STUDY OF MAGNETIC BLOCK ARRANGEMENT OF APPLE-II UNDULATOR

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Abstract

Two special magnet block configurations have been considered to enhance the field homogeneity of the APPLE-II type elliptically polarized undulator (EPU). It is find that the uniform region is improved much for vertical field, but little for horizontal field. The calculation results are presented.

INTRODUCTION

Polarization is one of the most important properties of the synchrotron radiation. Circular polarized radiation is widely used for many experiments such as circular dichroism. Therefore various planar elliptically polarizing undulator (EPU) structures have been developed, which can generate circularly or in general elliptically polarized radiation. Among them the APPLE II type [1] is presently preferred in many synchrotron radiation facilities because it offers the highest field and the largest variation of polarization properties. These devices consist of four rows of permanent magnets; each row has a conventional Halbach structure. By moving the opposing rows longitudinally with respect to the other two (a phase shift), it can produce polarized light of any kind. However, apart from that APPLE-II structure has many advantages over the previously designs, the transverse uniform field region of it is too narrow, especially for the horizontal field. Some methods have been proposed to enhance the transverse field homogeneity [2]. Nevertheless the horizontal field uniform region has not been improved. In this article we considered the special magnet block configurations for increasing both vertical and horizontal field homogeneity.

MAGNETIC STRUCTURE

To increase the uniform field region of the APPLE-II structure, two magnetic block shapes [5] were considered as shown in Figure 1. The first one (Figure 1b) has a cant towards the beam axis (y axis). It fits a round vacuum chamber. Another shape with a folded surface is considered for rectangle chamber. They are something similar to quadrupole magnet. In these configurations, the vertical (z-axis) and horizontal (x-axis) fields are strengthened. The schemes are easy to implement.

The magnetic design for the APPLE-II structure was performed using the Radia package [3]. The EPU10.0 of the SSRF [4] is taken as an example. The parameters of the undulator are listed in Table 1. The calculations of the uniform region in the two structures are presented as follows.

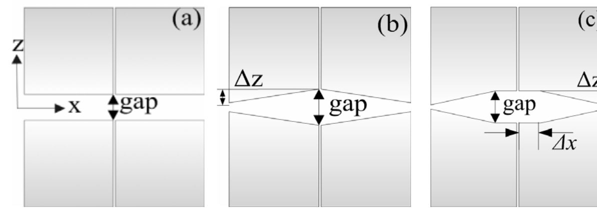

Figure 1: Several different block shapes (a) the original block (b) the canted block (c) the block with a folded surface

Table 1: Main Parameters of the EPU10.0

Period	100	mm
Number of periods	5	mm
Gap(fixed)	36	mm
Magnet block size(width*height)	40*40	mm
Vertical peak field	0.59	T
Horizontal peak field	0.35	T
Peak field at circular polarization	0.30	T
Phase shift range of two magnet rows	±60	mm
Phase of horizontal linear polarization	0	mm
Phase of vertical linear polarization	±50	mm
Phase of circular polarization	±33.3	mm

The canted block

We calculated the uniform region of both vertical and horizontal fields at a fixed gap (the distance between the poles center as shown in Figure 1b) for various cant heights. Figure 2 reveals the field roll-off distribution on the transverse x-axis for different cant heights. At phase 0, the pure vertical field B_z case, the uniform region varies with the height of the cant obviously. When the cant height is 2mm, the uniform field region is increased from ±8.3mm of the original block configuration to about ±17mm under field homogeneity $\Delta B/B \leq 0.5$ %. At phase π, the pure horizontal field B_x case, the uniform field region is increased with the cant height, but the variation is small. The uniform region of horizontal field is widened only 0.08mm under a field roll-off $\Delta B/B \leq 0.5$ % in the case of a 2mm cant height. As the polarization is varied from linear to circular, the uniform region of both vertical and horizontal fields remains almost constant for a given cant height. The uniform regions of B_z and B_x in the circular polarization condition are given in Figure 3.

