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DETERMINATION OF THE EFFECT MAGNETIC FILED INTENSITY ON REFRACTIVE INDEX BY MEANS OF FOCAL LENGTH MEASUREMENT

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ABSTRACT
Light refraction in a medium results from energy exchange between the medium and the magnetic field of the light. The phenomenon of the change of the refractive when it passes through a magnetic field is called Magneto choral. The empirical relation between the change in the magnetic field intensity and the value of the refractive index by measuring the focal length is shown in this work using the classical physical laws of the theory of parmagnetisum.

Keywords: refractive index, focal length, parmagntisum, magnetic susceptibility, electric permittivity

INTRODUCTION
Because electron optics makes use of many of the concepts of light optics, We will quickly review some of the basic optical principles. In light optics as well as magnetism, we can employ a glass lens for focusing, based on the property of refraction : deviation in direction of a light ray at a boundary where the refractive index changes. Refractive index is inversely related to the speed of light, which is $c = 3.00 \text{ X} 10^8$ m/s in vacuum (and almost the same in air) but c/n in a transparent material (such as glass) of refractive index(n). If the angle of incidence (between the ray and the perpendicular to an air/glass interface) isT_1in air (n_1|1), the corresponding value T_2 in glass (n_2|1.5) is smaller by an amount given by Snell's law [1]

$$n_1 \sin T_1 = n_2 \sin_2$$

In electromagnetism, the magnetic susceptibility χ(latin: susceptibilis "receptive") is a dimensionless proportionality constant that indicates the degree of magnetization of a material in response to an applied magnetic field. A related term is magnetizability, the proportion between magnetic moment and magnetic flux density.[3,2]

In atomic physics, the Bohr magneton (symbol μB) is a physical constant and the natural unit for expressing the magnetic moment of an electron caused by either its orbital or spin angular momentum.[3,4,5]
The Bohr magneton is defined in SI units by

$$\mu_{\mathrm{B}} = \frac{e\hbar}{2m_{\mathrm{e}}}$$

And in Gaussian CGS units by

$$\mu_{\mathrm{B}} = \frac{e\hbar}{2m_{\mathrm{e}}c}$$

Where
e is the elementary charge,
ħ is the reduced Planck constant,
m_e is the electron rest mass and
c is the speed of light.

With all these concepts the work is carried out.

EXPERIMENTAL SETUP

Apparatus:

The following apparatus were used in experiments: halogen lamp range V(volt) =12 v , optical bench, convex lens of focal length"15mm", screen, two coils with magnetic bar :N_1 = number of turns = 250turn and N_2 = number of turns =250 turn power supply(1):range V (volt) = 10v and power supply(2)range V(volt) = 10v digital multi meter: range of V(volt) = " 200mA" , and Tesla meter: range of V(volt) = " 200m tesla" .

Method:

The optical bench and halogen lamp were aligned, the convex lens was placed between the two magnetic coils. Different current values in the range from"0.25A to3.75A". were allowed to pass through the two coils .An image was found on the screen, when current changes ,the reading magnetic flux density "B ", was recorded. The corresponding values of found object distance "u" and image distance 'v" then the focal length "f". Focal length "f" was found from the equation:

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v} \qquad (1)$$

The corresponding focal length f for certain magnetic field intensity was found from its relation to the refractive index "n", where

$$\frac{1}{f} = (n-1)\frac{2}{r} \qquad (2)$$

Where

f ≡is focal length.

V ≡is the distance between the lens and screen.

n ≡ is the refractive index.

r ≡ is the radius of convex.

