A New Concept for the Elliptical Multipole Wiggler at SPring-8

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A new concept for the EMPW

In 1993, SPring-8 decided to construct a beamline for Compton scattering[1], as one of its first pilot beamlines. High brilliance circularly polarized X-rays will be provided in the energy range from 100 up to 300 keV by an elliptical multipole wiggler (EMPW) based on a new concept[2]. Actually, the two potential candidates had either a too low field (HELIOS[3]) or a poor tunability (APPLE[4]). The magnetic and mechanical designs of the new EMPW are schematically presented in Fig. 1. Arrows give the direction of the magnetization. The wiggler (N = 37 periods of length λ_u = 120 mm) has two jaws above and below the orbital plane of the electrons (i.e. a planar structure which meets the requirements of third generation synchrotron radiation sources). The horizontal and vertical fields on the wiggler axis are generated with two kinds of arrays, the inner pair located above and below the orbital plane, which create a strong vertical field, and the four outer arrays generating the horizontal field. The peak horizontal magnetic field is changed by sliding longitudinally the two upper outer rows of magnets (shift length D).

The horizontal magnetic component is eliminated by sliding the rows by one half the period length, switching from an elliptical wiggler (D = 0) to a pure vertical field wiggler (D = $\lambda_u/2$, K_x = 0). K_y is preserved at any shift: at the minimum gap of 20 mm the vertical peak field is 1 T , K_y = 11.2 and the critical energy ε_c is 42.6 keV. Polarization is switched from circular right to circular left by moving the 4 outer arrays by $\lambda_u/2$ in phase.

Performances

A detailed study of this new design has allowed to determine its effect on the electron beam, and the power radiated by this device[2]. Emphasis will be put here on the brilliance and circular polarization rates. With this design, high brilliance (>10^{15} Phot/s/0.1%/mr^2/mm^2) can be obtained on the axis with circular polarization degree, typically, of 65% for energies ranging up to 300 keV (Fig. 2.). Higher polarization rates of 85% (90%) can be obtained but at lower energies up to 200 (150)(150) keV. In the same way, higher energies can be used but with lower polarization rates and/or brilliance (≥10^{14} Phot/s/0.1%/mr^2/mm^2) of 65%

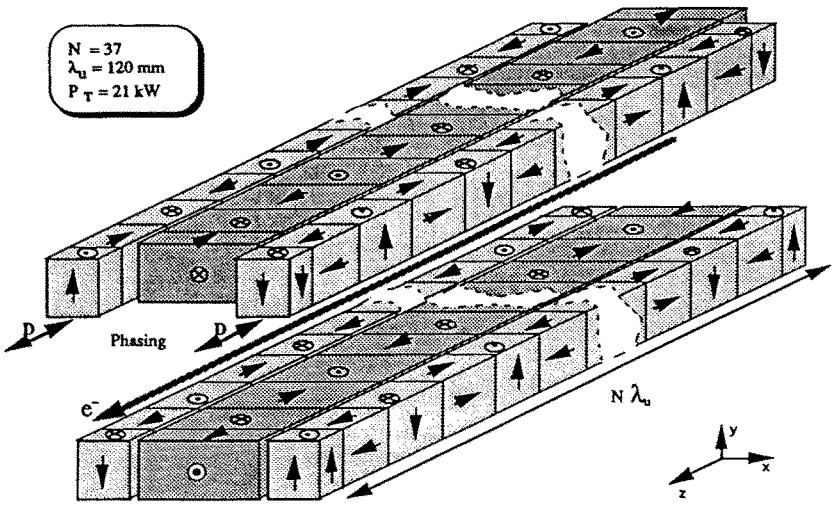

Fig. 1.: Schematic view of the new EMPW.

(20%) up to 400 (500) keV. For a pure vertical field wiggler (shift length D = λu/2), brilliance larger than 10^{14} Phot/s/0.1%/mr^2/mm^2 is obtained up to 500 keV. Such performance is much higher than what is obtainable with a SPring-8 BM.

The reduction of circular polarization rate due to the vertical angular divergence of the electron beam has also been determined[5]. Fig. 3. shows the variation of the circular and linear polarization rates on axis with increasing vertical angular divergence. At "large" divergence the radiation is mainly linearly polarized. The reduction of circular polarization rate is strong, at higher photon energies. Thus, a low angular divergence (in other words a low coupling) is required in order to keep the high performances of the EMPW.

