ON A SKELETON CASSINI OVALS CURRENT UNDULATOR

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Abstract
A new undulator structure for free electron lasers was presented. Current Skeleton CASSINI ovals produce magnetic fields which are spatially periodic. The current structure was in the shape of modified CASSINI ovals stacks. The current has alternating directions. The magnetic field components for each wire present 90 degree symmetry. The CASSINI undulator transverse cross-section (in arbitrary units) which is approximated by polygons was given by the relations:

X = Qcos(φ), y = Qsin(φ),

$$Q = R\sqrt{e^2\cos(2\varphi) \pm \sqrt{c^4 - e^4\sin(2\varphi)}}\text{, z = const.}$$

and (e<c),where c, e, R are parameters. In the Cartesian coordinates the Biot - Savart law was analytically evaluated. The magnetic field was mainly transversal and easily adjusted with the current. The versatility of this structure introduces a new type of two beams longitudinal undulator or wiggler design for transverse momentum.

INTRODUCTION

Free-electron lasers (FEL) implies the elaboration of compact devices [1, 2]. The phenomenon of tuned coherent radiation is given by the undulator which is the FEL principal component. The radiation is obtained by means of a relativistic electron beam injected in a periodic magnetic field produced by spatially periodic structures formed by permanent magnets or currents (undulator, wiggler). As a result a coherent radiation is generated in the Z - direction. In the new longitudinal undulators the Z magnetic field components are periodic with Z and the incoming electrons have transverse momentum.

MODEL

The Cassini ovals can be observed in transverse cross section of Medusa jelly fish structures [3].The CASSINI wire is described by the following equations:

X = Qcos(φ), y = Qsin(φ),

$$Q = R\sqrt{e^2\cos(2\varphi) \pm \sqrt{c^4 - e^4\sin(2\varphi)}}\text{, z = const.}$$

and (e<c),where c, e, R are parameters [4]. In Figure 1 the CASSINI undulator structure was represented in arbitrary units.

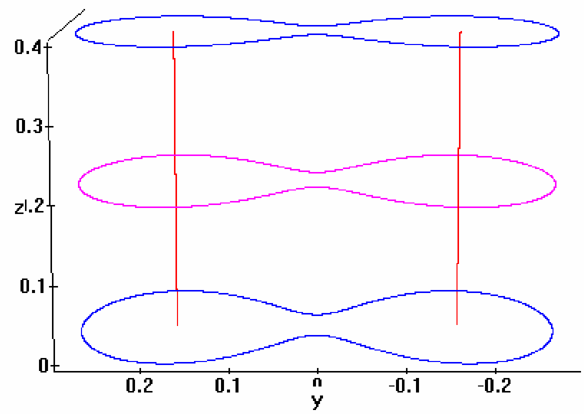

Figure 1: The CASSINI wires current undulator structure.

These ovals are replaced by polygonal skeletons. The transversal characteristic of the model was realized by electrons with transverse momentum. In this new structure the current is circulating in a stack of wires. The current in wires has alternating directions. The wire magnetic field was computed by the Biot-Savart law. The skeleton has 14 segment elements. The x, y, z magnetic field components for a segment are given by the following formula [5] with factor $\frac{\mu_r \mu_0}{4\pi} J$ for elliptic integrals:

$$B_x \approx (y2\cdot Z - y2\cdot zw - y1\cdot Z + y1\cdot zw)IE(aa,bb,cc)$$
$$B_y \approx (-x2\cdot Z + x2\cdot zw + x1\cdot Z - x1\cdot zw)\cdot$$
$$\cdot IE(aa,bb,cc) \quad (2a)$$
$$B_z \approx (x2\cdot Y - x2\cdot y1 - x1\cdot Yy2\cdot X +$$
$$+ y2\cdot x1 + y1\cdot X)IE(aa,bb,cc)$$

where the elliptic part is given by

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$$IE(aa,bb,cc) = 2\frac{2aa+bb}{\left(4aa\cdot cc - bb^2\right)\sqrt{aa+bb+cc}} -$$
$$-2\frac{bb}{\left(4aa\cdot cc - bb^2\right)\sqrt{cc}}$$
$$aa = (x2-x1)^2 + (y2-y1)^2 \qquad (2b)$$
$$bb = -2X(x2-x1) - 2Y(y2-y1) + x1^2 +$$
$$+2x1(x2-x1) + y1^2 + 2y1(y2-y1)$$
$$cc = X^2 + Y^2 + (Z-zw)^2 - 2X\cdot x1 - 2Y\cdot y1;$$

where J is the current, zw is the Z wire position.

In Figure 2 the magnetic field Z dependence along the direction of one Cassini fix point is given (B_{z_1} in relative units).

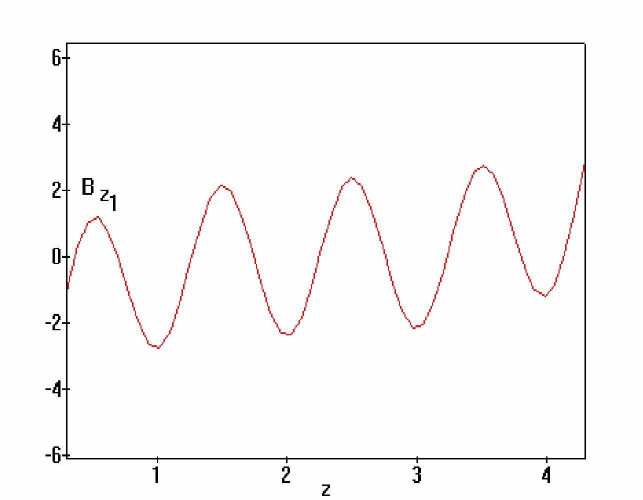

Figure 2: The undulator z magnetic field component vs. Z direction.

We noticed the periodic behavior of the z magnetic field components (given in relative units).

CONCLUSION

In this preliminary paper a new model of an undulator for free electron lasers is presented. The current undulator structure is given by a series of modified Cassini ovals wires. Each wire presents 90 degree symmetry. The magnetic field integrals components are analytical computed. The middle magnetic field aspect is mainly longitudinal. The transversal aspect was created by electrons with transversal components. This new treatment of the problem reduces the time and complexity for magnetic components evaluation for this structure. The model is sought for structures with two beams simultaneously.

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