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Biot-Savart Law for Determination of Speed of Particle Beyond the Speed of Light

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Abstract *This paper presents the modification of Biot-Savart law that thoroughly put to calculate magnetic field at any point in the space due to motion of charge in a complete circuit and further applies to determine velocity of particle faster than the speed of light. The modified Biot-Savart law provides complete mathematical result as given by ordinary Biot-Savart law, but most importantly, do not involve the need of derivative, integration of line element. In order to derive the relation* ($\vec{E} = \vec{B}\,X\,\vec{V}$) *among electric field* ($\vec{E}$) *magnetic field* ($(\vec{B})$ *and direction of propagation* $(\vec{v})$ *of electromagnetic wave, Biot-Savart law is given by formula* $B=\frac{qv\sin\theta}{4\pi\epsilon_0 c^2 r^2}$ *, Where* θ *be angle between direction of velocity v of moving charge and position vector of given point where magnetic field has to be determined. This formula is applicable to address the question of how is it possible to achieve velocity of particle in excess of C and to open a discussion towards a new way of acquiring speed of particle beyond speed of light, namely* $C \leq V \leq \infty$*, Although, there is popular statement "nothing can move faster than speed of light". In this highly controversial statement, the specific purpose is not to comprises the merits of existing Biot-Savart law, but rather to introduce a concise and careful reasoned account of Biot-Savart law to propagate particle faster than speed of light.*

Keywords*: Biot – Savart law, Electromagnetic wave, Magnetic field, speed of light.*

I. INTRODUCTION

Biot-Savart law plays a corner stone in electricity and magnetism. The magnetic field dB [1,2] caused by a short segment dl of a steady current carrying [3] conductor can be calculate using Biot-Savart's Law [4-7], i.e.

$$dB=\frac{\mu_0 I\, dl \sin\theta}{4\pi\, r^2} \qquad (1)$$

Where ɵ is the angle made by the straight line joining the point p to the center of the element dl. In vector from using unit vector [8,9] $\hat{r} = \frac{\vec{r}}{|\vec{r}|} r^2$ we have

$$\overrightarrow{dB} = \frac{\mu_0}{4\pi} \frac{I\,\overrightarrow{dl} \times \vec{r}}{r^2} \qquad (2)$$

Equation (1) and (2) are the law of Biot and Savart.

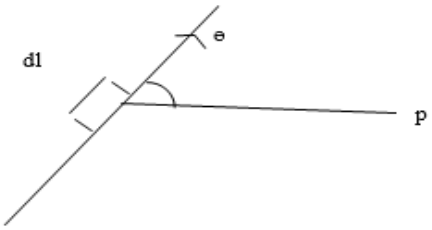

Figure (1): Magnetic Field Due to Current Element

A moving charge or a current creates a magnetic field in the surrounding space (in addition to its electric field). Velocity of charge is a foremost factor to generate magnetic field. But equation (1) and (2) given by Biot and savart has no explicit involvement of velocity of charge. Biot-Savart law has a issue for being difficult and mathematically complex. What makes Biot- savart seem difficult is that it has involvement of short segment dl, integration or derivative. Even through, there is a large literature on Biot-Savart Law, magnetic Field of electromagnetic wave using this law is not described in any relevant literatures yet. But this paper completely eliminates these issues and further open the new door to achive velocity in excess of speed of light. It present a modified version of Biot - savart law to calculate magnetic field due to moving charge [10,11]. and most importantly to present the criteria for a particle to gain the velocity beyond the speed of light. The structure of the remainder of the paper is organized as follows. In section 2, Biot- Savart law transfroms Such that magnetic field due to motion of charge depends on velocity of charge and use to find magnetic field at center of circular coil and along the axis of circular current loop. In section 3, we include a discussion on the modified form of Biot- Savart law to determine the behavior of electromagnetic wave and to present criteria to propagate particle faster than speed of light, such that $C \leq V \leq \infty$.

II. METHODS

2.1 The Modified Biot-Savart law

The flux density ΔB[12,13] at a point due to a small element Δl of a conductor carrying a current I is given by.

$$\Delta B = \frac{\mu_0}{4\pi} \frac{I\,\Delta l \sin\theta}{r^2} \qquad (3)$$

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Where ɵ is the angle between the element and the line joining point p.