Finally, in order to fully optimize the use of this EMPW, the figure of merit relevant to the Compton Scattering experiments was also studied[5]. Using a new approach, it was possible to determine the slit aperture angle that maximizes the figure of merit as a function of the photon energy and the horizontal deflection parameter Kx, for the cases with and without the effect of beam angular divergence.

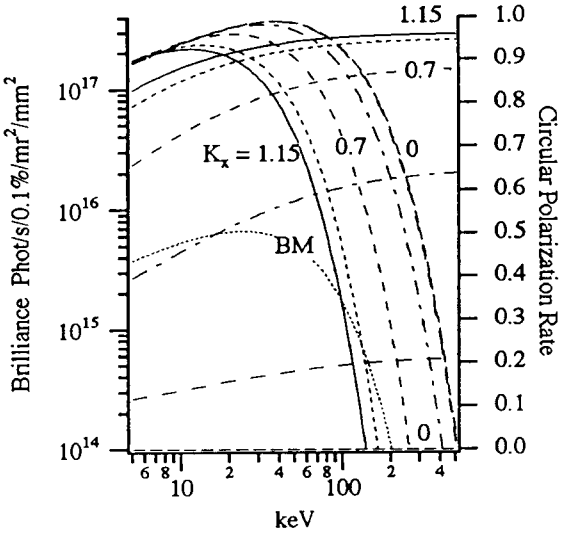

Fig. 2.: Brilliance and Circular polarization rates for different Kx values (0≤Kx≤1.15; SPring-8 high beta section with 10% coupling). Brilliance of a SPring-8 bending magnet (BM) is given for reference.

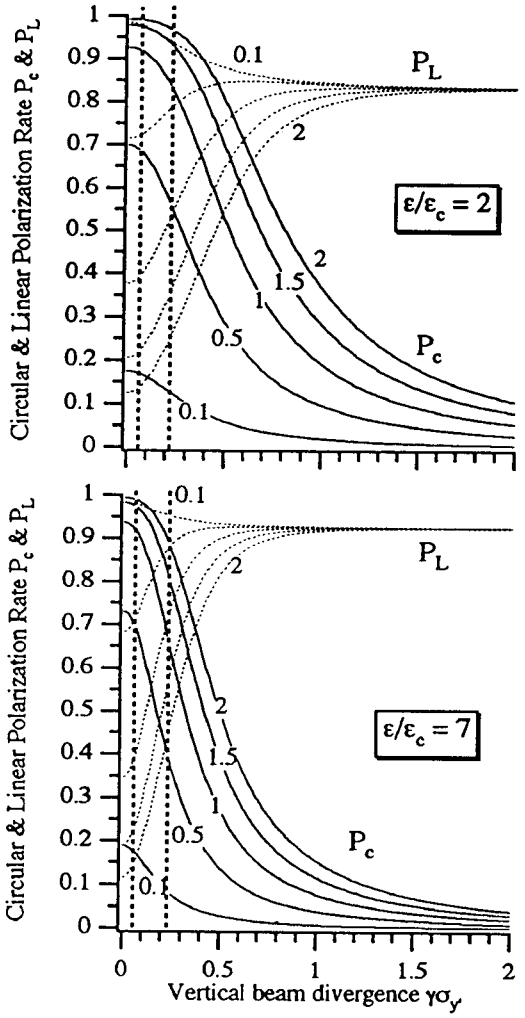

Fig. 3.: On axis circular and linear polarization rates vs. vertical angular beam divergence ($0.1 \leq K_x \leq 2$). Dashed vertical lines show the SPring-8 2-20% coupling range ($0.07 \leq \gamma\sigma_y' \leq 0.22$). EMPW: $100 \leq \varepsilon \leq 300$keV $\approx 2 \leq \varepsilon/\varepsilon_c \leq 7$

References

[1] Y. Sakurai, N. Sakai, Proc. of the 4th International Symposium on Synchrotron Radiation Facility and Advanced Science and Technology, Kobe 9-10 March 1994.

[2] X.M. Maréchal, T. Tanaka and H. Kitamura, to be published in Rev. Sci. Instrum.

[3] P. Elleaume, Nucl. Instr. and Meth. A 291, 371 (1990).

[4] S. Sasaki, K. Miyata, T. Takada, Jpn. J. Appl. Phys. 31, L1794 (1992).

[5] X.M. Maréchal, SPring-8 engineering note.