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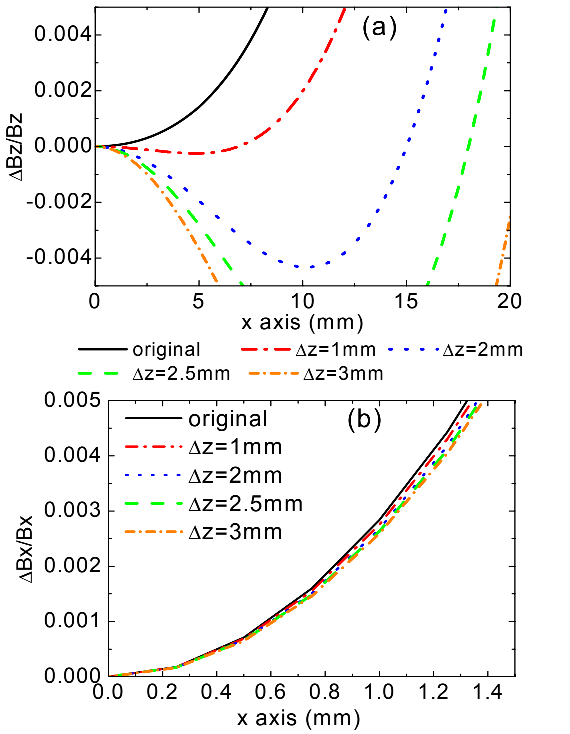

Figure 2: Roll-off of the peak field of the canted block at (a) phase 0 (B_z) and (b) phase π (B_x) for various cant heights

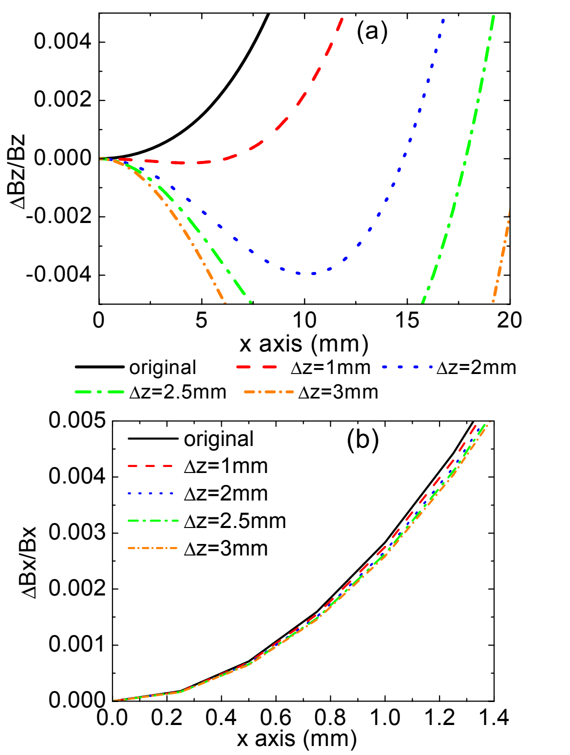

Figure 3: Roll-off of the peak field of the canted block in circular polarization mode for various cant heights

The above results are presented for given gap but under different peak field. As revealed in Figure 4, the peak field increases with the cant height. Figure 4 also shows that the phase of circular polarization has a slight variation when the cant height varied.

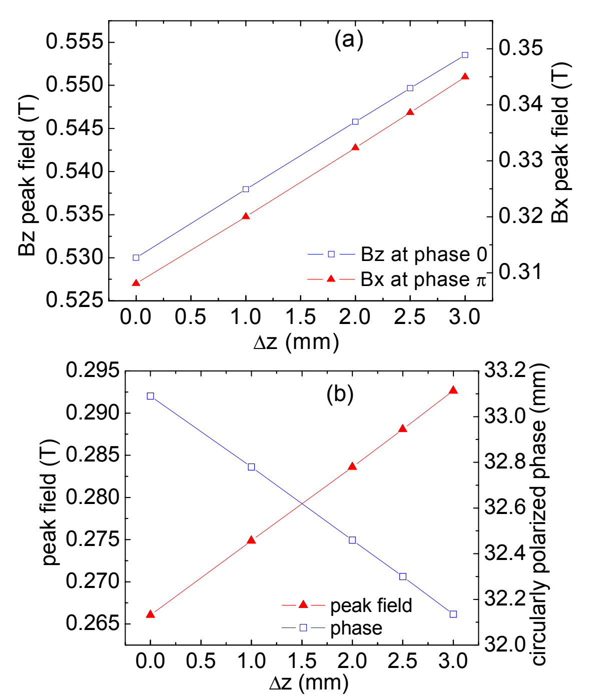

Figure 4: (a) Peak field vs the cant height at phase 0 and at phase π, (b) Peak field and phase of circular polarization vs the cant height.

To compare the uniform region under the same peak field, we adjusted the gap for different cant height. The calculation results are presented in Figure 5. The uniform region at phase 0 (π) is ±16.5mm (1.38mm) when the cant height is 2mm under a field roll-off $\Delta B/B \leq 0.5$ %. The variation of the uniform region at phase 0 (π) is less (greater) than that of the fixed gap case.

