Light Source Developments by Using Relativistic Electron Beams

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UVSOR is a synchrotron light source to provide low energy synchrotron light ranging from terahertz wave to soft X-rays. Although it was constructed about 30 years ago, its performance is still in the world top level. This is the result of the continuous effort on improving the machine. Our research group have been developing accelerator technologies toward producing bright and stable synchrotron light, such as high brightness electron beam optics, novel insertion devices or state-of-the-art beam injection technique. We have been also developing novel light source technologies toward producing synchrotron radiation with various characteristics such as free electron laser, coherent synchrotron radiation and laser Compton gamma-rays. We are also investigating future light sources for the facility, such as a diffraction limited light source or a linac-based free electron laser source.

Figure 1. UVSOR-III Electron Storage Ring and Synchrotron Radiation Beamlines.

Selected Publications

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- Y. Taira, H. Toyokawa, R. Kuroda, N. Yamamoto, M. Adachi, S. Tanaka and M. Katoh, "Photon-Induced Positron Annihilation Lifetime Spectroscopy Using Ultrashort Laser-Compton-Scattered Gamma-Ray Pulses," *Rev. Sci. Instrum.* **84**, 053305 (2013).

1. Light Source Technology Developments Based on Laser and Synchrotron and Their Applications to Molecular Science

We have demonstrated that coherent synchrotron radiation of various properties could be generated in an electron storage ring by using an external laser source. This research was supported by the Quantum Beam Technology Program of JST/MEXT. Under this support, a new experimental station has been constructed. The generation of coherent synchrotron radiation at the new site was successfully demonstrated in collaboration with Lille Univ. and Nagoya Univ. Some basic researches on coherent synchrotron radiation have been conducted with an ultrafast terahertz detector in collaboration with Karlsruhe Institute of Technology, Lille Univ., Nagoya Univ. and Kyoto Univ. Applications using coherent synchrotron radiation are under preparation. Some basic researches on the optical vortex beam have been started in collaboration with Hiroshima Univ.

Figure 2. Twin Polarization-variable Undulators for Coherent Synchrotorn Radiation generation.

Laser Compton scattering is a method to produce monochromatic and energy-tunable gamma-ray pulses. Laser pulses are injected to the storage ring and are scattered by the relativistic electrons circulating in the ring. We have developed a method to produce ultra-short gamma-ray pulses and have demonstrated a photon-induced positron annihilation lifetime spectroscopy experiment, in collaboration with AIST. We have started constructing a system to produce intense gamma-rays by using an optical cavity, in collaboration with Kyoto Univ.

2. Accelerator Technology Developments for Synchrotron Light Source and Free Electron Laser

The UVSOR facility has been operational as a national synchrotron light source for lower energy photons from the terahertz wave to the soft X-rays. The machine was born as a low energy second generation light source and now it is 30 years old. However, the accelerators have been upgraded continuously. We have succeeded in introducing a specially designed electron beam optics intended to higher brightness. We have succeeded in commissioning six undulators. We have succeeded in introducing a novel operation mode called Top-up operation, in which the electron beam intensity is kept quasi-constant at a high beam current, 300 mA. As the result of all these efforts, now, the machine is the brightest synchrotron light sources among the low energy machines below 1 GeV.

We continue upgrading the machine, year by year. In 2014, one old undulator at BL5U was remodeled. Now it has become capable of producing any polarization, such as horizontal and vertical linear polarizations and left and right circular polarizations. The non-linear focusing forces produced by such undulators make significant effects on the beam injection and storage. We are developing correction scheme for these non-linear effects.

Figure 3. Remodeling of Variable Polarization Undulator at BL5U.

Award

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