TWO PHOTON THEORY OF THE EVANS MORRIS EFFECTS: ANALOGY WITH COMPTON SCATTERING.

by

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ABSTRACT

A two photon theory of reflection and refraction is developed in which two incident photons of equal frequency and wavelength are refracted into one refracted and one reflected photon with different frequencies and wavelengths as observed in the Evans / Morris effects. The theory is developed with conservation of energy and momentum in analogy with the Compton effect. Photons with mass can be developed in general.

Keywords: ECE theory, two photon theory of the Evans / Morris effects.

4FT 289

1. INTRODUCTION

In recent papers of this series of two hundred and eighty papers to date the ECE theory with photon mass has been applied to the Evans / Morris effects {1 - 10} These are reproducible and repeatable frequency and wavelength changes in the refraction and reflection of light at visible frequencies. The theory has been developed to date by assuming that one incident photon with energy $\hbar\omega$ is split into two photons of energies $\hbar\omega_1$ and $\hbar\omega_2$ in the process of refraction and reflection. The theory has also been developed by considering the average energy of one Planck oscillator incident on a boundary between two materials producing the average energies of a refracted and reflected Planck oscillator. In each case plausible explanations for the Evans / Morris effects were found with rigorous conservation of energy and momentum in analogy with the well known theory of the Compton effect developed in UFT158 ff of this series on www.aias.us. In Section two a two photon theory of the Evans / Morris effects is developed in which two incident photons of equal frequency in a monochromatic beam are divided at an interface into one refracted photon and one reflected photon. In general the frequencies of the refracted and reflected photons are different. The theory is also developed n terms of wavelength, and conceptual analogies with Compton scattering discussed. In Section 3 the theory is analyzed numerically and discussed.

As usual this paper should be read with its background notes. Note 289(1) discuses the details of the Rayleigh Jeans density of states used in the theory of the Planck distribution. In Notes 289(2) to 289(4) the Compton theory is discussed and the scattered frequency expressed in terms of the incident frequency following the methods of UFT 158 ff. The two photon theory of reflection and refraction is developed in Notes 289(6) to 289(9) in terms of both frequency and wavelength.

2. TWO PHOTON THEORY

Consider a beam of light or electromagnetic radiation incident at a boundary between two materials such as air and glass. In general the beam is refracted and reflected in accordance with the experimental laws attributed to Snell but discovered long before him:

$$\theta = \theta_2 \quad -(1)$$

and

$$n \sin\theta = n_1 \sin\theta_1 \quad -(2)$$

Eq. (1) means that the angle of incidence is equal to the angle of reflection. In Eq. (2) the angle of refraction is θ_1 , the refractive index of the medium of incidence is n , and the refractive index of the medium of refraction is n_1 . The geometry is illustrated in Fig (1) and is a simple planar geometry. Consider two incident photons of angular frequency ω , one refracted photon of angular frequency ω_1 , and one reflected photon of angular frequency ω_2 . In UFT280 it was shown using simple vector analysis that:

$$\omega \neq \omega_1 \neq \omega_2 \quad -(3)$$

in general. As shown in Note 289(1) the intensity in watts per square metre generated by the Planck distribution in a monochromatic beam is proportional to the fourth power of frequency:

$$I = \frac{\hbar}{6\pi^2 c^2} \left(\frac{x}{1-x} \right) \omega^4 \quad -(4)$$

Here $\hbar$ is the reduced Planck constant, c is the vacuum speed of light, ω the angular freeuncy in radians per second, and where:

$$x = \frac{\hbar\omega}{kT} \quad -(5)$$

Here k is Boltzmann's constant and T the temperature.

So a general theory would consider:

$$I = I_1 + I_2 \quad -(6)$$

where I is the incident intensity, I_1 is the refracted intensity and I_2 the reflected intensity.

In general:

$$I \neq I_1 \neq I_2 \quad -(7)$$

so it follows immediately from Eq. (4) that the Evans Morris effects exist:

$$\omega \neq \omega_1 \neq \omega_2 \quad -(8)$$

as observed experimentally in many experiments over about five or six years in different laboratories. Some of the results are on the diary or blog of www.aias.us.