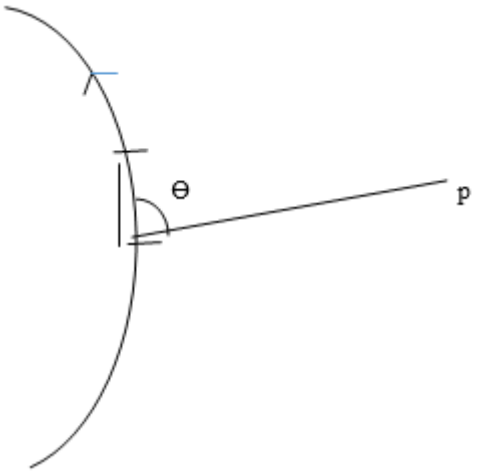

Figure (2): Magnetic Field Due to Motion of Charge

Let Δl be distance travelled by charge moving with velocity V at instantaneous time Δt.

$V=\frac{\Delta l}{\Delta t}$

: . $\Delta l= v\Delta t$

Also, current in a circuit is defined as rate of change of charge.

Mathematically,

$I=\frac{\Delta q}{\Delta t}$

Now, substituting value of Δl and I in equation (3), we get.

$\Delta B=\frac{\mu_0}{4\pi}\quad\frac{\Delta q v \Delta t sin\theta}{\Delta t\quad r^2}$

: . $\Delta B=\frac{\mu_0}{4\pi}\quad\frac{\Delta q\ v sin\theta}{r^2}$

It tells that when an infinitesimal charge Δq occur along given path segment of a conductor, it creates an infinitesimal contribution to the total magnetic field B denoted by ΔB [14]. So making it free from integration, we get

$$B=\frac{\mu_0}{4\pi}\quad\frac{qvsin\theta}{r^2} \qquad (4)$$

The permeability of free space also relates two other constant;ϵ_0, the permittivity of free space and C, the speed of light in a vacuum [14].

$$C=\frac{1}{\sqrt{\mu_0\epsilon_0}}$$

$$\mu_0=\frac{1}{c^2\epsilon_0}$$

Substituting value of μ_0 in equation (4),

$$B=\frac{qvsin\theta}{4\pi\epsilon_0 c^2 r^2} \qquad (5)$$

This equation reveals that magnetic field (B) creates whenever charge (q) is in motion (V) and plays a crucial to determine magnetic field due to motion of charge when velocity of moving charge is known. Some applications of equation (5) to determine magnetic field due to moving charge are given below.

2.2 Field at Center of a Circular Coil

consider a charge q flowing in a circular loop of radius r. We have to calculate the magnetic field due to this moving charge q at the center of loop as shown in figure (3)

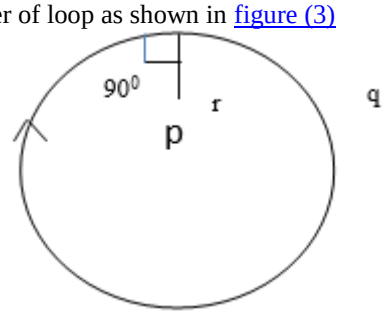

Figure (3): Magnetic Field Due to Circular Coil

Magnetic field at center of coil due to velocity v of moving charge in Coil can be written from equation (5) as,

$$B=\frac{qvsin\theta}{4\pi\epsilon_0 c^2 r^2}$$

The direction of this field is normal to the plane of this diagram and going inwards. So, $sin\theta= sin\pi_{/2} =1$ and r=R

Now, total net magnetic field,

$$B=\frac{qv}{4\pi\epsilon_0 c^2 R^2} \qquad (6)$$

Let T be time taken by charge to complete one cycle with velocity v of coil of radius R.

$Velocity=\frac{cricumference\ of\ coil}{time\ to\ complete\ one\ cycle}$

$V=\frac{2\pi R}{T}$

Substituting value of V in equation (6) we get

$B=\frac{q}{4\pi\epsilon_0 C^2 R^2}\quad\frac{2\pi R}{T}$

Or, $B=\frac{q}{2\epsilon_0 C^2 RT}$

Also , we have , $\mu_0=\frac{1}{\epsilon_0 c^2}$ and $I=\frac{q}{T}$

then,

$$B=\frac{\mu_0 I}{2R} \qquad (7)$$

This is same value of field at center of circular current carrying coil as determined by using Biot- Savart Law.

