Measurements of Spatial Distribution of Radiated Power from the SPring-8 Undulators using the Thin-foil I_0 Monitor

Masaki OURA, Sunao TAKAHASHI*, Yoshiharu SAKURAI** and Hideo KITAMURA
Harima Institute, The Institute of Physical and Chemical Research (RIKEN),
Mihara 323-3, Mikazuki-cho, Sayo-gun, Hyogo 679-5143, Japan

1. Introduction

Various insertion devices, such as in-vacuum undulators [1-3], twin helical undulator [4], figure-8 undulators [3,5] and elliptical multipole wiggler [6], are installed in the straight section of the SPring-8 storage ring in order to obtain high brilliant synchrotron radiation over the wide energy range. The characteristics of the spectral and the spatial distributions of those radiation can be well described by sophisticated calculations. Most of the insertion devices installed are the ordinary planar undulators whose on-axis power density is extremely high (P_d^{max}～450 kW/mrad^2), so that the utilization of such intensive radiation without any spatial limitation will bring an unreasonable heat load onto the front-end Be windows or the first optical element [7]. Recent progress in the insertion device technology, however, has made the approaches for obtaining fundamental radiation with low on-axis power density possible especially in the soft x-ray region [4,5]. To characterize such insertion devices themselves, we need to measure the spectral and the spatial distributions as well as the degree of polarization of the radiation. Both measurements of the spectral and the spatial distribution of the radiation can be achieved using an energy spectrometer by scanning the front-end XY-slits assembly (FE-SLIT) [8].

In this report, we describe the simple measurements of spatial distribution of the radiated power using the thin-foil I_0 monitor [9] and the FE-SLIT.

2. Measurements

Here we show three typical examples of the spatial distribution of the radiated power measured at the different type of the undulators. Each measurement was carried out at the early stage of the beamline commissioning.

2.1 *In-vacuum undulator*

There are three types of the in-vacuum undulator installed in the storage ring. Five standard undulators (λ_u = 32 mm, N = 140) [1] and the vertical tandem undulators (λ_u = 37 mm, N = 40 x 2) [2] are in operation, and the other one, namely the figure-8 undulator, is in commissioning. The spatial distributions of the radiated power emitted from the standard and the vertical undulators are symmetric with respect to the beam axis, respectively. Figure 1 shows the surface plot of the radiated power distribution measured at the vertical undulator beamline (BL45XU).

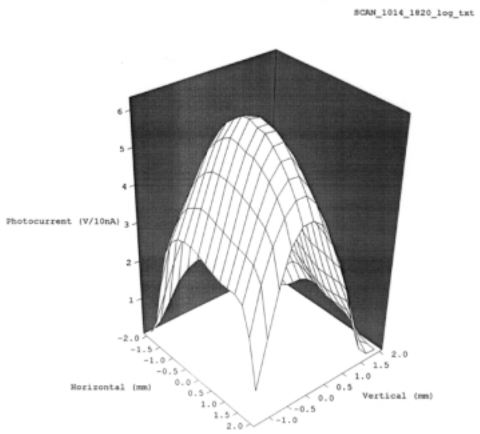
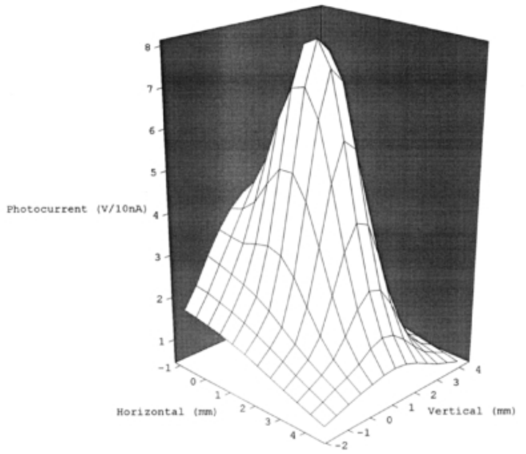