Derivation change of focal length and refractive index due to change of magnetic intensity:

This change is derived using classical physical laws of theory of parmagnetisum[3,6]

The physical quantities magnetic field strength "H" and magnetic induction "B", in vacuum, are related by the equation

$$\beta = \mu_0 H \qquad (3)$$

where μ_0=4π× 10^{-7} v.s/A.m is the permeability of free space the magnetic state of the system will be specified by the magnetization M which is related to Band H by

$$\beta = \mu_0(H+M) \qquad (4)$$

$$\beta = \mu_0 H + \mu_0 M \qquad (5)$$

The magnetic property of a material is usually measured by its magnetic susceptibility as the increase in the magnetization per unit magnetic field intensity

i .e.

$$X_m = M/H \qquad (6)$$

$$M = X_m H \qquad (7)$$

(M) Being the magnetization and H the field intensity inserting (7) in equation (5)

$$\beta = \mu_0 H + \mu_0(X_m H) \qquad (8)$$

$$\beta = \mu_0 (1 + X_m) H \qquad (9)$$

But μ is given by $\mu_0 (1 + X_m)$

$$\beta = \mu H \qquad (10)$$

in a magnetic field H the energy levels are split. with the separation of

$$\Delta E = g\beta H m_s \qquad (11)$$

Where g is the lande splitting factor, β is the Bohar magneton, and m_s is spin quantum number. Suppose that there are only two split levels in the presence of magnetic field, let $n_1$and n_2 represent the population of the lower and upper levels. And n = n_1 + n_2 in the total number of atom according to Boltzmann's statistics, the population is thermals equilibrium are[7]

$$n_1 = e^{\frac{\Delta E}{KT}} \quad \text{and} \quad n_2 = e^{-\frac{\Delta E}{KT}} \qquad (12)$$

$$\text{Thus} \quad \frac{n_1}{n} = \frac{e^{\frac{\Delta E}{KT}}}{e^{\frac{\Delta E}{KT}} + e^{\frac{-\Delta E}{KT}}} \quad \text{and} \quad \frac{n_2}{n} = \frac{e^{\frac{-\Delta E}{KT}}}{e^{\frac{\Delta E}{KT}} + e^{\frac{-\Delta E}{KT}}} \qquad (13)$$

The resultant magnetization for n atoms per unit volume is

$$M = g\beta m_s\,(n_1 - n_2) \qquad (14)$$

Let $x = \frac{\Delta E}{KT} = \frac{g\beta m_s H}{KT}$ (15)

$$M = g\beta m_s n\left(\frac{e^x - e^{-x}}{e^x + e^{-x}}\right) \qquad (16)$$

$e^x = 1 + \mathrm{x} + \cdots$
$e^{-x} = 1 - x + \cdots$

$$M = g\beta m_s n\left(\frac{(1+x)-(1-x)}{(1+x)+(1-x)}\right) = g\beta m_s n\,x \qquad (17)$$

$x = \frac{gBm_sH}{KT}$ in (17)

inserting $M = g\beta m_s n\frac{g\beta m_s H}{KT} = (g\beta m_s)^2 nH$ (18)

Substituting $m_s = \frac{1}{2}$ and $g = 2$ we get for the magnetic susceptibility

$$X_m = M/H = (g\beta m_s)^2 nH/H = (g\beta m_s)^2 n = \beta^2 n \qquad (19)$$

Put $n = n_1 + n_2 = (1+x+x^2/2) + (1-x+x^2/2) = 2 + x^2$

$$X_m = \beta^2(2 + \mathrm{x}^2) \qquad (20)$$

Inserting eqn. (15) in eqn. (20)

$$X_m = \beta^2\left(2 + (\tfrac{\beta H}{KT})^2\right) \qquad (21)$$

The speed of light in any medium v by applying a magnetic field of on appropriate value.

Where $v = \frac{1}{\sqrt{\mu\varepsilon}}$ (22)

Where μ represent the magnetic permittivity, while stand for electric permittivity. the refractive index[8]

$$n = \frac{c}{v} \qquad (23)$$

Is strongly dependent on the external magnetic field.

