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

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

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

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.

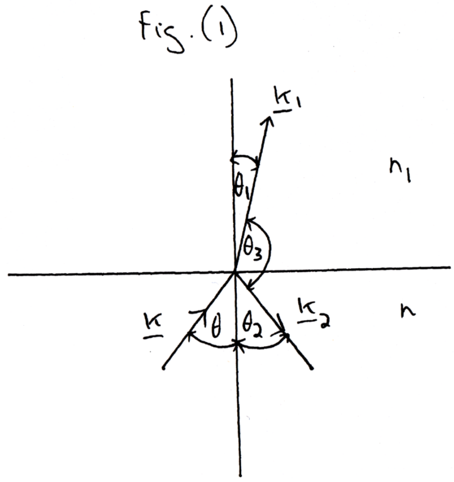

Figure 1: Diagram of refraction/reflection at a surface.

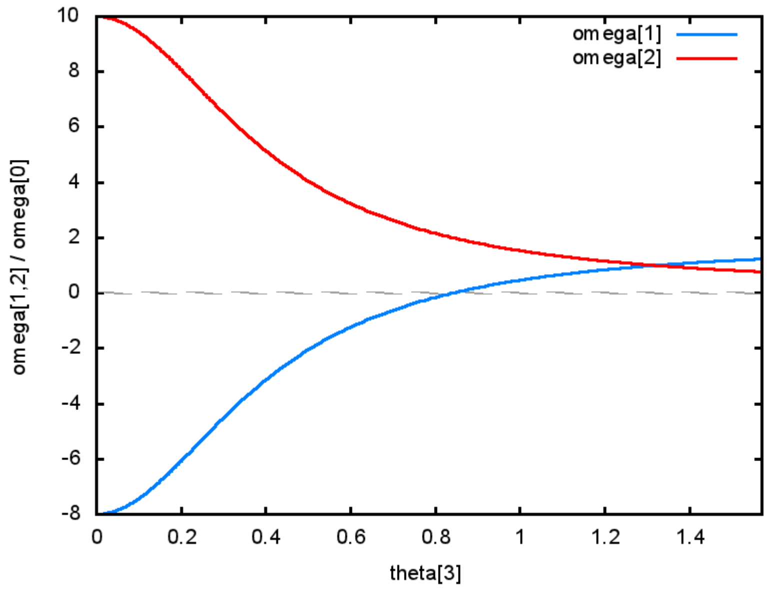

Figure 2: Refracted and reflected frequencies ω_1, ω_2 for $n_1 > n$, θ_3 dependence.

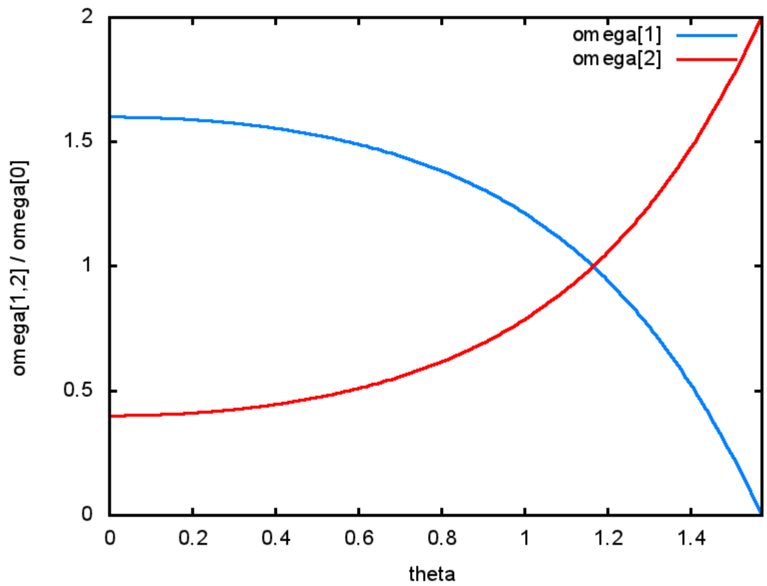

Figure 3: Refracted and reflected frequencies ω_1, ω_2 for $n_1 > n$, θ dependence.

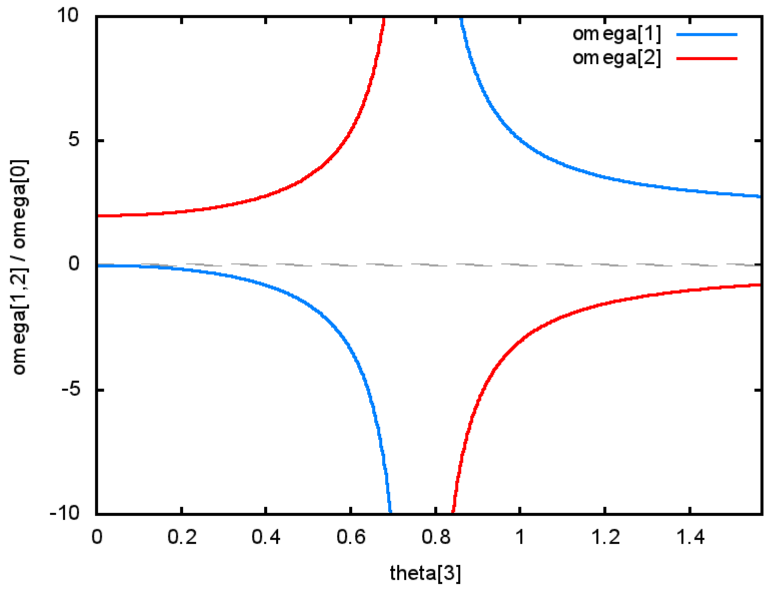

Figure 4: Refracted and reflected frequencies ω_1, ω_2 for $n_1 < n$, θ_3 dependence.

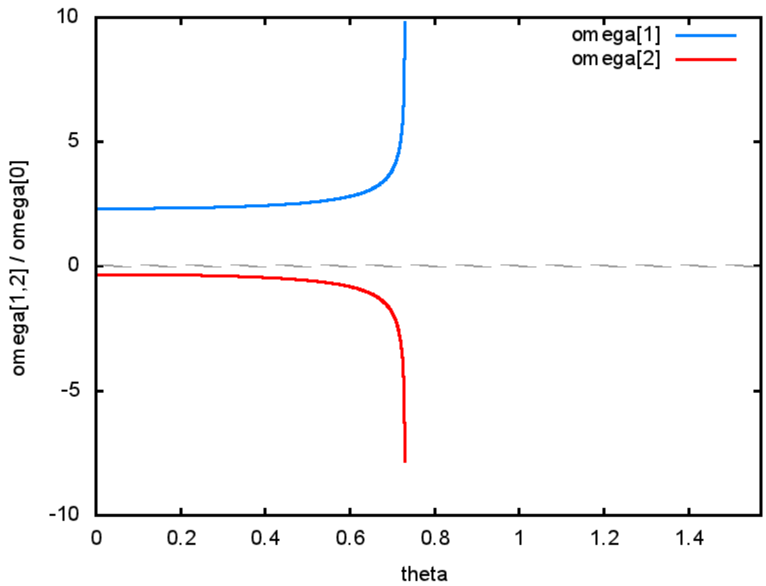

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Figure 5: Refracted and reflected frequencies ω_1, ω_2 for $n_1 < n$, θ dependence.