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SPring-8 twin helical undulator

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There are several ways of producing circularly polarized light, such as using asymmetric devices, crossed undulators *etc.* The SPring-8 helical undulator introduces a simple way of producing both horizontal and vertical fields in one undulator. All the magnet arrays are arranged above and below the plane of the electron orbit, so there is no limitation of access from the sides of the undulator. For the SPring-8 BL25SU, two helical undulators will be installed in tandem, and the helicity of the polarization can be switched at up to 10 Hz using five kicker magnets.

Keywords: undulators; helical undulators; helicity switching.

1. Introduction

The SPring-8 BL25SU is being constructed for experiments in soft X-ray spectroscopy of solids, including photoelectron holography (PEH), magnetic circular and linear dichroisms in angular distribution (MCDAD and MLDAD) and spin-resolved photoemission (Saito *et al.*, 1998). For these experiments, a twin helical undulator system, consisting of two out-of-vacuum helical undulators and five kicker magnets, will be installed in a 5 m straight section.

In the soft X-ray region, the heat load of the undulator radiation becomes a serious issue because of the high K value. However, for a helical undulator, the on-axis radiation contains only fundamental radiation: all higher harmonics are off-axis. Thus, most of the heat load is off-axis, and can be absorbed at the front end. Fig. 1 compares the on-axis radiation of the helical and linear undulators.

There is a large demand for fast switching of the helicity of polarization. At SPring-8, five kicker magnets make two local orbit bumps and switch the helicity at up to 10 Hz.

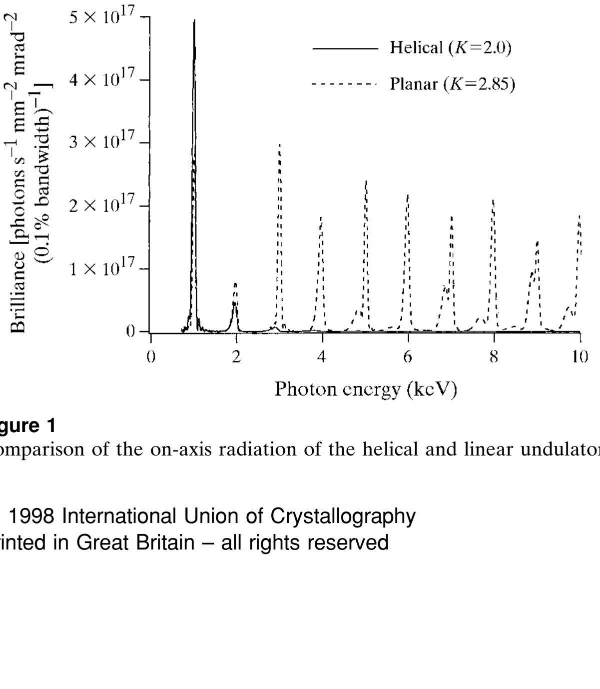

Figure 1
Comparison of the on-axis radiation of the helical and linear undulators.

Table 1
Main parameters of the SPring-8 twin helical undulator.

Type	Pure permanent-magnet device
Length	1.5 m × 2
Number of periods	12 × 2
Period length	120 mm
Minimum gap	30 mm (20 mm for future plan)
K_{max}	K_x, K_y = 3.0 (6.5 for future plan)

2. SPring-8 helical undulator

The magnet configuration of the SPring-8 helical undulator is sketched in Fig. 2. There are six magnet arrays: two centre arrays produce a vertical field like conventional planar undulators, while four side arrays, which are on the same planes as the centre ones, give a horizontal field. Thus there is no limitation of the access to the undulator from the sides. By shifting the two centre arrays, the phase between the horizontal and vertical fields is changed, and both linear and circular polarizations can be obtained. When the phase is set to $+\pi/2$ or $-\pi/2$, the electrons follow a spiral orbit in the undulator, and thus the radiation field has a circular polarization.

In order to assure complete circular polarization, the centre and side magnet blocks (centre block width = 24 mm, side block width = 40 mm) are designed so that the vertical and horizontal K values (K_x, K_y) are equal for any undulator gap. The gap dependence of K_y and K_x is plotted in Fig. 3. To enlarge the flat top of the vertical magnetic field, the middle of the centre magnet block is carved.

Magnetic field corrections are carried out independently for the horizontal and vertical fields by inserting small magnet chips on the back of the magnet holders. The end effect of the undulator is cancelled by the same end-magnet configuration employed for the SPring-8 in-vacuum undulators (Hara *et al.*, 1998). The surface of the magnet blocks is also coated with 5 µm

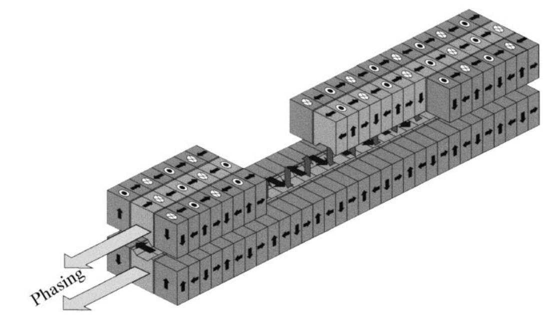

Figure 2
Schematic diagram of the SPring-8 helical undulator.