By conservation of energy in the simplest theory:

$$\hbar\omega + \hbar\omega = \hbar\omega_1 + \hbar\omega_2 \quad -(9)$$

and by conservation of momentum:

$$\hbar\underline{k} + \hbar\underline{k} = \hbar\underline{k}_1 + \hbar\underline{k}_2 \quad -(10)$$

where $\underline{k}$ is the incident wave vector, and where $\underline{k}_1$ and $\underline{k}_2$ are the refracted and reflected wave vectors. Eqs. (9, 10) are fundamental to the quantum theory of light.

Therefore:

$$2\omega = \omega_1 + \omega_2 \quad -(11)$$

and:

$$2\underline{\kappa} = \underline{\kappa_1} + \underline{\kappa_2} \quad -(12)$$

From Eq. (12):

$$4\kappa^2 = \kappa_1^2 + \kappa_2^2 + 2\kappa_1\kappa_2 \cos\theta_3 \quad -(13)$$

where:

$$\theta_3 = \pi - (\theta_1 + \theta_2) \quad -(14)$$

is the angle between $\underline{\kappa_1}$ and $\underline{\kappa_2}$.

Assume that the incident medium is air and that the refracting medium is glass. It has been assumed that the phase velocity in air is c, and that the phase velocity in glass is v. The refractive index of the glass is:

$$n = \frac{c}{v} \quad -(15)$$

It follows from Eq. (13) that:

$$4\frac{\omega^2}{c^2} = \frac{\omega_1^2}{v^2} + \frac{\omega_2^2}{c^2} + 2\frac{\omega_1\omega_2}{cv}\cos\theta_3 \quad -(16)$$

where:

$$\omega_2^2 = (2\omega - \omega_1)^2. \quad -(17)$$

These equations can be solved to give the refracted frequency in terms of the incident frequency:

$$\omega_1 = 2\omega\left(1 + \frac{n^2}{y}\right)^{-1} \quad -(18)$$

where:

$$y = 1 - 2n\cos\theta_3 . \quad -(19)$$

In order for ω_1 to be positive:

$$2n\cos\theta_3 \leq 1 \quad -(20)$$

and:

$$\theta_3 \leq \cos^{-1}\left(\frac{1}{2n}\right). \quad -(21)$$

Assuming that the refractive index of the glass is:

$$n = 1.5 \quad -(22)$$

then:

$$\theta_3 \leq 70.53^\circ \quad -(23)$$

i.e.

$$\theta + \theta_1 \leq 109.47^\circ. \quad -(24)$$

If:

$$\theta_3 = 70.53^\circ \quad -(25)$$

then

$$\omega_1 = 0, \; \omega_2 = 2\omega. \quad -(26)$$

At this angle the reflected light appears to be blue shifted and the refracted light is shifted to zero - the maximum red shift.

Similarly the reflected frequency is:

$$\omega_2 = 2\omega \left(\frac{n^2}{4+n^2} \right). \quad -(27)$$

This simplest type of two photon theory can be developed into the general theory of intensities given by Eq. (4) in a monochromatic beam but gives a plausible explanation of the Evans / Morris effects. The general theory of intensities will be developed in future work.

3. NUMERICAL ANALYSIS AND GRAPHICS

Section by Dr. Horst Eckardt.

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Two photon theory of the Evans/Moris effects: analogy with Compton scattering

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3 Numerical analysis and graphics

The solutions of Eq.(16) for the two photon theory have been studied for refraction and reflection. A plausibility check of the solutions has been given in section 2. The two general solutions of this quadratic equation for ω_1 are

$$\omega_1 = \frac{4\, n_0^2\, \omega_0\ (n_1 \cos(\theta_3) - 1)}{2\, n_0^2\, n_1 \cos(\theta_3) - n_1^2 - n_0^2}, \tag{28}$$

$$\omega_1 = 0. \tag{29}$$

Obviously the second solution is trivial but has a physical meaning for total reflection as we will see. The first solution depends on the difference angle θ_3 as defined in Fig. 1. Obviously we have

$$\theta_3 = \pi - \theta_1 - \theta \tag{30}$$

where the refraction angle θ_1 is defined by the two experimental laws of Snell as in previous papers:

$$\theta_1 = \arcsin\left(\frac{n_0}{n_1}\sin(\theta)\right). \tag{31}$$

Using these releations, we can graph the functions $\omega_1(\theta_3)$ as well as $\omega_1(\theta)$. The reflection frequency ω_2 then can simply be calculated from the energy conservation Eq.(11):

$$\omega_2 = 2\,\omega_0 - \omega_1. \tag{32}$$

The solution (28) can be normalized to ω_0 as in previous papers. The graphs of ω_1 and ω_2 in dependence of θ_3 and θ are shown in Figs. 2 and 3 for $n = 1$, $n_1 = 1.5$, that means refraction and reflection of light crossing a surface of a medium from outside. Obviously there is a negative refraction range for θ_3, but

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this range never occurs for the reflection angle θ so that both frequencies are positive and therefore physical, see Fig. 3. At grazing angles of incidence the refracted frequency goes to zero, leading to a blue shift of the reflected photon, compared to the frequency of a single incoming photon.

The diagrams look different for total internal reflection, $n = 1.5$, $n_1 = 1$. There is a pole at the angle of total reflection in both diagrams for θ_3 and θ (Figs. 4 and 5). The frequencies in Fig. 5 are only defined below the angle of total reflection, this is a physical result, however there is only a negative frequency for reflection. This leads to the conclusion that the first solution (28) for ω_1 is not valid in this case. For total reflection we have to take the second solution (29):

$$\omega_1 = 0, \tag{33}$$

$$\omega_2 = 2\,\omega_0. \tag{34}$$

This is plausible because all energy of the incident beam is reflected. Another reason why the first solution is not possible is that for total reflection holds

$$\theta_1 > \theta. \tag{35}$$

This means that the vector sum of $\boldsymbol{\kappa}_1$ and $\boldsymbol{\kappa}_2$ cannot come to lie on the elongation of the line defined by $\boldsymbol{\kappa}$. The only solution is defined by Snell's first law, $\theta = \theta_2$, in this case. In total, the two photon theory gives reasonable results and the Evans Morris effects for refraction can be explained.

Fig. (1)

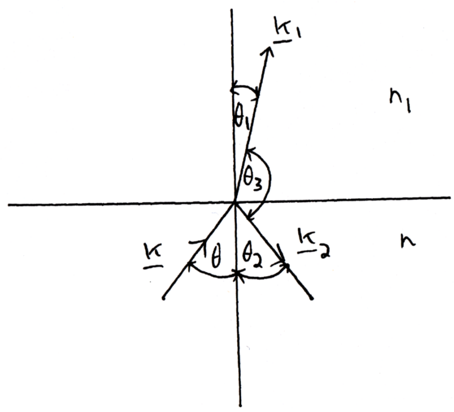

Figure 1: Diagram of refraction/reflection at a surface.

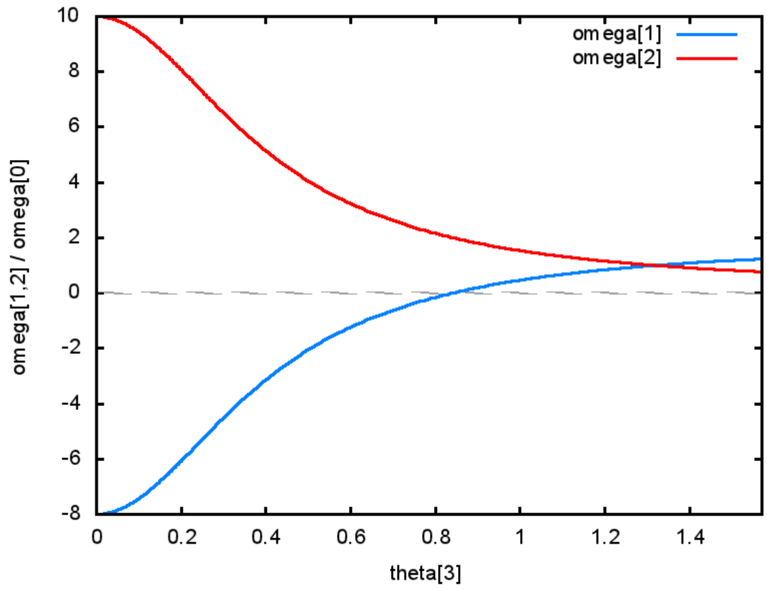

Figure 2: Refracted and reflected frequencies ω_1, ω_2 for $n_1 > n$, θ_3 dependence.

