The intensity of laser beam as a function of the applied magnetic field is displayed in figure (5) according to table (1) [9]. Obtained that the laser intensity increases with increases of magnetic field [9]

3. The Effect of Magnetic field on Amplification factor and Intensity of Laser Beam according to Generalized Special Relativity

In Einstein general relativity (GR) the length, time, frequency and mass are not affected by fields. However in generalized special relativity (GSR), they are affected by any field. To see how can this happen, consider the amplification factor [10,11].

$$\beta = B(n_2 - n_1)\frac{hf}{c} \tag{1}$$

Where B is Einstein coefficient, n_2, $n_1$are the number of atoms in the upper and lower level respectively.

If one takes into account the wave properties of light, the frequency f is related to the periodic time T according to the relation

$$f = \frac{1}{T} \tag{2}$$

But according to generalized special relativity GSR [12-14].

$$T = \gamma T_0 = T_0\left(1 + \frac{2\varnothing}{c^2} - \frac{v^2}{c^2}\right)^{-1/2} \tag{3}$$

Where T_0, is the time in the rest frame, $\varnothing$ is potential per unit mass, and v is the speed.

Thus,

$$f = \frac{\left(1 + \frac{2\varnothing}{c^2} - \frac{v^2}{c^2}\right)^{1/2}}{T_0}$$

Neglecting the velocity of frame of reference v, i.e. the atoms emitting photons, and for small $\varnothing$.

$$f = \frac{\left(1+\frac{2\varnothing}{c^2}\right)^{1/2}}{T_0} = \frac{\left(1+\frac{2\varnothing}{c^2}\right)}{T_0}$$

$$f = \frac{\left(1+\frac{m_0\varnothing}{m_0c^2}\right)}{T_0} = \frac{\left(1+\frac{V}{m_0c^2}\right)}{T_0} \tag{4}$$

But the magnetic flux density B induces a potential V.given by

$$V = \frac{enB}{c} \tag{5}$$

Where n, is the number of particles per unit volume. Thus inserting equation (5) and (4) in (1) yields.

$$\beta = \frac{B_0(n_2 - n_1)}{cT_0} = \left(1 + \frac{eB}{m_0c^3}\right)$$

This can be written as.

$$\beta = C_1[1 + C_2B] \tag{6}$$

With

$$C_1 = \frac{B_0(n_2 - n_1)}{cT_0}$$

$$C_2 = \frac{en}{m_0c^3} \sim \frac{10^{-19}n}{10^{-31} \times 10^{25}} \sim 10^{-13}\ n$$

For $n \sim 10^{12}$ then $C_2 = 10^{-1}$ plotting equation (8) for I, where

$$I = I_0e^{\beta L} \tag{7}$$

for small βL

$$I = I_0[1 + \beta L] = I_0[1 + C_1 + C_1C_2B] \tag{8}$$

The relation between I and B becomes as in figure (6).

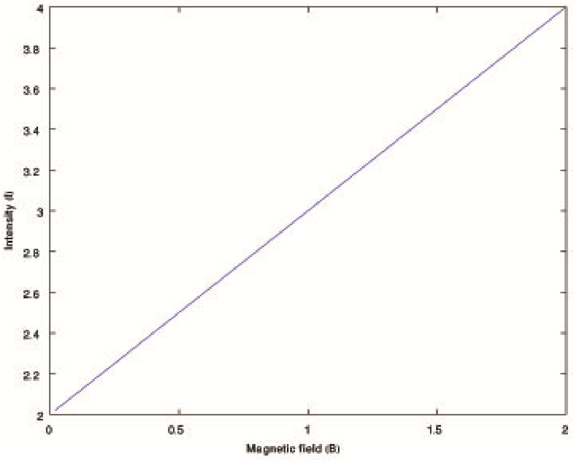

Figure 6: Relation between I and B

The relation between I and B can also be investigated, by considering the particle nature of light, where the mass is affected by the field according to equation (1), by replacing hf by mc^2 to get

$$\beta = B(n_2 - n_1)mc \tag{9}$$

And by using the relation [15].

$$m = \frac{g_{00}m_0}{\sqrt{g_{00} - \frac{v^2}{c^2}}} \tag{10}$$

m_0 stands for the rest mass, v is the speed and $\varnothing$ is the potential per unit mass [15-17], where

$$g_{00} = 1 + \frac{2\varnothing}{c^2}$$

$$\beta = B(n_2 - n_1)\frac{g_{00}m_0}{\sqrt{g_{00} - \frac{v^2}{c^2}}}$$

$$\beta = B(n_2 - n_1)\left(1 + \frac{2\varnothing}{c^2}\right)m_0\left(1 + \frac{2\varnothing}{c^2} - \frac{v^2}{c^2}\right)^{-1/2} \tag{11}$$

Neglecting again v, for small $\varnothing$, β, becomes

$$\beta = B(n_2 - n_1)m_0\left(1 + \frac{2\varnothing}{c^2}\right)\left(1 - \frac{\varnothing}{c^2}\right)$$

$$= C_3\left(1 + \frac{\varnothing}{c^2} - \frac{2\varnothing}{c^2}\right) \tag{12}$$

Using equation (1)

$$\beta = C_3\left(1 + \frac{enB}{m_0c^3} - \frac{2e^2n^2}{m_0^2c^5}B^2\right)$$

$$\beta = C_3(1 + C_4B - C_5B^2) \tag{13}$$

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Where,

$$C_3 = B(n_2 - n_1)m_0 \qquad (14)$$

$$C_4 = \frac{en}{m_0 c^3}$$

$$C_5 = \frac{2e^2 n^2}{m_0^2 c^5}$$

$$I = I_0 e^{C_3(1+C_4B-C_5B^2)} \qquad (15)$$

Plotting I against B according to equation (15) one gets figure (7).