Fig.1 Surface plot of the radiated power distribution

2.2 *Twin helical undulator*

The twin helical undulator system consists of out-vacuum tandem undulators (λ_u = 120 mm, N = 12 x 2, 1.5 m long x 2) and five kicker magnets, and generates circularly polarized soft x rays with low on-axis power density [4]. It is well known [10] that the angular distribution of the radiation produced in strong-field case is quite different from that produced in the case of weak-field. For K > 1 (strong field case), although the fundamental radiation concentrates on its axis, most of the radiation, i.e. the higher harmonics, is emitted into a cone of half-angle K/_ and its spatial distribution measured at a distance can be observed just like a somma. Figs. 2a and 2b show the spatial distributions measured in weak- (K_x = 0.338, K_y = 0.332) and strong-field (K_x = 1.286, K_y = 1.17) cases, respectively. In the case of strong-field, an aluminum filter (1 mm thick) was inserted into the beam axis in order to clarify the

(a)



(b)

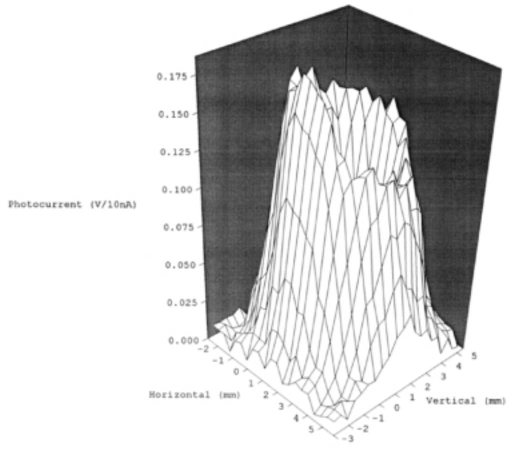


Fig.2 Spatial distributions of the radiated power measured in weak- (a) and strong-field (b) cases

power distribution by reducing the soft x-ray contributions. The size of the observed somma, which is the projected power distribution at the FE-SLIT location (29.4 m), can be well described by K_y/_ and K_x/_. Figure 3 shows the contour plot of the radiated power distribution in strong-field case.

2.3 *Figure-8 undulator*

The out-vacuum figure-8 undulator (λ_u = 100, N = 44) has been developed to provide linearly polarized soft x rays with low on-axis power density [5]. The pronounced feature of this undulator is its spatial distribution of the radiated power. The measurement was performed for the upper half of the distribution since the spatial distribution is symmetric with respect to θ_y (vertical direction) and the gap was set to be 50 mm (K_x = 3.12, K_y = 3.41). Figs. 4a and 4b show the contour and the surface plots, in which lower half of the both plots are mirror images of upper one, measured with utilization of an aluminum filter (1 mm thick). The characteristic V-figure is successfully observed by present measurement.

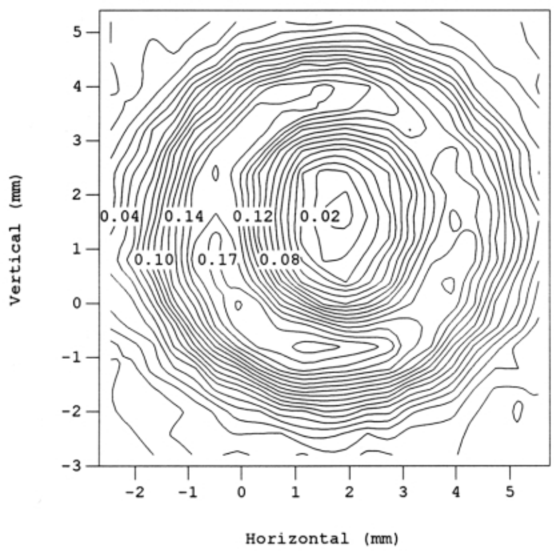


Fig.3 Contour plot of the radiated power distribution measured in strong-field case