Inserting equation (22) in eqn. (23) [9]

$$n = c\sqrt{\mu\,\varepsilon_0} \qquad (24)$$

Suppose $\mu = \sqrt{(1 + X_m)}$ in eqn.(24)

$$n = c\sqrt{\varepsilon_0}\sqrt{\mu} = c\sqrt{\varepsilon_0}\sqrt{(1+X_m)} = c\sqrt{\varepsilon_0}\,(1+X_m)^{\frac{1}{2}} = c\sqrt{\varepsilon_0}\left(1 + \frac{1}{2}X_m\right) \qquad (25)$$

Put eqn. (21) in eqn. (25)

$$n = c\sqrt{\varepsilon_0}\left[\left(1 + \tfrac{1}{2}\beta^2\left(2 + \left(\tfrac{\beta H}{KT}\right)^2\right)\right)\right] \qquad (26)$$

$$n = c\sqrt{\varepsilon_0}\left(1 + \frac{2}{2}\beta^2 + \frac{1}{2}\beta^2\left(\frac{\beta^2 H^2}{K^2T^2}\right)\right)$$

$$n = c\sqrt{\varepsilon_0}\,(1+\beta^2) + c\sqrt{\varepsilon_0}\left(\frac{\beta^2}{2}\left(\frac{\beta^2H^2}{K^2T^2}\right)\right) \qquad (27)$$

$$n = C_1 + \mathrm{C}_2\,\mathrm{H}^2 \qquad (28)$$

Where : C_1 and C_2 are constant, $C_1 = c\sqrt{\varepsilon_0}\,(1+\beta^2)$,
$C_2 = c\sqrt{\varepsilon_0}\left(\frac{\beta^2}{2}\left(\frac{\beta^2 H^2}{K^2 T^2}\right)\right)$

where :

$$n \propto H^2 \qquad (29)$$

The focal length is related to refractive index according to the relation eqn. (4) , thus from eqn. (28) in eqn.(2)

$$\frac{1}{f} = (n-1)\frac{2}{r}$$

$$\frac{1}{f} = (C_1 + C_2\ H^2 - 1)\frac{2}{r} \qquad (30)$$

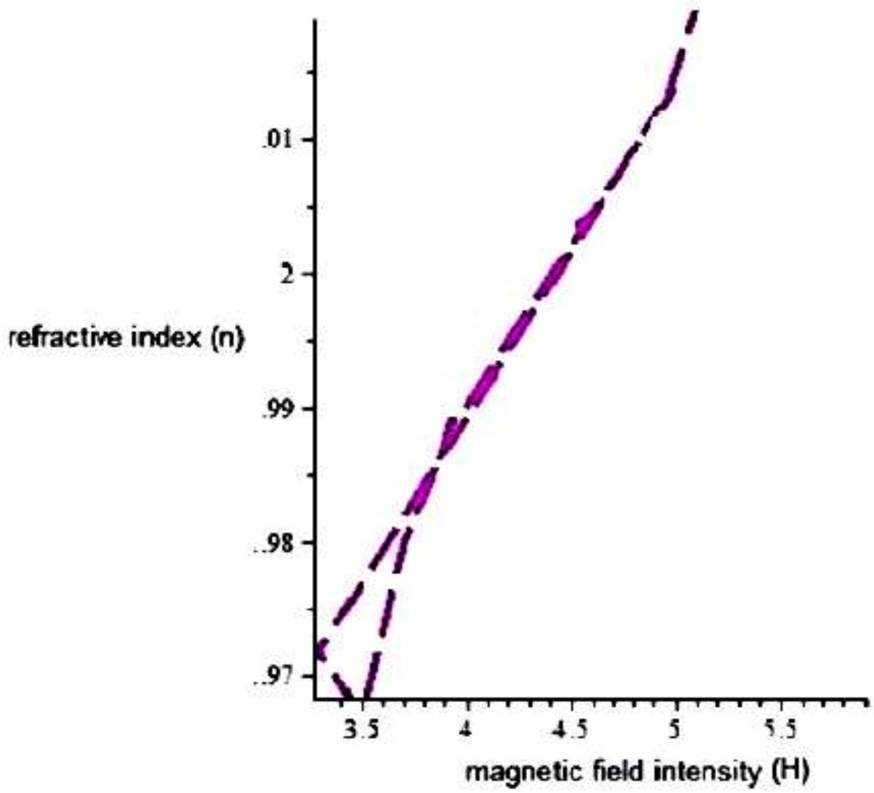
RESULTS

Table (1): change of (f) due to the change of (H) according to relation (2) and (3):