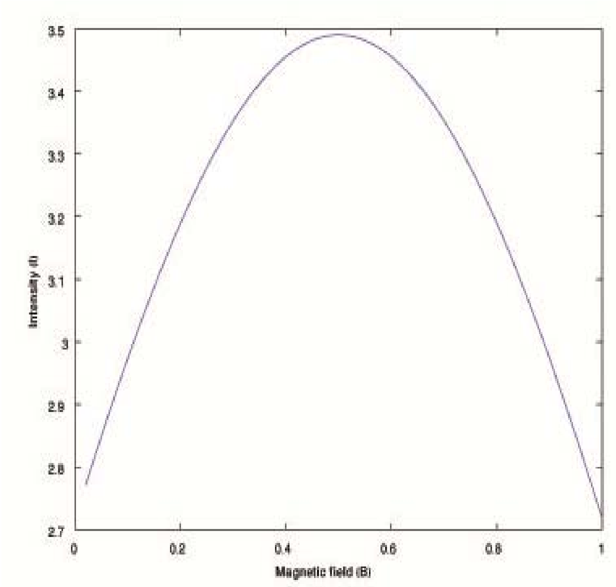

Figure 7: Relation between I and B

If one considers the electrons and atoms emitting laser photons, as harmonic oscillators, the situation becomes different. The amplification factor becomes according to equation in form [11].

$$\beta = \frac{2\pi^3 f}{3c}(n_2 - n_1)(n+1)^2 m_0 \left(\frac{\omega}{m\omega^2}\right) \qquad (16)$$

But according to harmonic oscillator model [11].

$$K = m\omega^2$$

Thus,

$$\beta = \frac{2\pi^3 f}{3c}(n_2 - n_1)(n+1)^2 m_0 \left(\frac{2\pi f}{K}\right) \qquad (17)$$

$$= \frac{4\pi^4(n_2 - n_1)(n+1)^2 f^2}{3c}$$

$$= C_5 f^2$$

But,

$$f = \frac{1}{T} = \frac{\left(1 + \frac{2\emptyset}{c^2} - \frac{v^2}{c^2}\right)^{1/2}}{T}$$

Neglecting v and for small $\emptyset$,

$$f = \frac{\left(1 + \frac{\emptyset}{c^2}\right)}{T_0} = T_0^{-1}\left(1 + \frac{\emptyset}{c^2}\right)$$

Thus,

$$f = T^{-2}\left(1 + \frac{\emptyset}{c^2}\right)^2 = T_0^{-2}\left(1 + \frac{2\emptyset}{c^2} + \frac{\emptyset}{c^2}\right)$$

If the magnetic field apposes the motion

$$V = m_0\emptyset = \frac{-enB}{c}$$

Therefore,

$$f^2 = T_0^{-2}\left(1 - \frac{2enB}{c} + \frac{e^2n^2B^2}{c^4}\right) \qquad (18)$$

Inserting (18) in equation (17) yields

$$\beta = C_5 T_0^{-2}(1 - C_6 B + C_7 B^2)$$

$$\beta = C_8 - C_9 B + C_{10} B^2 \qquad (19)$$

Thus,

$$I = I_0 e^{\left(C_8 - C_9 B + C_{10} B^2\right)} \qquad (20)$$

Where, C_8, C_9, and C_{10} are constants that can be found by substituting the values of e, c and $n \sim 10^{12}$ plotting I versus B according to equation (20) yields figure (8).