2.2 Field along the axis of circular current loop Consider q charge carrying circular coil of radius R.

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let p be point on the axis of coil at a distance x from center of coil where magnetic field due to moving charge has to be determined. As well r be the distance of point p from circular coil and ɵ be angle made by r with axis of coil as show in figure (4).

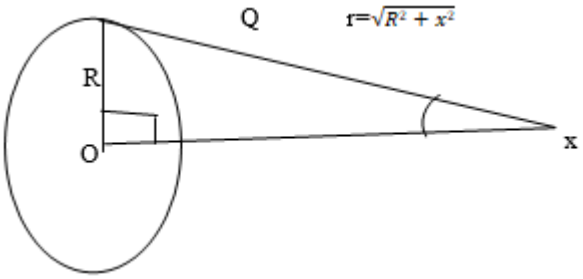

Figure (4): Magnetic Field at A Point on the Axis Due to Coil.

Magnetic field at point p can be written from equation (5).

$$B=\frac{qv\sin\theta}{4\pi\epsilon_0 c^2 r^2}$$

now from the figure, $r=\sqrt{R^2+x^2}$ then

$$B=\frac{qv\sin\theta}{4\pi\epsilon_0 c^2(\sqrt{R^2+x^2})^2} \quad (8)$$

Let T be time taken by charge to complete one cycle with velocity V of coil of radius R.

Velocity of charge = $\frac{cricumference\ of\ coil}{time\ to\ complete\ one\ cycle}$

$$V=\frac{2\pi R}{T}$$

Also , in triangle OPQ,

$\sin OPQ=\sin\theta=\frac{QO}{PQ}=\frac{R}{r}$

$$\therefore \sin\theta=\frac{R}{\sqrt{R^2+x^2}}$$

Substituting value of V and sinɵ in equation (8), we get

$$B=\frac{q}{4\pi\epsilon_0 c^2(R^2+x^2)}\ \frac{2\pi R}{T}\ \frac{R}{\sqrt{R^2+x^2}}$$

Or, $B=\frac{R^2}{2\epsilon_0 c^2(R^2+x^2)^{\frac{3}{2}}}\ \frac{q}{T}$

Also we have , $\mu_0=\frac{1}{\epsilon_0 c^2}$ and $I=\frac{q}{T}$ then,

$$B=\frac{\mu_0 I R^2}{2(R^2+x^2)^{\frac{3}{2}}} \quad (9)$$

This is same value of magnetic field along the axis of circular current loop as calculated by using Biot-Savart law.

III. RESULTS AND DISCUSSION

The Corresponding modified Biot-Savart law is applied to determine magnetic field at center of circular coil and along the axis of circular current loop which are stated above in equation (7) and (9) respectively. The modified Biot –savart law from equation (5) is

$$B=\frac{qv\sin\theta}{4\pi\epsilon_0 C^2 R^2} \quad (10)$$

The electric intensity E at a point P at a distance r from a charge q is given by

$$E=\frac{q}{4\pi\epsilon_0 r^2}$$

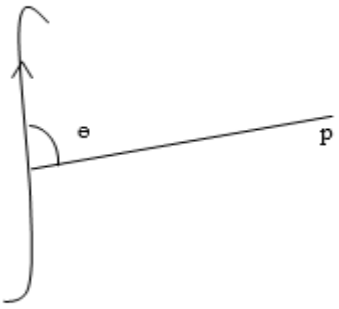

Figure (5): Field at Point P Due to Charge

Putting this value of E in equation (10)

$$B=\frac{EV\sin\theta}{c^2} \quad (11)$$

Also , we know that,

E= B×V= BVsinɵ

Where ɵ be angle between direction of magnetic field at point P and direction of velocity of charge. putting value of E in above equation, we get,

$$B=\frac{BV\sin\theta\ V\sin\theta}{c^2}$$

Or, $\sin^2\theta=\frac{c^2}{v^2}$

$$\therefore \sin\theta=\frac{c}{v} \quad (12)$$

But $\sin\theta \leq 1$

Or, $\frac{c}{v} \leq 1$

$C \leq V$

Which is completely impossible because nothing move faster that speed of light. So this relation must be C=V

