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Effect of Electric Susceptibility on Amplification of Electromagnetic Waves

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Abstract

In this work amplification of electromagnetic waves is related to the phase between the external and internal field .it is shown that amplification exists when the external and internal fields are in phase. When the two fields are normal to each other no amplification exists. While absorption occurs when the two fields are opposite to each other.

Keywords: *Amplification, density, phase, polarization, absorption.*

Introduction

The term LASER is an acronym for the light amplification by the stimulated emission of radiation, which serves the explanation of most but not all the critical physical interactions that occur within a laser generation cavity [1]. The first actual continuously generating laser was attributed to Gavan and colleagues in 1961 that used a mixture of helium and neon. One of the most practical lasers used in oral and maxilla facial surgeries was developed by Patel in 1964[2].Laser is a highly intensive light, all light consist of waves traveling through space, the color of the light is determined by the frequency of these waves .The beam of a laser is a very pure red color – it consists of an extremely narrow range of wave lengths within the red portion of the spectrum, it is said to be nearly “monochromatic “ or nearly “single –colored”. Near monochromatic is a unique property of laser light meaning that consists of light of almost a single wavelength [3].Four functional elements are necessary in lasers to produce coherent light by stimulated emission of radiation Active medium, Excitation mechanism, Feedback mechanism, and Output coupler. The types of lasers it is solid crystalline and glass lasers, gas lasers, liquid bye lasers, and semiconductor lasers (diode laser). Laser is now widely used in computer to store information in CDs. it is also used in telecommunication to transmit information and calls through optical fibers. Laser is also useful in medicine especially in surgery [4, 5, and 6]. Despite the wide variety of application of laser in modern technology, its theoretical background

ISSN 2348 – 7968

suffers from noticeable setbacks. One of the most problems is related to the theory of amplification which needs to be promoted to relate amplification to more physical parameters [7, 8, 9, and 10] so as to produce new laser types. And from literature review, amplification conditions that are responsible for inducing laser are discussed by many anthers. Some of them, like the paper of Sihtay and the work of Hagger, relate amplification to the internal field [11, 12]. In some papers of Peter Othow and Amd Ra beside Zhi-Mingzhang the amplification is related to photon coherence [13, 14, and 15]. The two approaches seem to talk the same language. Since the coherence is produced by the medium in which fields and structures are responsible for forcing photons to be coherent. In This work amplification and is obtained by lasing the relation between polarization field and external field.

Amplification conditions on the basis of phase relation to electric susceptibility:

The electric dipole moment P is related to the displacement

xBetween the nucleus and electron cloud according to the equation:

$$P = Zex \qquad (1)$$

Where Z is the atomic number, thus $Ze$is the charge of each dipole the displacement$x$ is given with:

$$x = \int v\, dt \;=\; v_{\circ} \int \cos(\omega t + \emptyset)\, dt$$

$$x = \frac{v_{\circ}}{\omega} \sin(\omega t + \emptyset)$$

$$x = x_{\circ} \sin(\omega t + \emptyset)\,,\; x_{\circ} = \frac{v_{\circ}}{\omega} \qquad (2)$$

Inserting (2.2) in (2.1) yields

$$P = Zex_{\circ} \sin\,(\omega t + \emptyset)$$

$$P = Zex_{\circ} cos\emptyset sin\omega t - Zex_{\circ} sin\emptyset \cos \omega t \qquad (3)$$

The electric dipole moment can also be written in terms of the applied external electric field E and the medium field perpendicular to it E_m in the form

$$p = x_1 E + x_2\, E_m$$

$$p = \mathcal{X}_1\, E_{m_{\circ}} \cos \omega t + \mathcal{X}_2 E_{\circ} \sin \omega t \qquad (4)$$

Comparing equation (2.3) and (2.4) yields:

ISSN 2348 – 7968

$x_1 E_{0m} = -Zex_0 \sin \emptyset$

$x_2 E_0 = Zex_0 \cos \emptyset$ (5)

The electric dipole moment can be write in a complex form in terms of x_1 and x_2 to be:

P = ($x_1 + jx_2$)E =($x_1 + jx_2) E_0 \ e^{j\omega t}$ (6)

But the current generated by p is given by:

$$\beta = \frac{dp}{dt} = x\frac{dE}{dt} = x\frac{dE_0 \ e^{j\omega t}}{dt}$$

jω $x\underline{E}$ =j$\omega(x_1 + jx_2\ )\underline{E}$ =($-\omega x_2 + j\omega x_2$)E

= (-$\omega x_2 + j\omega x_1$) $\underline{E}$ (7)

Since $x = x_1 + jx_2$one can write

$x_2 = x cos\alpha, x_1 = x sin\alpha$ (8)

The current density J can also be written in terms of σ_1 and σ_2 to be

$J = (\sigma_1 + \sigma_2)\underset{\sim}{\underline{E}}$ (9)

Thus comparing (2.7) and (2.9) yields

$\sigma_1 = -\omega x_2$, $\sigma_2 = \omega x_1$ (10)

Thus according to equation of amplification factor is given by

$\beta = -\frac{\mu \, c \, n\omega}{n_1} x_2$ (11)

to express β in terms of the phase ∅ , one uses equation (2) and (5) and (8)to get from(11)

$\beta = -\mu \, c \frac{qv_\circ}{E_\circ} \cos \emptyset$ (12)

Where q =ze

Again, when v and E are in phase ∅ = 0 , and

ISSN 2348 – 7968

$$\beta = \mu\, c \frac{nqv_{\circ}}{E_{0_m}} \qquad (13)$$

and amplification takes place , as far as β is to vanish . if $\emptyset = 90$, $\beta = 0$ and no amplification takes place for $\emptyset = \pi$

$$\beta = -\mu\, c \frac{nqv_{\circ}}{E_{0_m}}$$

the incident radiation is absorbed by the medium .

Discussion

The amplification factor in equation (2.12) depends on the angle $\emptyset$ between The total field or polarization field (see equation 2.3) external field E and internal field E_m as shown by equations (2.4) and (2.5). It is very interesting to note that when the external field is parallel to the polarization field which absorb the incident photon and eremite it , and amplification take place (see equation(2.13)) this agrees with the fact that the polarization and external field are in phase thus they are coherent .but when the polarization field and external one are out of phase by 90^0 no amplification takes place , this is due to the fact that the two waves are out of phase by 90^0 does not this means that there is no field component the polarization field in the direction of external field .Thus the amplitude does not increase and remains constant, thus no amplification is observed . However when the external and polarization field apposes each other β is negative which means that the external photon is absorbed by the polarized atom.

Conclusion

If one can consider the polarization atom to emit two components one is parallel to the external applied field and the other to the internal field which is perpendicular to the external field in this case one can predict amplification and absorption process easily in terms of the angle between polarization vector and the external field.

ISSN 2348 – 7968

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