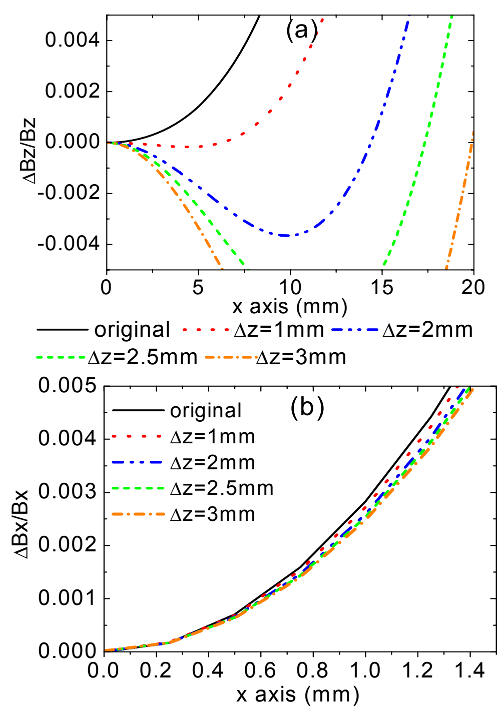

Figure 5: the uniform field region at (a) phase 0 and (b) phase π for various cant heights under fixed peak field

Figure 6 shows how the gap at fixed peak field varies with the cant height.

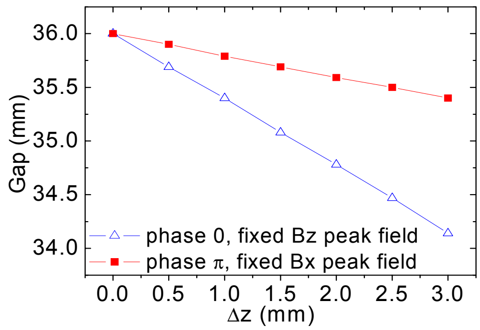

Figure 6: Gap as a function of the cant height for fixed peak field

The block with a folded surface

Another magnet block shape considered to increase the uniform region is the block with a folded surface (see Figure 1c). Where Δx is the length of the horizontal area of the folded surface. We investigated various Δx for the same cant height. As shown in Figure 7a the uniform region of B_z is better compared with that of canted block configuration when Δx is less than 3 mm. After that it decreases with the increase of Δx. The horizontal field homogeneity is little changed as revealed in Figure 7b.

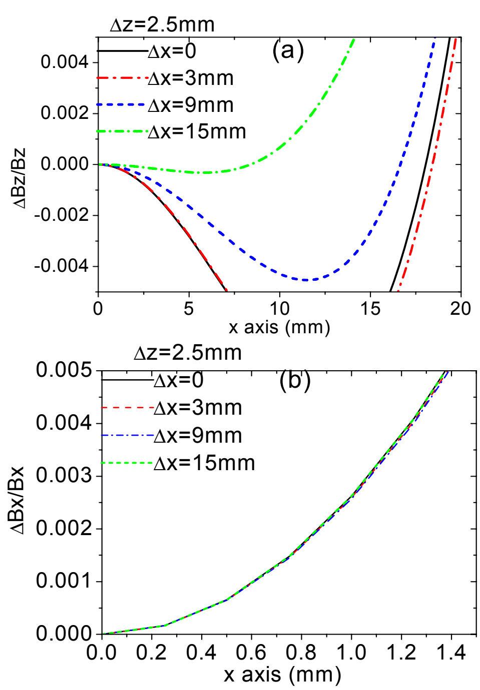

Figure 7: The block with a folded surface case, roll-off of the peak field of at (a) phase 0 and (b) phase π

CONCLUSIONS

The two block shapes have been considered to improve the uniform field region. The canted block configuration obviously enlarges the uniform region of the vertical field, but the improvement of the uniform region of horizontal field is small. The block with a folded surface has a little larger uniform region of the vertical field compared with that of the canted block case. However it neither improves the uniform region of horizontal field significantly. The more magnet structures should be investigated to obtain further improvement on the horizontal field homogeneity.

REFERENCES

[1] Richard P. Walker , June 1997, "Insertion Device: Undulators and Wigglers", June 1997, ST/M-97/02.

[2] C.S. Hwang, "Magnet block arrangements for the APPLE-II elliptically polarized undulator", EPAC 2007, p. 1079-1081.

[3] Radia software, http://www.esrf.fr/machine/groups/insertion_devices/Codes/Radia/Radia.html.

[4] Q. Zhou, J. Zhang, H. Zhang, et al, "The Design of a Variable Elliptically Polarized Undulator for the Coherent THz Light Source", Applied Superconductivity, VOL. 14, NO. 2, 2004, p. 1343-1345.

[5] B.J.A. Shepherd, et al, Proceedings of EPAC 2004, Lucerne, Switzerland, p. 464-466.