Focal length(f)	Current(I)	Magnetic field Intensity (H)	Refractive index (n)
14.3	3.75	6.2	2.050
14.4	3.50	6.1	2.041
14.5	3.25	5.3	2.034
14.6	3.00	5.1	2.030
14.7	2.75	5.0	2.020
14.8	2.50	4.8	2.014
14.9	2.25	4.1	2.006
15.0	2.00	4.0	2.000
15.1	1.75	3.9	1.990
15.2	1.50	3.7	1.987
15.3	1.25	3.5	1.980
15.4	1.00	3.2	1.974
15.5	0.75	3.1	1.967
15.6	0.50	3.0	1.961
15.7	0.25	2.9	1.955

Table (2)
Relation between Refractive index (n) and magnetic field intensity (H), (see equations (29)).

Magnetic field Intensity (H)	**Refractive index (n)**
6.2	2.050
6.1	2.041
5.3	2.034
5.1	2.030
5.0	2.020
4.8	2.014
4.1	2.006
4.0	2.000
3.9	1.990
3.7	1.987
3.5	1.980
3.2	1.974
3.1	1.967
3.0	1.961
2.9	1.955



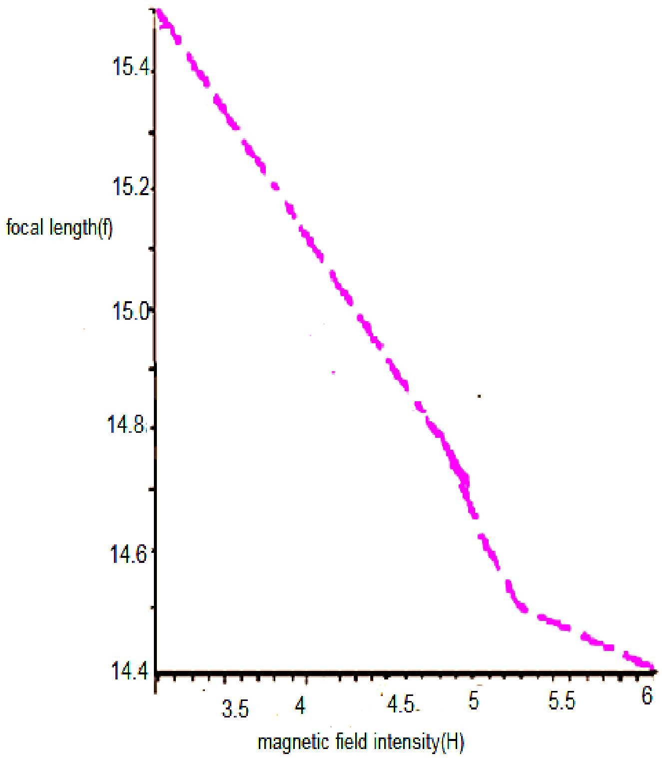
Fig(1):experimental relation(n) versus(H)

Table (3)

Relation between Focal length (F) and magnetic field intensity (H),(see equations (30)) .

Focal length(f)	Magnetic field Intensity (H)
14.3	6.2
14.4	6.1
14.5	5.3
14.6	5.1
14.7	5.0
14.8	4.8
14.9	4.1
15.0	4.0
15.1	3.9
15.2	3.7