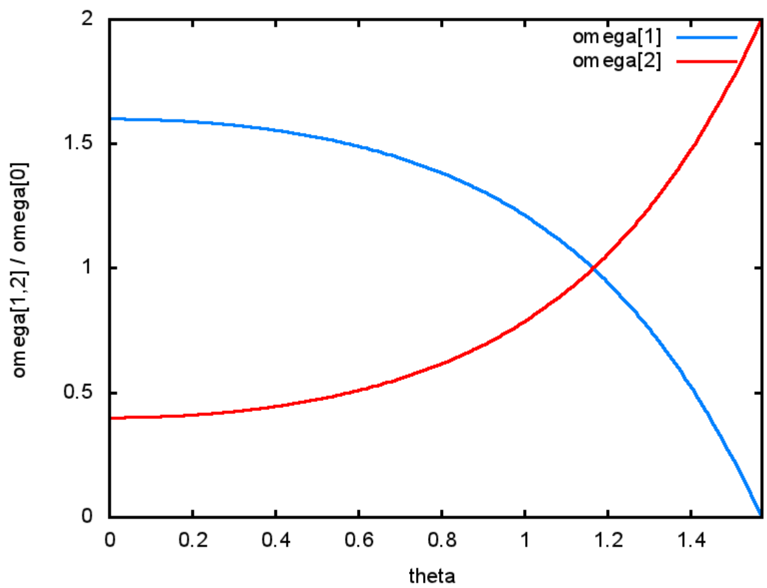

Figure 3: Refracted and reflected frequencies ω_1, ω_2 for $n_1 > n$, θ dependence.

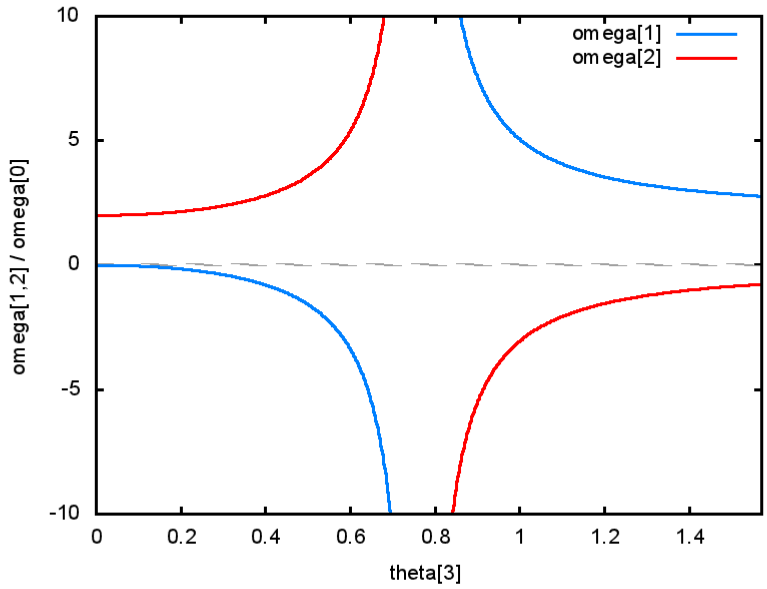

Figure 4: Refracted and reflected frequencies ω_1, ω_2 for $n_1 < n$, θ_3 dependence.

