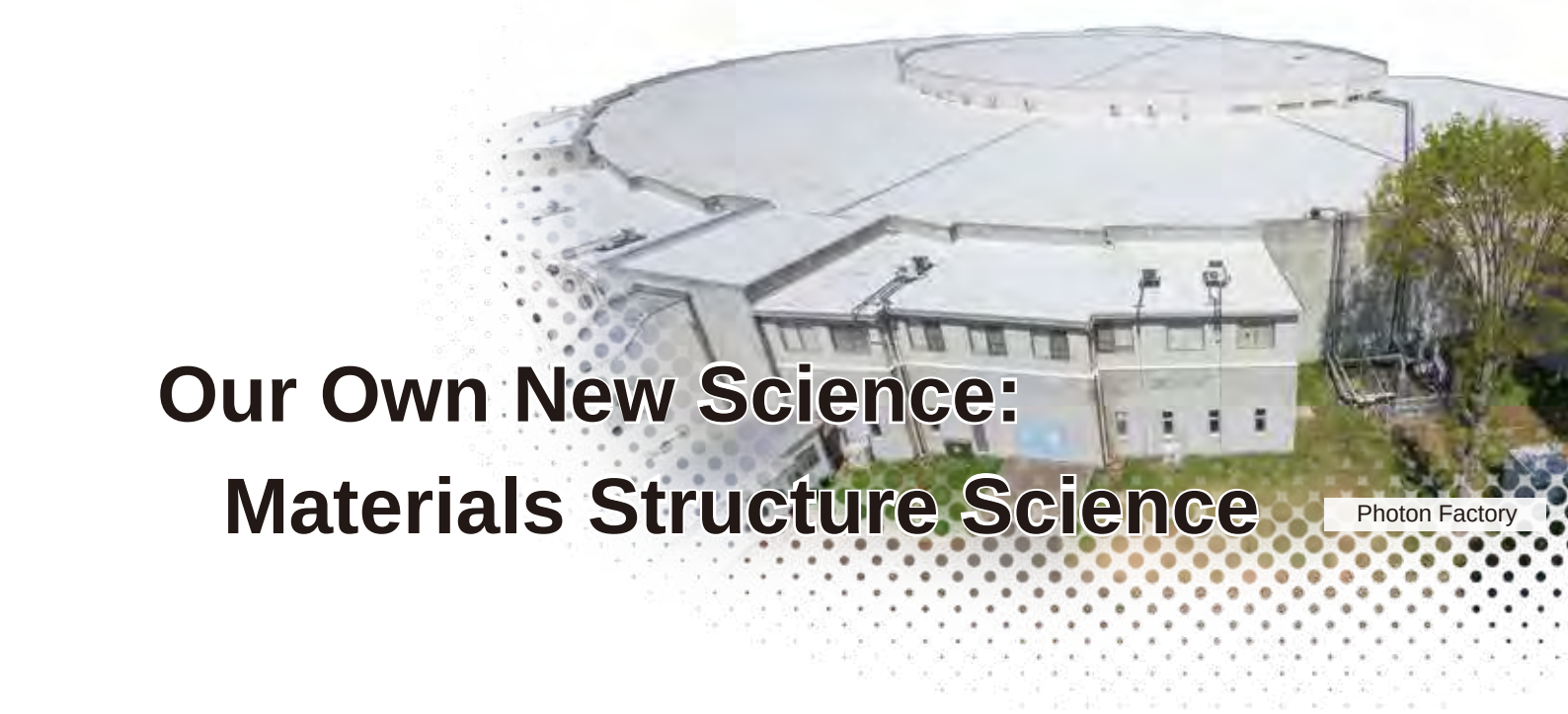
IMSS
物質構造科学研究所

Institute of Materials Structure Science

High Energy Accelerator Research Organization





Photon Factory

Our Own New Science: Materials Structure Science

The Institute of Materials Structure Science (IMSS) was founded in 1997, as one of 19 Inter-University Research Institutes belonging to the Ministry of Education, Culture, Sports, Science and Technology, Japan. The Inter-University Research Institute is leading academic research in national universities and specialized research organizations, by performing collaborative research among its member groups and international collaborators. The IMSS is pioneering a new field called materials structure science.

Director Nobuhiro Kosugi

In materials structure science, we can determine atomic-level and electronic structures of any material, including living systems, natural and artificial materials, and even materials from outer space. Knowledge of these material structures makes it possible to synthesize new materials for technological development.

In the 20th century, the science of materials was based on the extraction of components contained within the materials themselves. However, the characterization of each component is not sufficient to fully understand the properties of materials, because they have multi-functionalities, and the interactions of components govern this phenomenon. A key concept in materials structure science, starting around the turn of the 21st century, is the multi-characterization of the multi-functionality of materials. The IMSS leads materials structure science by combining scientific skills and knowledge via our unique research environment, which utilizes multi-quantum beams, such as photons, neutrons, muons, and positrons in the study of materials.