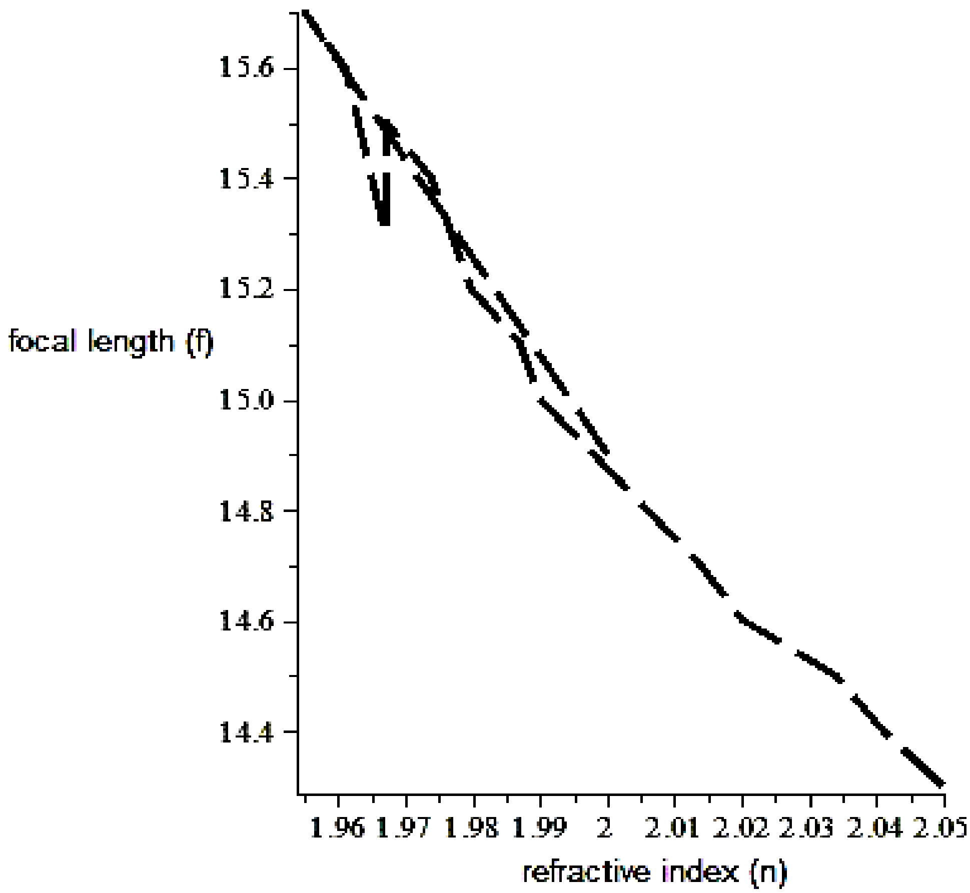
15.3	3.5
15.4	3.2
15.5	3.1
15.6	3.0
15.7	2.9



Fig(2):experimental relation (f) versus (H)

Table (4)
Relation between Focal length (F) and refractive index (n) (see equations (2))

Focal length(f)	**Magnetic field Intensity (H)**
14.3	2.050
14.4	2.041
14.5	2.034
14.6	2.030
14.7	2.020
14.8	2.014
14.9	2.006
15.0	2.000
15.1	1.990
15.2	1.987
15.3	1.980
15.4	1.974
15.6	1.961
15.7	1.955



Fig(3):experimental relation (f) versus(n)

DISCUSSION

According to equation (29) and (30) the refractive index (n) and focal length (f) increases and decreases upon increasing magnetic field intensity (H) respectively. The derivation of this relation is based on the paramagnetic properties of the material used in the experiment, the graphs which relate refractive index and focal length to magnetic field intensity theoretically are drawn in Fig(1) and(2).The experimental work done shows that refractive index (n) increases as magnetic field intensity (H) increases(see Fig (1)) which resembles theoretical relation in Fig (1).The experimental relation in Fig(2) shows also that focal length (f) decreases as magnetic field intensity (H) increases. This relation is also conforms with the theoretical relation between focal length (f) and magnetic field intensity(H) in Fig (2).

CONCLUSION

The refractive index and focal length for glasses change with the magnetic field intensity, this change can be used in a wide variety of applications .where it can be used to change lens power for these who have no visual a accommodation.

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