What is synchrotron radiation?

Synchrotron radiation is electromagnetic waves (light) emitted when electrons accelerated to nearly the speed of light undergo a magnetic field that changes their direction. It covers a wide range of wavelengths from infrared to X-rays. X-rays, soft X-rays, and vacuum ultraviolet, which are light with short wavelengths, can observe the nanoscale properties of materials, such as the atomic arrangement and the behavior of electrons. Synchrotron radiation is a bright light with highly directional properties that enables precise and accurate measurement of small samples. It also has polarizing and pulsed properties, and research is being conducted by using these properties, such as studying the orientation of molecules and observing chemical reactions or phase transitions.

The synchrotron radiation facility at the High Energy Accelerator Research Organization (KEK), is widely known as the ‘Photon Factory’. Synchrotron radiation is bright, short-wavelength light produced by accelerators and is an excellent tool for observing materials and life at the nanoscale.

The 2.5 GeV Photon Factory ring (PF ring), in operation since 1982, is the first dedicated synchrotron radiation facility in the X-ray region in Japan. Over the past 40 years, several major upgrades have been carried out to increase the brightness of the synchrotron radiation.

Another light source accelerator at KEK, Photon Factory Advanced Ring (PF-AR), is the world’s only synchrotron radiation source dedicated to pulsed X-rays. The PF-AR began to use synchrotron radiation in 1987 in coexistence with a particle physics experiments, and was upgraded to a dedicated light source in 2002.

As an Inter-University Research Organization, KEK has provided many researchers throughout Japan and abroad with research platforms and associated technologies using Photon Factory. The findings generated from these efforts have led to a deeper understanding of materials and life, as well as to technologies for creating a sustainable society.

Photon Factory is a facility belonging to KEK, a global center of excellence in accelerator science. Fully utilizing this advantage, Photon Factory has continuously produced new accelerator technologies and human resources that are leading the world’s synchrotron radiation science. And now we are on our way to an even better “factory of photon” that will make visible what was previously invisible.
Photon Factory has undergone several upgrades based on the latest accelerator technology since its establishment in 1975. The ring-shaped light source accelerator has a circular array of bending magnets that bend electron beams into the collider SuperKEKB. In 2017, an upgrade was completed to allow each ring to be injected with 72,000 electrons per bunch. Special arrangements in which two beams are irradiated to a sample at the same time for the development of technologies necessary for future synchrotron radiation research and to promote research and development for the future light source. Beamlines of PHARE are also available to promote research and development for the future light source.

**Concept of Hybrid Ring**

The hybrid ring concept allows for the use of two rings to generate continuous spectrum of light, which interferes with each other. Electrons change their direction by each magnetic pole towards the construction of synchrotron radiation facilities around the world. The development of in-vacuum undulators, in which a superconducting magnet is installed in-vacuum undulators, began at KEK around 1988, and light was successfully generated over a wide energy range from injector linac (under construction).

**Productivity**

Photon Factory is currently discussing a new light source accelerator suitable for undulator radiation science, including environmen-
tal research equipment including beamline. Using BL-2 as an example, we will introduce the technologies used in the process of generating soft X-rays using a 1.2 m undulator at BL-2).

**Mainly diffraction and scattering experiments**

Since 2009, the beamline has been operated as a synchrotron radiation source for small angle X-ray scattering. The beamline is capable of structural analysis of small crystals with a diameter of 50-500 nm, and it is also used for X-ray imaging experiments with the highest performance in the world.

**Beam line**

BL-4B2. The second undulator was installed in 1988. The storage ring (SRS) was used as the basic structure function of photoemission experiments with the highest performance in the world. X-ray microdiffraction experiments with the highest performance in the world.

**Insertion device (generation of light)**

Photon Factory has a wide range of experimental facilities covering a variety of fields, including environmental research, medical research, and material science. The synchrotron radiation produced by accelerators is processed in beamlines and directed to experimental instruments. The beamline has a 24-meter-long undulator at BL-2), which is capable of structural analysis of small crystals with a diameter of 50-500 nm, and it is also used for X-ray imaging experiments with the highest performance in the world.

**Synchrotron radiation experiments - create light and illuminate with light**

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Using the Photon Factory

Photon Factory supports research and development mainly in academic fields. In particular, we actively support innovative research projects that involve trial and error. We also offer charged programs that can be used by companies and other organizations. Some beamlines offer optional services such as "user support", "consulting" and "substitutional measurement and analysis".

Degree in the Photon Factory

The Graduate University for Advanced Studies (SOKENDAI) is a graduate university to utilize the advanced research environment of an inter-university research institute. At Photon Factory, graduate students at SOKENDAI are conducting research under research guidance. Several universities, including the University of Tokyo and Hokkaido University, have concluded agreements to cooperate in supervising students.

Tours of the Photon Factory

Group tours of 10 or more people are accepted. There are also events that are open for everyone such as KEK Open Campus, Spring Science and Technology Week.

Support the Photon Factory

The donation program for the Photon Factory’s advanced research will be used to improve the research environment and promote future plans for the Photon Factory. We appreciate your warm support for the future of the Photon Factory.