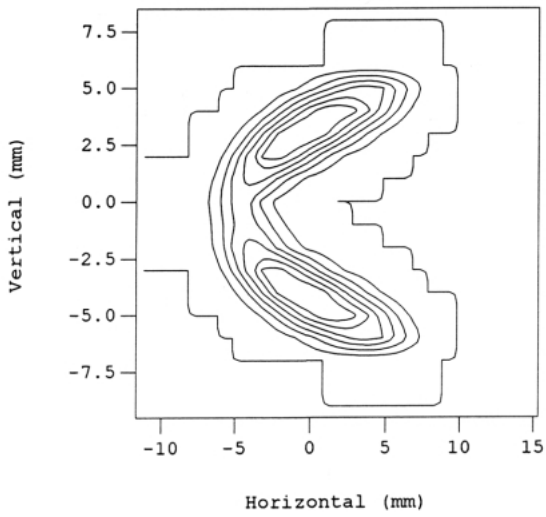
3. Summary

The simple measurement employed here has a potential obviously to characterize the insertion device by measuring the spatial distribution of the radiated power, although it can not provide an absolute measurement. By replacing the thin-foil I_0 monitor with an energy spectrometer, more detailed characterization will be possible.

*Present address : Kobe Steel Ltd., 2-3-1, Shinhama, Arai-cho, Takasago-shi, Hyogo 676-8670, Japan

**Present address : Japan Synchrotron Radiation Research Institute (JASRI), Mihara 323-3, Mikazuki-cho, Sayo-gun, Hyogo 679-5198, Japan

(a)



(b)

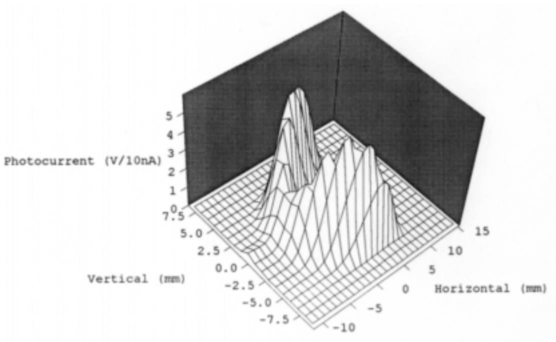


Fig.4 Contour (a) and surface (b) plots of the radiated power distribution

References

[1] T. Hara, T. Tanaka, T. Tanabe, X. Marechal, S. Okada and H. Kitamura, to be published in J. Synchrotron Rad. 5 (1998).

[2] T. Tanaka, X. Marechal, T. Hara, T. Tanabe and H. Kitamura, to be published in J. Synchrotron Rad. 5 (1998).

[3] T. Tanaka, X. Marechal, T. Hara, T. Tanabe and H. Kitamura, to be published in J. Synchrotron Rad. 5 (1998).

[4] T. Hara, T. Tanaka, T. Tanabe, X. Marechal, K. Kumagai and H. Kitamura, to be published in J. Synchrotron Rad. 5 (1998).

[5] T. Tanaka and H. Kitamura, Nucl. Instrum. Methods A364 (1995) 368. ; J. Electron Spectroscopy and Related Phenomena 80 (1996) 441. ; J. Synchrotron Rad. 3 (1996) 47.

[6] X. M. Marechal, T. Hara, T. Tanabe, T. Tanaka and H. Kitamura, to be published in J. Synchrotron Rad. 5 (1998).

[7] M. Oura, H. Sakae, Y. Sakurai and H. Kitamura, J. Synchrotron Rad. 5 (1998) 609.

[8] M. Oura, Y. Sakurai and H. Kitamura, J. Synchrotron Rad. 5 (1998) 606.

[9] M. Oura, S. Takahashi, T. Kudo, Y. Sakurai and H. Kitamura, in this issue.

[10] B. M. Kincaid, J. Appl. Phys. 48 (1977) 2684.