Now we have, C= V and $\sin\theta=\frac{c}{v}=1=\sin\frac{\pi}{2}$ putting this value of V and sinɵ in equation (11)

$E=BC=BC\sin\frac{\pi}{2}=B\times C$

This expression has a beautiful meaning to perceive nature of electromagnetic wave [15, 16] correctly. Where E be electric field produce by charge [$E=\frac{q}{4\pi eor^2}$]and B be magnetic Field measured by using Biot-savart law. This equation reveals that electric field E is perpendicular to plane containing vector B×C. magnetic field (B) and direction speed of light is also perpendicular.

Hence, magnetic field (B), electric field (E) and direction of propagation (C) are mutually perpendicular, which is most important property of electromagnetic wave. Thus, it is explicitly exhibited by Biot-Savart law. As well, equation (12) provides meaningful mathematical expression to acquire speed in excess of C.

$$\sin\theta = \frac{c}{v}$$

$$\therefore v = \frac{c}{\sin\theta} \qquad (13)$$

It tells that V is greater than C when sinθ is less than one (sinθ < 1 Implies $\frac{C}{V} < 1$ implies C< V). Thus, if angle (θ) between magnetic field (B) and direction of propagation (V) is less than $\pi/2$ (sinθ <1), then we acquire speed of particle faster than speed of light (C). As well, the different values of angle between magnetic field and direction of propagation to achieve velocity greater than speed of light are presented in the given table.

Table (1): Speed of Particle in Excess of C

S.N.	Angle (θ) between magnetic field (B) and direction of propagation (V)	Velocity of Particle ($v = \frac{c}{\sin\theta}$)
1	$\theta = \pi/2$ (B and V are perpendicular to each other.)	$v = \frac{c}{\sin\pi/2} = 1$ (Velocity of particle (V) is equal to speed of light.)
2	$\theta < \pi/2$	$\sin\theta < 1$ $\frac{C}{V} < 1$ C< V (Velocity of particle (v) is faster than speed of light.)
3	θ = 0 (B and V are parallel to each other.)	$v = \frac{c}{\sin 0} = \infty$ (Velocity of particle (v) is infinite.)

The magnetic field due to motion of charge can be determined applying ordinary Biot-savart's law as

$$dB = \frac{\mu_0 I\, dl \sin\theta}{4\pi \quad r^2}$$

The integration must be taken to calculate magnetic field using this formula that make it little bit complex. This formula does not describe about the magnetic field of electromagnetic waves. on focusing these drawbacks, this paper has modified Biot-savart's such that it is free from derivative and integration as follows.

$$B = \frac{qv\sin\theta}{4\pi\epsilon_0 c^2 r^2}$$

This equation helps to derive the relation among electric field, magnetic field and direction of propagation of electromagnetic wave. Therefore, this modified form of Biot-savart's law is more potent than any other form of Biot-savart's law.

IV. CONCLUSION

This paper extend the range of applicability and the formal structure of Biot-Savart law by deriving very simple formula to compute magnetic without integration and illustrate the usefulness of this approach to draw relationship ($\vec{E} = \vec{B} \times \vec{V}$) among electric field($\vec{E}$) magnetic field ($\vec{B}$) and direction of propagation ($\vec{V}$) of electromagnetic wave. The mathematical formalism suggests a connection of angle between magnetic field and direction of propagation electromagnetic wave with velocity of particle (V) for $C \leq V \leq \infty$. On the basis of this connection, the new formula (equation 13) is given for electromagnetic wave to achive speed greater than speed of light. The objective is to explore mathematical criteria to acquire speed faster than speed of light. The speed of particle of all possible values beyond the speed of light have been thoroughly presented in the table (1). These theoretical framework have been derived from experimentally verified Biot-Savart law. thus it must be valid experimentally. hence, it opens a door for scientist to develop experimental technique for verification of this theory and will play a crucial role to perceive the speed beyond the speed of light.

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Authors Contributions	I am only the sole author of the article.

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