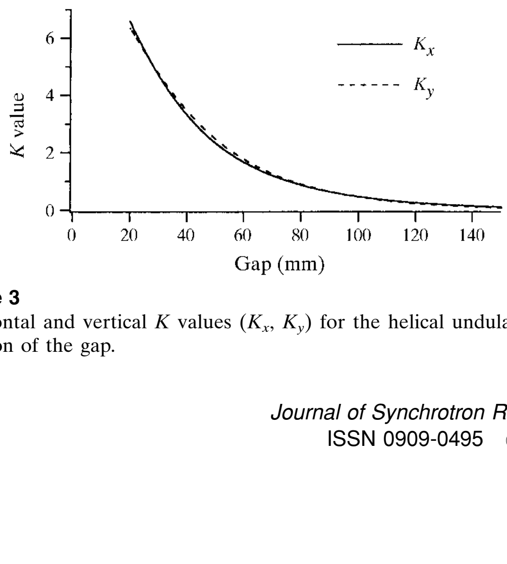

Figure 3
Horizontal and vertical K values (K_x, K_y) for the helical undulator as a function of the gap.

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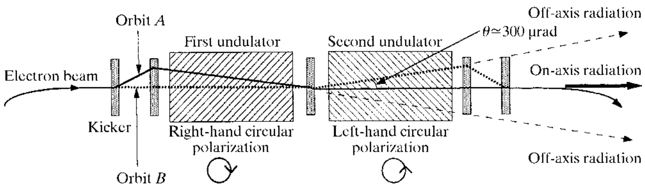

Figure 4
SPring-8 twin helical switching system.

of TiN to prevent oxidation. The residual field integral error will be corrected by two steering coils at the entrance and the exit of the undulator.

The main parameters of the SPring-8 helical undulator are given in Table 1. The minimum undulator gap is designed to be 20 mm, which corresponds to 120 eV fundamental radiation. However, the height of the slot at the bending magnet, which is used for the extraction of the undulator radiation, presently limits the maximum K value to 3 and the minimum gap to 30 mm.

3. Helicity switching of the circularly polarized light

There seems to be three common techniques for switching the helicity of undulator radition: by using electromagnetic devices, by moving the magnet array mechanically, or by changing the electron beam orbit at the undulator. At SPring-8, we use five kicker magnets to make and switch two local orbit bumps of the electron beam (orbits A and B in Fig. 4). For helicity switching purposes, the two helical undulators are set to the left- and right-handed circular polarizations, respectively. When the electron beam follows orbit A, the radiation from the first undulator travels off-axis and is stopped at the front-end absorber, whereas the radiation from the second undulator is on the beamline axis and passes through to the experimental station. For orbit B, the situation is reversed. Thus, by switching these two orbits, the circularly polarized light of alternate helicities is emitted on the optical axis of the beamline.

The kick angle, θ (300 μrad in Fig. 4), should be large enough to separate two undulator beams. Fig. 5 shows the angular distribution of the power density from one helical undulator. At the moment, the lowest photon energy is limited to 500 eV, so 300 μrad is sufficient. One notes that the optics must endure the heat load of the peak power during the transition time of switching. However, the kicker magnets are driven by a quasi-square wave, and the transition time will be less than 10 ms, so the crossing power is rather small if averaged. The switching frequency is limited to 10 Hz due to the capacity of the power source for the kickers.

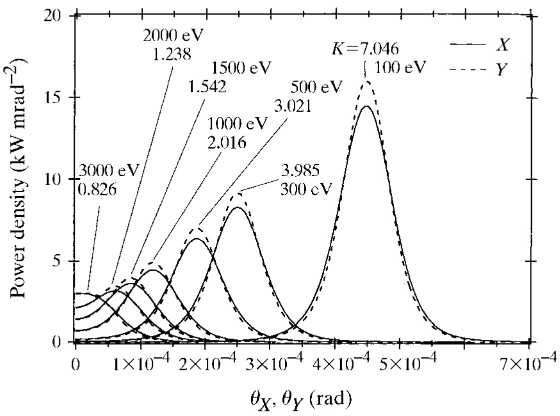

Figure 5
Angular distribution of the power density from the helical undulator.

Concerning the periodic beam displacement around the ring excited by the helicity switching kickers, the residual magnetic field integral of the five kickers should always be zero. To realize this, kicker magnets may be connected in series to prevent the time lag and fluctuation of the individual power source output.

4. Summary

For dichroism experiments, there is a demand for fast helicity switching of circularly polarized light. For the SPring-8 BL25SU, two helical undulators, having a simple magnet configuration, and five kicker magnets will be installed. This twin helical undulator system can realize helicity switching of the circularly polarized light at up to 10 Hz.

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