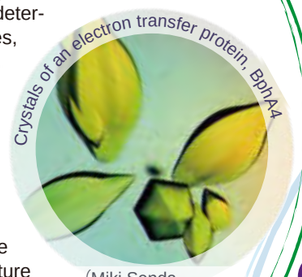
J-PARC Materials and Life Science Experimental Facility

Satisfying your "curiosity"

Crystral structure

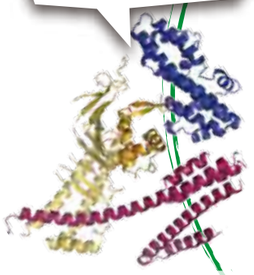
A crystal is a solid material whose atoms or molecules are arranged in a repeating pattern. The arrangement of atoms can be determined by the diffraction of particles, such as X-rays and neutrons. X-ray crystallography is the most commonly used diffraction method for protein structure analysis.

Proteins are large, complicated molecules that play an essential role in life. Determining the three-dimensional (tertiary) structure of proteins can provide important insights into their biological functions. Protein structures are also important for the understanding of diseases and the development of therapeutic drugs.



(Miki Senda
Assistant Professor)

We identified why East Asian strains of *Helicobacter pylori* have a higher carcinogenic risk.



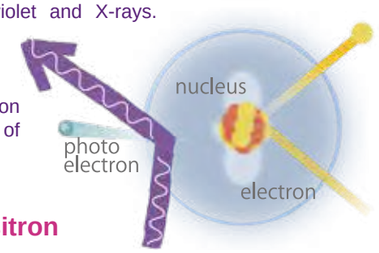
Structure of the cancer-causing protein CagA derived from *Helicobacter pylori*
(Professor Toshiya Senda)

Accelerators are huge microscopes

Light and particle beams generated by accelerators enable us **to observe materials in atomic scale**.
Complementary use of synchrotron radiation, neutrons, muons, and slow positrons is effective for materials structure science.

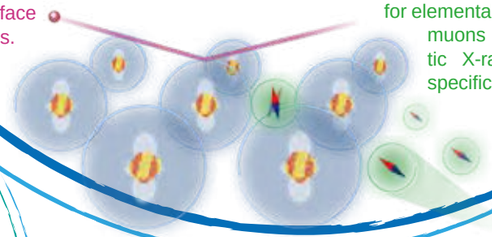
Synchrotron Radiation

Synchrotron radiation is highly brilliant light with a wide range of wavelengths, including vacuum ultraviolet and X-rays. Synchrotron radiation interacts with electrons in matter, and is used to investigate the configuration of atoms and the behavior of various materials.



Slow Positron

A positron is the antiparticle of an electron. It is highly sensitive to material surfaces, due to its electronic properties, and can be used to investigate details of the atomic arrangement of the outermost and near-surface layers.



Neutron

Neutrons, having no electric charge, are useful for observing the structure of light elements, such as hydrogen and lithium. Neutrons can identify isotopes with high contrast, and can observe the structure inside materials due to their high penetrating power.

Muon

Muons created in an accelerator have polarized spins. Using them as atomic scale compasses, the local magnetic field of a material can be measured. Negative muons are used for elemental analyses, because the muons produce characteristic X-rays with energies specific for the element.

The structure of surface and interface

The surface and the interface, where materials meet each other, are important sites for chemical reactions. Surface diffraction and reflection can examine the layer-by-layer atomic structure at the surface, the electronic behavior at the surface and interface, and the structural changes during the reactions.

Reactions by catalysts and those in batteries occur at the surface and interface of materials. For example, the efficiency of batteries can be improved by understanding detailed mechanisms of the structural changes in the electrodes during charge and discharge.

Chemical-state imaging

X-ray microscopes can perform three-dimensional imaging of chemical states as well as microstructures and elements.

Turbine

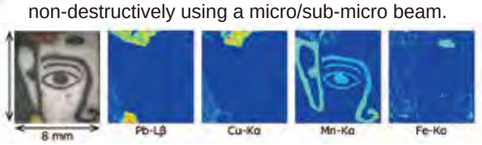
5μm

One recent target is the structural material used in airplanes, such as jet turbine blades.

3D imaging of degradation and voids
(Professor Masao Kimura)

Elemental imaging

The distribution of trace elements can be examined non-destructively using a micro/sub-micro beam.

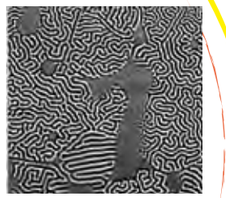


Ancient Egyptian mosaic glass
(Professor Izumi Nakai, Tokyo University of Science)

In Tempo oval gold coins, the gold is richer at the surface than inside.

Magnetism and spin

Magnetic structure is examined using polarized X-rays, spin of neutrons, and muons. Magnetic moment, momentum, and temporal and spatial fluctuations are widely studied.