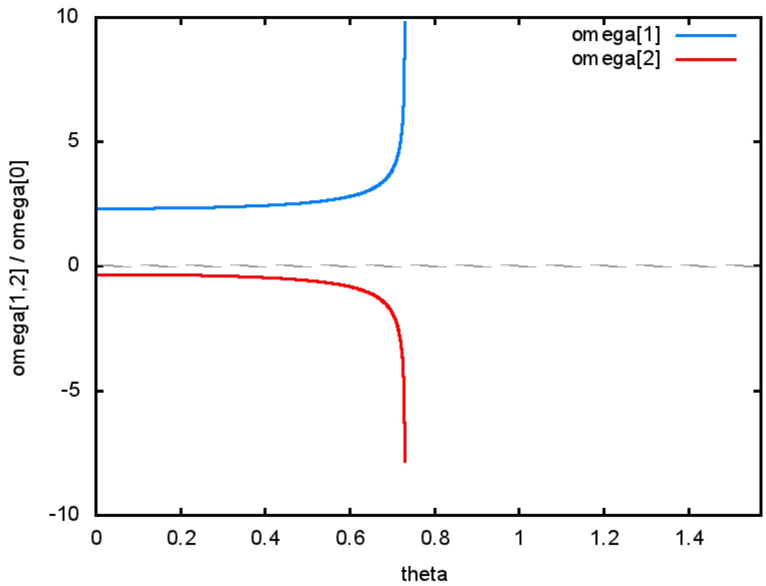

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Figure 5: Refracted and reflected frequencies ω_1, ω_2 for $n_1 < n$, θ dependence.

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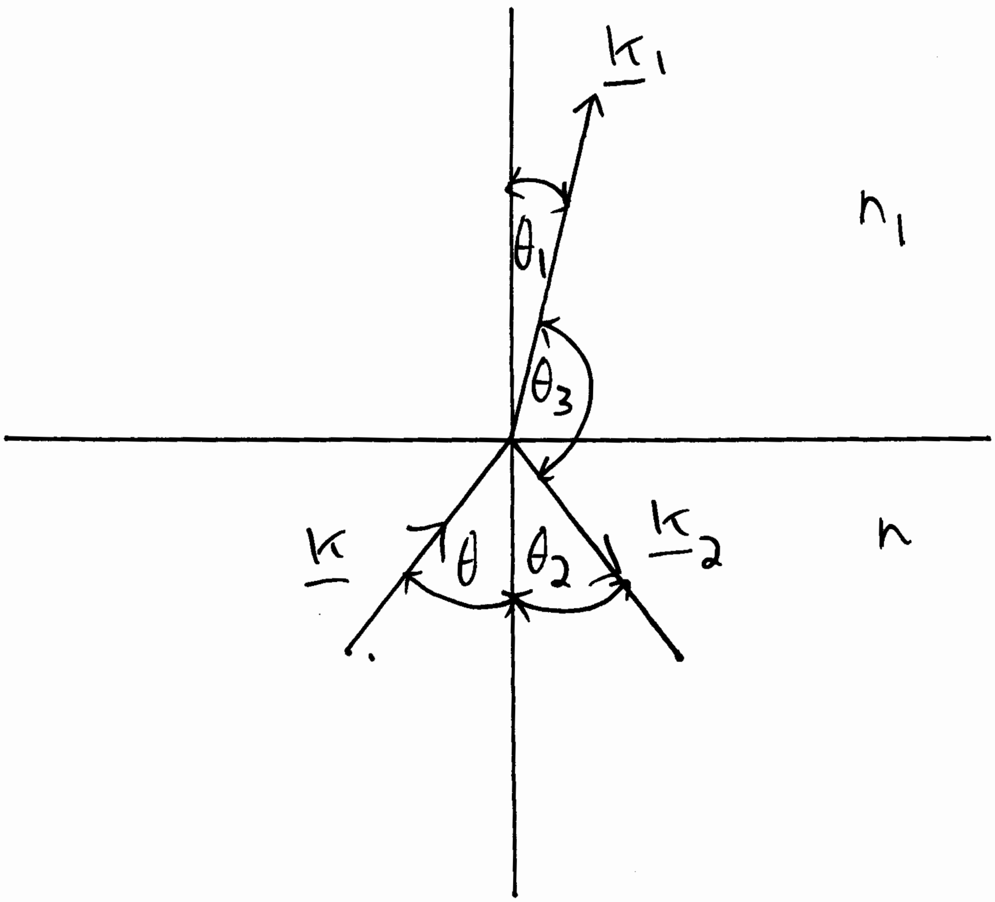
Fig. (1)


$\underline{k}_1$
θ_1
n_1
θ_3
$\underline{k}$
θ
θ_2
$\underline{k}_2$
n