SPring-8 Beam Performance

Recent update of accelerators

A new undulator, referred to as Helical-8 undulator, which facilitates operation mode can be switched between helical and figure-8 modes, has been proposed and developed at SPring-8. For soft X-ray (SX) undulators, a large K value is required for the high electron energy of SPring-8, that is, 8 GeV, and typically polarization control is necessary. One solution for this may be the APPLE-type undulator that can provide both linear and circular polarized radiation; however, it is unsuitable to SPring-8 because of its large on-axis heat load in a linearly polarized radiation mode. Another solution is the Figure-8 undulator, which has a considerably lower on-axis heat load than that of the APPLE-type undulator. However, circularly polarized radiation cannot be obtained from the Figure-8 undulator. Thus, one of the SX beamlines in SPring-8, BL25SU is equipped with twin helical undulators with a fast helicity switching function and is devoted only to experiments using circular polarized radiation. Another SX beamline, BL27SU, used to provide only linearly polarized radiation along the horizontal or vertical axis from a Figure-8 undulator. The newly developed Helical-8 undulator can be switched between helical and figure-8 modes, thus providing both circularly and linearly polarized radiations. For the circular polarization mode, both right and left polarization are available. Whereas, for the linear mode, both horizontally and vertically polarized radiation can be produced. Further, for all the polarization modes, the on-axis heat load is well suppressed. Such an undulator with an undulator period of 120 mm and a minimum gap of 20 mm has been constructed during the period of FY2021 to 2022. Consequently, it was verified that the magnetic field distributions inside the undulator were consistent with the designated ones. Spatial radiation patters of radiation generated from the undulator were also consistent with those expected from the design. The undulator was installed in BL17SU in the summer of 2022, and user experiments have already started.

In-vacuum undulators (IVU) are key insertion devices in SPring-8. Most of the currently operated insertion devices in SPring-8 are standard IVUs. We have developed a new IVU, referred to as IVU-II, for a future major upgrade, SPring-8-II. Since the installation of the first type of IVU-II in BL10XU in 2019, various improvements have been made. The latest design of IVU-II offers many new features compared with the conventional IVU, such as, avoiding demagnetization of permanent magnets, reducing manufacturing costs, etc. The strong attractive force between the upper and lower magnet arrays of an undulator is canceled via the addion of two more pairs of magnetic arrays such that the additional magnet arrays generate repulsive forces that are identical to the attractive force for any gap length [1]. Thus, the mechanical supports for the undulator can be simplified considerably, reducing the manufacturing cost. The manufacturing process of the permanent magnet, configuration of the permanent magnet pieces, and others such as a mechanical structure for assembling magnet pieces have been extensively improved. We plan to begin the replacement of the present IVUs with the latest design of IVU-II anticipating the future upgrade, SPring-8-II.

In addition to the insertion devices, other components of accelerators have also been updated anticipating SPring-8-II. One of the recent developments for present SPring-8 is the replacement of all the conventional low-level RF (LLRF) systems based on NIM modules with a new technology mTCA.4 [2]. Most of the replacements have already been completed, and the new system has been improved for the daily operation of SPring-8. To date, reliable user operations have been conducted without severe problems, and the new mTCA.4 based LLRF and other systems have been modified as needed.

Other recent updates such as the replacement of the injector based on a combination of the 1 GeV linac and the 8 GeV booster to the SACLA linac [3], the new bunch cleaner in the storage ring, and the adaptive feedforward control of electron beam orbit [4] have all worked smoothly, providing reliable and stable beam operations [2]. The future plan has not been officially approved yet; however, once it is funded and the storage ring is upgraded, the new generation storage ring will benefit from these machine upgrades.

Shiro Takano and Takahiro Watanabe*

Japan Synchrotron Radiation Research Institute (JASRI)

*Email: twatanabe@spring8.or.jp

References
[1] R. Kinjo *et al.*: Rev. Sci. Instrum. **88** (2017) 073302.
[2] SPring-8/SACLA Research Frontiers 2021.
[3] T. Hara *et al.*: Phys. Rev. Accel. Beams **24** (2021) 110702.
[4] M. Masaki *et al.*: J. Synchrotron Rad. **28** (2021) 1758.