Figure-8 Undulator for VUV and Soft X-ray Region

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Although planar or helical undulators are expected to be most powerful sources at the SPring-8, heat load problems limit the available energy range particularly in the case of planar undulators, because the higher K value (=0.934B(Tesla)λu(cm)) causes the increase of unwanted higher harmonics, which results in higher heat load falling on the optical elements. In the case of helical undulators, however, no higher harmonics are observed on axis even when very high K values are applied and the on-axis power density is much lower compared to that in the previous case. Therefore, helical undulators have been considered to be the main sources for VUV and soft x-ray region. But only circularly polarized radiation is available.

We have proposed a new type undulator for linearly polarized radiation [1]. It is called a figure-8 undulator and has the advantage that the on-axis power density is much lower than that of an ordinary planar undulator. The ideal trajectory projected on the x-y plane is shown in Fig. 1. The electron moves on a right handed and a left handed circle alternately. The polarization is linear since the component of the circular polarizations is canceled out. However, it is difficult to realize such a trajectory, because the magnetic field does not satisfy the Maxwell equations. Figure 2 is the practical trajectory which is readily realized.

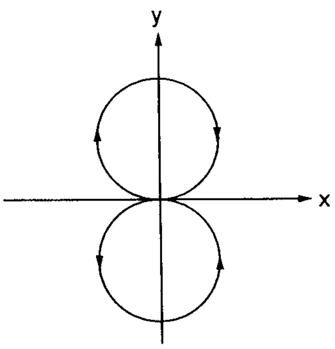

Fig. 1. Ideal trajectory in the figure-8 undulator.

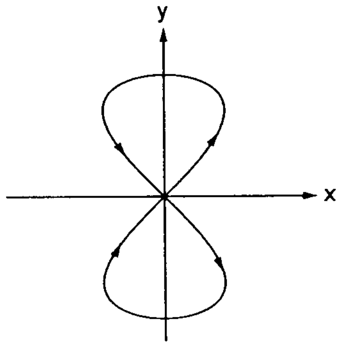

Fig. 2. Practical trajectory in the figure-8 undulator.

A schematic illustration of the figure-8 undulator is shown in Fig. 3. A pair of magnet arrays located above and below the axis compose an ordinary planar undulator which generates the vertical field (horizontal undulator), and the four outer arrays generate the horizontal field (vertical undulator). It should be noted that the period length of the vertical undulator is twice longer than that of the horizontal undulator.

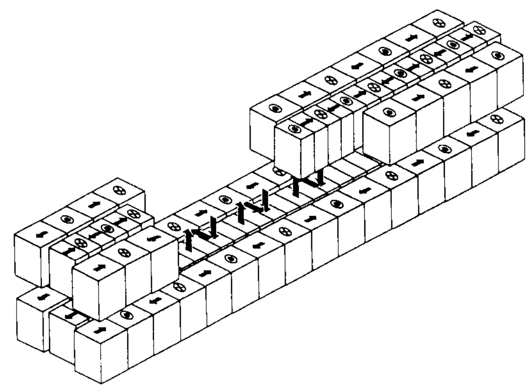

Fig. 3. Schematic illustration of the figure-8 undulator.

Figures 4a and 4b are the on-axis spectra obtained from an ordinary planar undulator and the figure-8 undulator, respectively. The electron energy is assumed to be 8GeV, the beam current 100mA, the period length 10cm, the number of periods 44 and the K values 4.72 (K_x=0, planar) or 3.34 (K_x=K_y, figure-8). In the case of the planar undulator, the contribution of the higher harmonics to the spectrum is very large, which gives rise to unreasonable heat load.

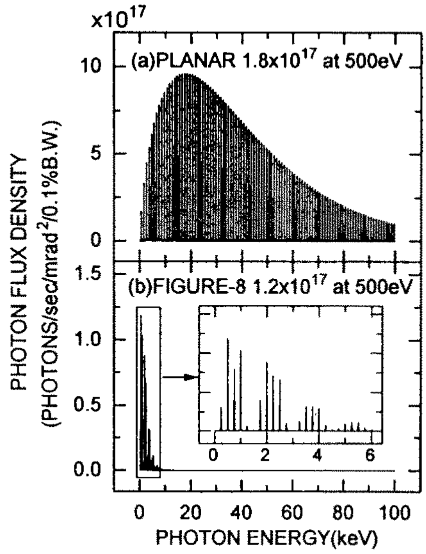

Fig. 4. On-axis spectra obtained from (a) an ordinary planar undulator and (b) the figure-8 undulator.

In the case of the figure-8 undulator, the intensity of the fundamental radiation is about two thirds of that of the planar undulator, although the contribution of the higher harmonics is negligibly small. Half-odd-integer harmonics are found to appear in the spectrum, which is caused from the vertical undulator having the period length, $2\lambda u$. The polarizations of integer/half-odd-integer harmonics are horizontal/vertical. The on-axis power densities calculated by using the above parameters are 98kW/mrad^2 (planar) and 1.4kW/mrad^2 (figure-8). In this way, the figure-8 magnet array effectively suppresses the higher harmonics on axis.

References

[1] T. Tanaka and H. Kitamura, to be published in Nucl. Instr. and Meth. A