ON A BISCUIT CURRENT UNDULATOR

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Abstract

A new undulator structure for free electron lasers was presented. Current BISCUIT devices produce magnetic fields which are spatially periodic. The current structure was in the shape of wires stacks. The current has alternating directions. The magnetic field components for each wire presents symmetry with two axis. The BISCUIT undulator transverse cross-section (in arbitrary units) is a function depending directly on cosine (for x component) and sine (for y component) and inverse on the square root of the sum of forth power of sine and cosine. The z component is a constant. The Biot - Savart law was numerically evaluated. The magnetic field is longitudinal and easily adjustable with the current. The versatility of the constant parameter covers longitudinal undulator or wiggler design for one or two beams devices with transverse momenta.

INTRODUCTION

Free-electron lasers (FEL) implies the elaboration of compact devices [1,2,3]. The phenomenon of tuned coherent radiation is given by undulator 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 BISCUIT wire structures can be observed in transverse cross section [4]. The BISCUIT wire is described by the following equations:

$$x = \frac{a \cdot \cos\theta}{\sqrt{\cos^4\theta + \sin^4\theta}}$$
$$y = \frac{a \cdot \sin\theta}{\sqrt{\cos^4\theta + \sin^4\theta}} \qquad (1)$$
$$zw = const$$

where a is a parameter. In Figure 1 The BISCUIT undulator structure was represented in arbitrary units.

The transversal caracteristic of the model was realised 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.
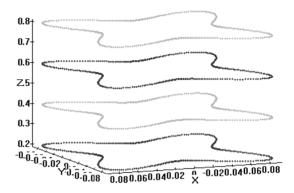

Figure 1: The BISCUIT wires current undulator structure.

The wire magnetic field was computed by Biot - Savart law . The B_x, B_y, B_z magnetic field components (the integrals) for a wire are given by the following formula multiplied by the factor $\frac{\mu_r \cdot \mu_0}{4\pi} \cdot J$:

$$B_x \sim \int_0^{2\pi} \frac{dl_y \cdot r_z - dl_z \cdot r_y}{\sqrt{r^3}}; \quad r_x = X - x$$

$$B_y \sim \int_0^{2\pi} \frac{dl_z \cdot r_x - dl_x \cdot r_z}{\sqrt{r^3}}; \quad r_y = Y - y$$

$$B_z \sim \int_0^{2\pi} \frac{dl_x \cdot r_y - dl_y \cdot r_x}{\sqrt{r^3}}; \quad r_z = Z - zw$$

$$dl_x = -\frac{dr_x}{d\theta}; \quad dl_y = -\frac{dr_y}{d\theta}; \quad dl_z = 0$$

$$r^2 = r_x^2 + r_y^2 + r_z^2 \qquad (2)$$

Where J is the current, μ_r the relative magnetic permitativity, μ_0 the vacuum magnetic permitivity, zw is the Z wire position. X, Y, Z are the cartesian coordinates of the point where the magnetic field components are evaluated.

The B components were evaluated with the values : $a = 0.06$, $dd = 0.1$ is the distance between wires.

In figures 2 and 3 the magnetic field Z dependence along the direction of one BISCUIT fix point is given (for x, z components in relative units).

Also we have for the magnetic components the relation: $B_x < B_y < B_z$. B_y represents a third part from B_z component. Because B_x is the tenth part from B_y component it can be neglected. In figures 2 and 3 we

noticed the modulation of the magnetic field amplitudes. We underline the periodic behaviour of the y and z magnetic field components (given in relative units).
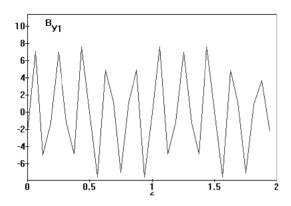

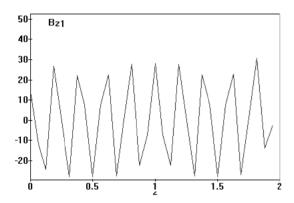Figure 2: The undulator y magnetic field normalised component vs. Z direction.

Figure 3: The undulator z magnetic field normalised component vs. Z direction.

CONCLUSIONS

In this preliminary paper a new model of an undulator for free electron lasers is presented. The curent undulator structure is a series of BISCUIT wires. Each wire present a 90 degree symmetry. The magnetic field integrals components are numerically evaluated. The middle magnetic field aspect is mainly longitudinal and have also a less important transversal component. The transversal aspect was created by electrons with transversal components. This new model is sought for structures with two electron beams simultaneously.

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