Biot Savart Law

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Abstract

Notes on the Biot Savart law.

1 The Biot Savart Law

1.1 B field produced by a current

A current I produces a magnetic field $\vec{B}$. $\vec{B}$ has the following characteristics:

- its magnitude is **inversely proportionnal to the square of the distance** between the wire and the observation point,
- it is **tangential** to the current direction.

1.2 Biot Savart law

The Biot Savart law is used to compute the magnetic field (*Bfield*) produced by **steady** a current in a **straight** portion of a wire. Complex current paths are computed by decomposing in **small wire portions**, called $\vec{dl}$.

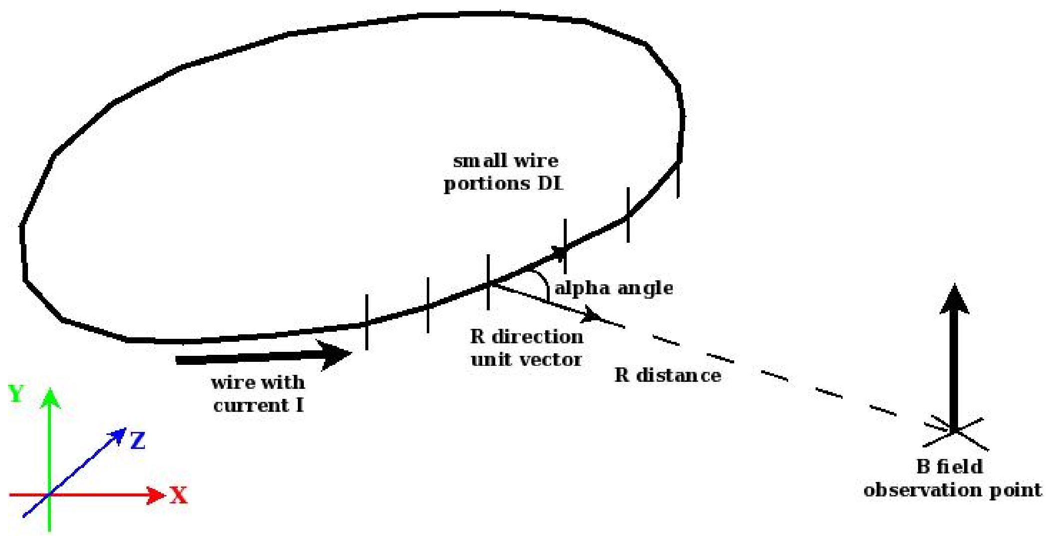
$$\boxed{B = \frac{\mu_0 \times I}{4 \times \Pi} \int \frac{dl \times \hat{r}}{r^2}}$$

where:

- μ_0 the vacuum permeability,
- I the current intensity,
- $\vec{dl}$ the current direction vector,
- $\hat{r}$ a unit vector in the direction of r,
- r the distance between the location of dl and the measurement point.

This forumla clearly shows:

- the magnitude varies with the square of the distance,
- the B field is normal to the plan (ie. because of the cross product).



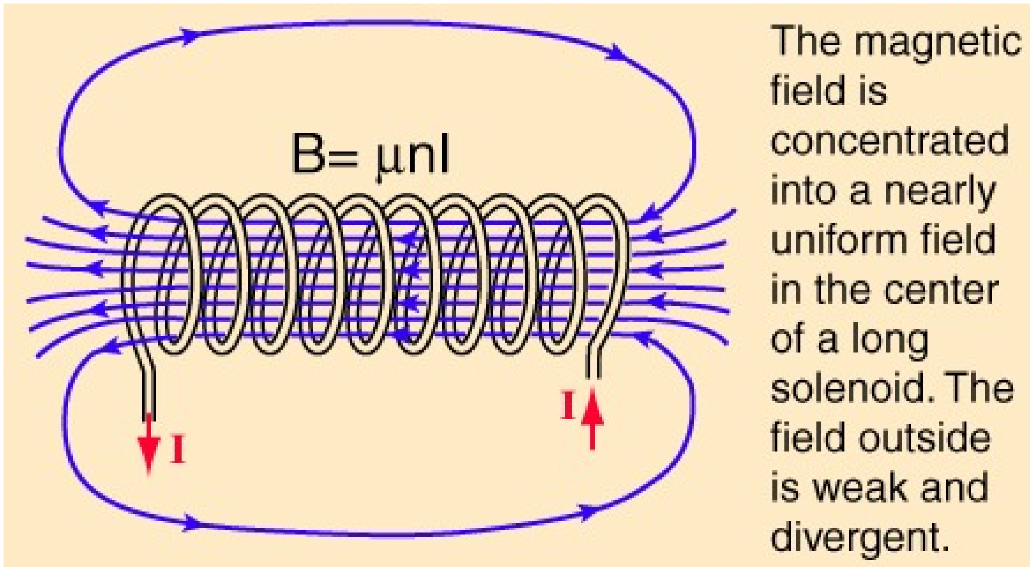
1.3 Solenoid B field approximation

At the **center** of **long** a solenoid (that is, whose length is greater than diameter), the B field can be approximated with the formula:

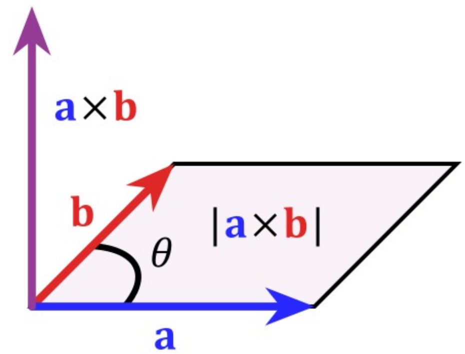
$$\boxed{B = \mu \times n \times l}$$

where:

- μ the medium permeability,
- n the turn density,
- l the solenoid length.


B= μnI
I
I
The magnetic field is concentrated into a nearly uniform field in the center of a long solenoid. The field outside is weak and divergent.

2 Vector cross product



The cross product of 2 vectors $\vec{A}$ and $\vec{B}$ is **another vector** $\vec{A} \times \vec{B}$. $\vec{A} \times \vec{B}$:

- has the same **magnitude** as the diagonal of the parallelogram formed by $\vec{A}$ and $\vec{B}$,
- is **normal** to the plan formed by $\vec{A}$ and $\vec{B}$.

Mathematically:

$$\boxed{\vec{A} \times \vec{B} = sin(\alpha) \times |A| \times |B| \times \hat{n}}$$

where:

- α is the angle between $\vec{A}$ and $\vec{B}$,
- $\hat{n}$ is a vector normal to than plan containing $\vec{A}$ and $\vec{B}$.

3 References

- http://academicearth.org/lectures/biot-savart-law-gauss-law-for-magnetic-fields
- http://en.wikipedia.org/wiki/Biot%E2%80%93Savart_law
- http://dev.physicslab.org/Document.aspx?doctype=3&filename=Magnetism_BiotSavartLaw