

# Biot Savart Law

Fabien Le Mentec

`texane@gmail.com`

## **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.

## 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  $\vec{dl}$ .

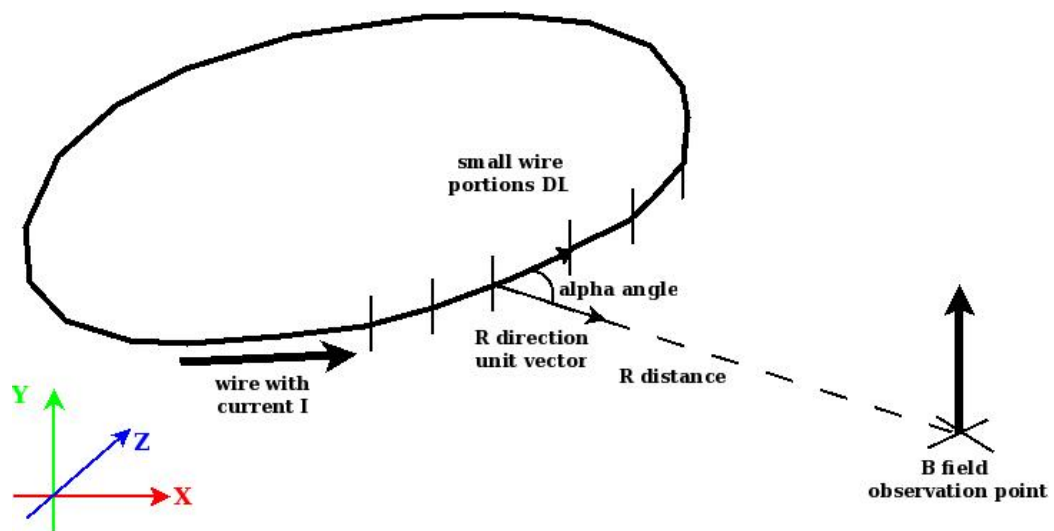
$$B = \frac{\mu_0 \times I}{4 \times \Pi} \int \frac{dl \times \hat{r}}{r^2}$$

where:

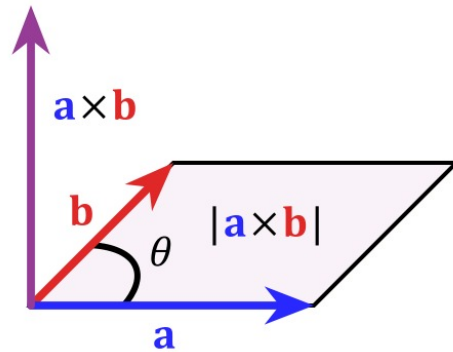
- $\mu_0$  the vacuum permeability,
- $I$  the current intensity,
- $\vec{dl}$  the current direction vector,
- $\hat{r}$  a unit vector in the direction of  $r$ ,
- $r$  the distance between the location of  $dl$  and the measurement point.

This formula 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).



### 3 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:

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

where:

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

## 4 References

- <http://academicearth.org/lectures/biot-savart-law-gauss-law-for-magnetic-fields>
- [http://en.wikipedia.org/wiki/Biot%E2%80%93Savart\\_law](http://en.wikipedia.org/wiki/Biot%E2%80%93Savart_law)
- [http://dev.physicslab.org/Document.aspx?doctype=3&filename=Magnetism\\_BiotSavartLaw](http://dev.physicslab.org/Document.aspx?doctype=3&filename=Magnetism_BiotSavartLaw)