Exp3 (I)   Measuring magnetic fields

Object

Measuring the magnetic field for a straight conductor and for circular loops.

Principle

The magnetic field of a long, straight conductor is measured for various currents I as a function of the distance r from the conductor. The result is a quantitative confirmation of the relationship.

$$B = \frac{\mu_0 I}{2\pi r} \tag{1}$$

The magnetic field of circular coils with different radius r are measured as a function of the distance s from the axis through the center of the coil. The measured values are compared with the values which are calculated using the equation.

$$B = \frac{\mu_0 I r^2}{2(r^2 + s^2)^{3/2}} \tag{2}$$

Derived from the Biot-Savart Law, where I: Currents through the conductor, r: Coil radius, s: Distance on the axis, μ_0: Magnetic field constant.

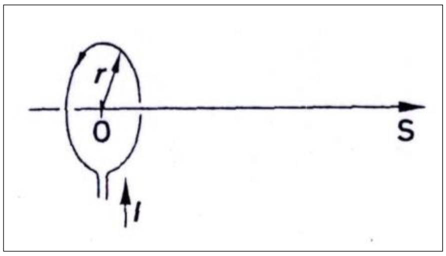

Fig1.

Designations for equation (2): Field strength along the axis of a narrow circular coil.

Equiments

The equiments shown as in Fig. 2.

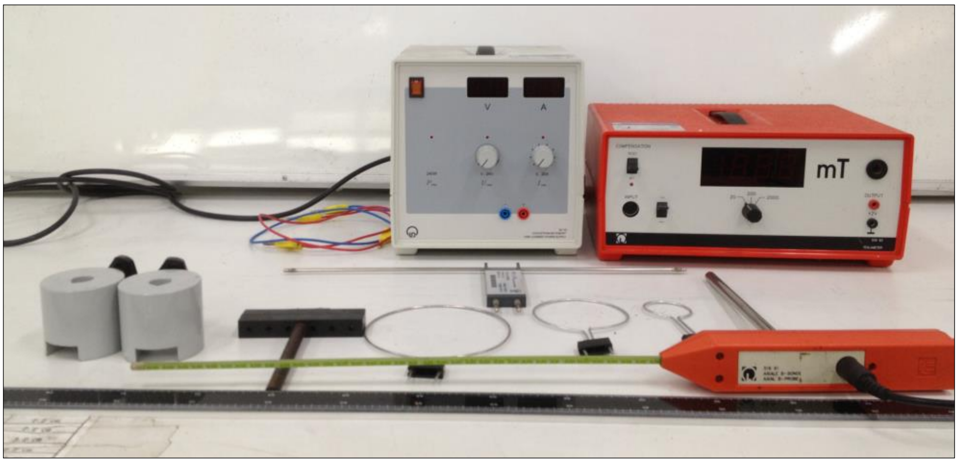

Fig.2.

Setting up

Set up the equiments as in Fig. 3

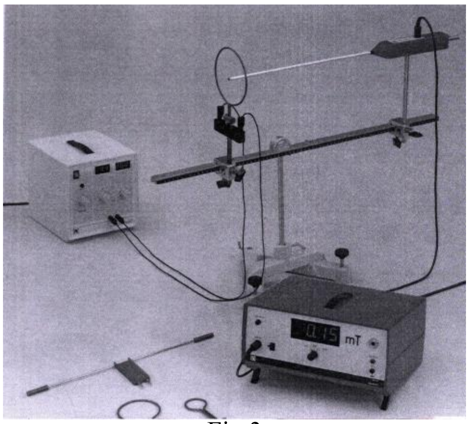

Fig.3

Procedure

1. Calibrate the measurement module and axial field probe using the calibrating coil.
2. Measured as a function of the distance s from the axis through the center of the coil.

The magnetic flux density B along the axis of the circular coils with different radius r.

I=10(A)						
s(cm)	B(mT) for r=2(cm)		B(mT) for r=4(cm)		B(mT) for r=6(cm)	
	實驗值	理論值	實驗值	理論值	實驗值	理論值
3.0						
2.7						
2.4						
2.1						
1.8						
1.5						
1.2						
0.9						
0.6						
0.3						
0						
-0.3						
-0.6						
-0.9						
-1.2						
-1.5						
-1.8						
-2.1						
-2.4						
-2.7						
-3						

The magnetic flux density B along the axis of the long, straight conductor.

I=10(A)		
r=0.19cm		
s(cm)	B(mT)	
	實驗值	理論值
0.19		
0.49		
0.79		
1.09		
1.39		
1.69		
1.99		
2.29		
2.59		
2.89		
3.19		

Exp3 (Ⅱ)　Measuring magnetic fields

Object

Confirming the Helmholtz conditions for a pair of coils Measuring the magnetic field of two coils at varying distances apart. Comparing the measurement results with the Helmholtz condition for a pair of coils.