Magnetic domain structure of a neodymium magnet
(Kanta Ono
Associate Professor)

The development of rare-metal-free magnets and heat resistant magnets has led to better performance and more energy-saving motors in electric and hybrid vehicles.

High-speed reaction

The time scale of chemical reactions ranges from a long period of time to a femtosecond (10^{-15} seconds). Using a pulsed light source, reactions can be captured and displayed as single frames like the images of a high-speed camera.

Inter-University Research Institute

The IMSS operates large accelerators and associated facilities, as an Inter-University Research Institute, which are difficult for individual universities to run. The Photon Factory (PF), the Slow Positron Facility (SPF) in Tsukuba Campus, and the Materials and Life Science Experimental Facility (MLF) of the Japan Proton Accelerator Research Complex (J-PARC) in Tokai Campus are open to users at universities and public research institutions, including those outside Japan, at no charge.

Academic-industrial collaboration

Materials evaluation and characterization are indispensable for manufacturing industries.
The PF and the MLF provide materials evaluation and analytical techniques, which lead to the creation of new products and quality improvement.

【Contact】

Consultation desk for PF experiments
(including Slow Positron experiments)
pfexconsult@pfiqst.kek.jp

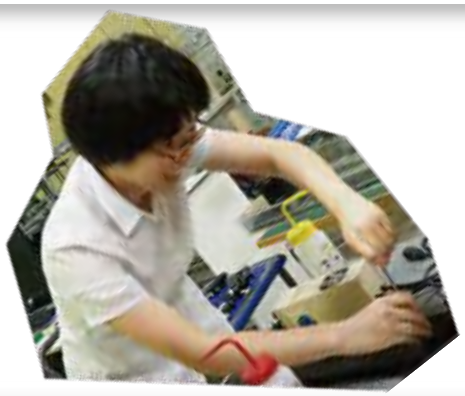
Consultation desk for MLF experiments
j_proposal@ml.j-parc.jp

Graduate education

The IMSS is a partner of SOKENDAI (the Graduate University for Advanced Studies) and co-manages the Department of Materials Structure Science in the School of High Energy Accelerator Science. In addition to accepting students from SOKENDAI, the IMSS also enrolls graduate students from universities throughout Japan and all over the world. Students receive the highest level of training, and learn state-of-the-art scientific techniques preparing them for a future career in science.

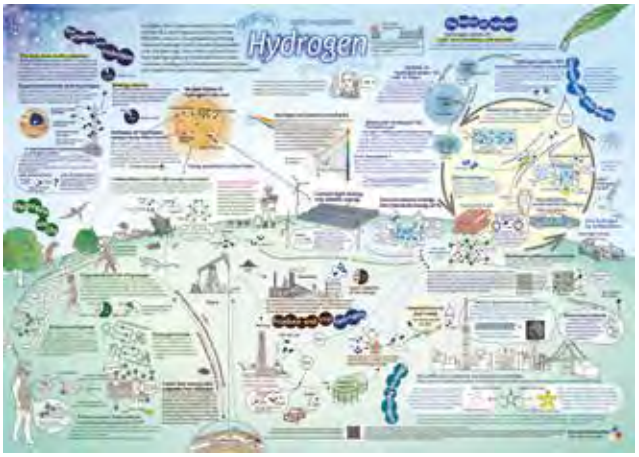
【Contact】

Research Cooperation Division,
Graduate Education Section kyodo2@mail.kek.jp



Outreach

The IMSS organizes many events and lectures in science museums and schools, where people can learn about and enjoy materials science.
In 2016, the IMSS's poster of "Hydrogen" was adopted in the "one for every household" posters project by the Ministry of Education, Culture, Sports, Science and Technology. This poster has been distributed nationwide to elementary, junior, and high schools, and cooperative science museums.



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International collaboration

At the PF, the Indian Beamline has been preferentially used by researchers from India since 2009. The IMSS has been working on synchrotron research collaboration in the Asia-Oceania region, and has been contributing to the construction of the SESAME accelerator in the Middle East.
The Japan-UK agreement, since 1986, resulted in the construction of the neutron chopper spectrometer, MARI, at ISIS in the UK with long-term visiting researchers thereafter. This formed the foundation of neutron science technology at MLF, J-PARC.
The IMSS sponsors the exchange of researchers with the Paul Scherrer Institute (PSI) in Switzerland, and the Tri-University Meson Factory (TRIUMF) in Canada, conducting advanced experiments using muon beams as well as the collaborative development of experimental devices and analytical techniques.

Accepting students from Africa at the PF

Tsukuba campus (KEK)

Photon Factory: PF / Slow Positron Facility: SPF

Synchrotron Radiation

Slow Positron

1-1 Oho, Tsukuba-shi, Ibaraki 305-0801, Japan

Tokai campus (J-PARC)

Materials and Life Science Experimental Facility: MLF

Neutron **Muon**

203-1 Shirakata, Tokai-mura, Naka-gun,
Ibaraki 319-1106, Japan

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