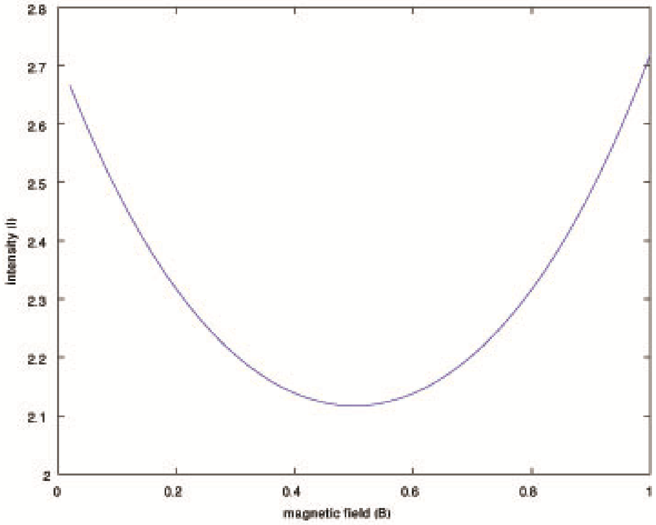

Figure 8: Relation between I and B

4. Discussion

The generalized special relativistic time and mass in equations (3), and (10) can explain the effect of magnetic field on laser amplification factor as well as laser intensity. The relations based on generalized special relativity, which relates laser amplification and magnetic field strength, can explain the empirical relations mentioned in section (2). Comparing the theoretical relation between I and B in figure (6), with the empirical relation in figure (5), it is clear that the two curves are similar. This is not surprising as well as the active lasing media is plasma which consist of free atoms that oscillates and act as a harmonic oscillator. The effect of magnetic field on Helium cadmium (He-Cd) laser discharged gas is displayed in figures (3) and (4) These empirical relations are similar to the theoretical relations in figures (7) and (8) which are concerned with particle nature of light and harmonic oscillator. This is not surprising since the discharged gas which has free isolated ionized atoms treat light as particles called photons with mass m. The ionized atoms also oscillate and thus behave as harmonic oscillator.

Finally the effect of magnetic field on semiconductor laser is linear as shown in figure (5). This empirical relation conforms to the linear theoretical one in figure (6), which

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was derived by considering the change of frequency by the magnetic field. This is not surprising, since for the semiconductor laser, which is a balk matter, light behaves as waves with a certain frequency.

5. Conclusion

The fact that generalized special relativity (GSR) predicts that the mass, time and length is affected by physical field open a new horizon for explaining a wide variety of physical phenomena on bases of GSR. The (GSR) succeeded in explaining the change of laser intensity with the magnetic field strength.

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References

[1] Orazio Svelto, and David C. Hanna, Principles of Lasers, Springer Science + Business Media, Inc., (1998).
[2] Amnon Yariv, and Pochi Yeh, Photonics, Optical Electronics in Modern Communications, Oxford University Press, (2007).
[3] William T. Silfvast, Laser Fundamentals, Cambridge University Press, (2004).
[4] K. Thyagarajan · Ajoy Ghatak, Lasers: Fundamentals and Applications, Springer Science + Business Media, LLC 1981, (2010).
[5] B. E. A. Saleh and M. C. Teich, Fundamentals of Photonics, John Wiley & Sons, Inc. All rights reserved (2007).
[6] Toshiyuki Shiozawa, Classical Relativistic Electrodynamics: Theory of Light Emission and Application to Free Electron Lasers, Springer-Verlag Berlin Heidelberg, (2004).
[7] F. G. Tomasel, V. N. Shlyaptsev, and J. J. Rocca, Enhanced beam characteristics of a discharge-pumped soft-x-ray amplifier by an axial magnetic field, September, (1996), Physical Review A volume **54**, No 3, P 2476.
[8] Gailan Asad Kazem, The effect of a weak axial magnetic field on a He-Cd laser, (2009), Diala , Journal , Volume , **39**
[9] R. Abd Elgani, Influence of magnetic field on semiconductor laser, P. 60, (2003).
[10] A. H. Abdelrahman, M. D. Abdallah, A. A. Osman, Kh. M. Haroun. Amplification of Free Electron due to the Effect Internal Fields and Forces, University of Africa Journal of Science, (2010), U.A.J.S, Vol.**1**, No.1, PP 44 -53.
[11] A. H. Abdelrahman, The Role of Material's Internal Fields and Forces in lasing, (2007), thesis PP 48-66.
[12] Hilo, M. H. M., Abd Allah, M. D., Haroun, Kh. M., Abd Elrahman, A. M.: Natural Science **3**, 141-144 (2011) Using of the Generalized Special Relativity (GSR) in estimating the proton (nucleon) mass to explain the mass defect, doi. 10.4236/ns.2011.32020
[13] Hilo, M. H. M., Abdallah M. D., Haroun, Kh. M., Abd Elrahman A. H, Natural Science **4**, 336-339 (2012), Generalized general and special relativity in the presence of the gravitation, related to the space-time curvature, doi 10.4236/ns.2012.45046.
[14] Hilo, M. H. M, Natural Science **3**, 334-338 (2011), Using of the generalized special relativity (GSR) in estimating the neutrino masses to explain the conversion of electron neutrinos, doi. 10.4236/ns.2011.34044
[15] Hilo, M. H. M, J. Mod. Phys. **2**, 370-373 (2011), Using of the Generalized Special Relativity in Deriving the Equation of the Gravitational Red-Shift, doi.10.4236/jmp.2011.25045.
[16] Savickas, D, Am. J. Phys. **70**, 798-807 (2002) Relations between Newtonian Mechanics, general relativity and quantum mechanics, doi. 10.1119/1.1479740.
[17] Dirrar, Mubarak, Hilo, M. H. M., Abd Elgani., R, Bakheet, A. M. A, Natural Science **5**, 685- 688 (2013) Neutrino speed can exceed the speed of light within the frame work of the Generalized special relativity and savickas model, dx.doi.org/10.4236/ns.2013.56084

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