Principle

$$B = \frac{\mu_0 I r^2}{2(r^2 + s^2)^{3/2}} \tag{1}$$

The magnetic flux density $\vec{B}$ at a distance s on the axis of a flat circular coil is equal to

$$B = \frac{\mu_0 n I r^2}{2(r^2 + s^2)^{3/2}} \tag{2}$$

If two identical, series-connected coils are arranged in parallel and coaxially (Shown as Fig.4.), the magnetic fields are added together

$$B = \frac{\mu_0 n I r^2}{2}\left[\frac{1}{\left[r^2 + \left(s - \frac{a}{2}\right)^2\right]^{3/2}} + \frac{1}{\left[r^2 + \left(s + \frac{a}{2}\right)^2\right]^{3/2}}\right] \tag{3}$$

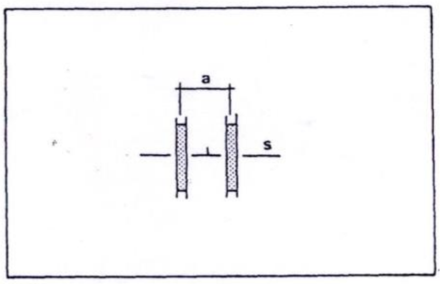

Fig.4
Designations for (3): Field strength along the axis of a pair of Helmholtz coils

Derived from the Biot-Savart Law :

n: Number of coil turns

I: Currents through the conductor

r: Coil radius

s: Distance on the axis

μ_0: Magnetic field constant

a:Distance between the two coils

Equiments

The equiments shown as in Fig. 5.

Fig.5

Setting up

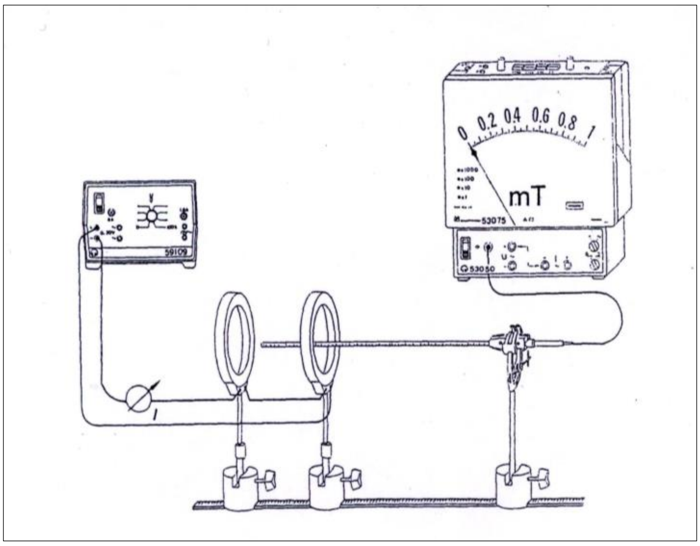

Fig.6 Measuring the magnetic flux density B along the axis of a pair of Helmholtz coils

Set up the equiments as in Fig. 6. Set the distance between the two coils to 2r(r=radius of the coil=6.8cm). Connect the coils so that they are series –aided. Increase the voltage until the ammeter indicates a current of 0.5A.

Notice: The maximum permissible current through the coils is 1.5A!

Move the point of the axial field probe so that it is in the center between the two coils (zero point of the S-axis).

Procedure

Move the axial field probe along the axis of both coils ,measuring the magnetic field at regular intervals ,for example every 0.5cm. Enter the measured values in a graph. Vary the distance between the coils, e.g.

$a = 4cm$; $a = r = 6.8cm$;$a = 2r = 13.6cm$

Helmholtz coils

I=0.5(A)								
s (cm)	B(mT) for a=4(cm)		s (cm)	B(mT) for a=6.8(cm)		s (cm)	B(mT) for a=13.6(cm)	
	實驗值	理論值		實驗值	理論值		實驗值	理論值
						9.0		
						8.5		
						8.0		
						7.5		
						7.0		
						6.5		
						6.0		
			5.5			5.5		
			5.0			5.0		
4.5			4.5			4.5		
4.0			4.0			4.0		
3.5			3.5			3.5		
3.0			3.0			3.0		
2.5			2.5			2.5		
2.0			2.0			2.0		
1.5			1.5			1.5		
1.0			1.0			1.0		
0.5			0.5			0.5		
0.0			0.0			0.0		
-0.5			-0.5			-0.5		
-1.0			-1.0			-1.0		
-1.5			-1.5			-1.5		
-2.0			-2.0			-2.0		
-2.5			-2.5			-2.5		
-3.0			-3.0			-3.0		
-3.5			-3.5			-3.5		
-4.0			-4.0			-4.0		
-4.5			-4.5			-4.5		
			-5.0			-5.0		
			-5.5			-5.5		
						-6.0		
						-6.5		
						-7.0		
						-7.5		
						-8.0		
						-8.5		
						-9.0		