279(7): Determination of Photon Mass from Reflection and Refraction, One Photon Theory

The two relevant equations are:

$$\omega = \omega_1 + \omega_2 \quad -(1)$$

and

$$\underline{\kappa} = \underline{\kappa}_1 + \underline{\kappa}_2 \quad -(2)$$

in the notation of previous notes and papers. Therefore

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

and

$$\underline{\kappa}_2 = \underline{\kappa} - \underline{\kappa}_1 \quad -(4)$$

It follows that:

$$\omega_2^2 = \omega^2 + \omega_1^2 - 2\omega\omega_1 \quad -(5)$$

and

$$\kappa_2^2 = \kappa^2 + \kappa_1^2 - 2\kappa\kappa_1 \cos\theta_3 \quad -(6)$$

where θ_3 is the angle between the incoming and refracted vectors. So:

$$\omega_2^2 - c^2\kappa_2^2 = \omega^2 - c^2\kappa^2 + \omega_1^2 - c^2\kappa_1^2 - 2\left(\omega\omega_1 - c^2\kappa\kappa_1\cos\theta_3\right) \quad -(7)$$

Consider a photon of mass m, then it obeys the Einstein energy equation:

$$E^2 = c^2p^2 + m^2c^4 \quad -(8)$$

where

$$E = \hbar\omega, \quad \underline{p} = \hbar\underline{\kappa} \quad -(9)$$

so:

$$\omega_2^2 - c^2 \kappa_2^2 = \omega_1^2 - c^2\kappa_1^2 = \omega^2 - c^2\kappa^2$$
$$= \left(\frac{nc^2}{\ell}\right)^2 := x \quad -(10)$$

Fm eqs. (7) and (10):

$$2\left(\omega\omega_1 - c^2 \kappa\kappa_1 \cos\theta_3\right) = x \quad -(11)$$

so
$$2c^2 \kappa\kappa_1 \cos\theta_3 = 2\omega\omega_1 - x \quad -(12)$$

and
$$4c^2\kappa^2\kappa_1^2 \cos^2\theta_3 = (2\omega\omega_1 - x)^2 \quad -(13)$$

where:
$$\kappa^2 = \frac{\omega^2}{c^2} - \left(\frac{nc}{\ell}\right)^2 \quad -(14)$$

and
$$\kappa_1^2 = \frac{\omega_1^2}{c^2} - \left(\frac{nc}{\ell}\right)^2 \quad -(15)$$

It follows that:

$$4(\omega^2 - x)(\omega_1^2 - x)\cos^2\theta_3 = (2\omega\omega_1 - x)^2 \quad -(16)$$

<u>This is an equation for photon mass in terms of ω and ω_1.</u>

Fm eq. (16):

$$4\cos^2\theta_3\left(\omega^2\omega_1^2 - x(\omega^2 + \omega_1^2) + x^2\right) \quad -(17)$$
$$= 4\omega^2\omega_1^2 - 4\omega_1\omega x + x^2$$

3) So:

$$x^2\left(4\cos^2\theta_3 - 1\right) - 4\left(\omega^2+\omega_1^2\right)x\cos^2\theta_3 = \omega^2\omega_1^2\left(1-4\cos^2\theta_3\right) \quad -(18)$$

i.e.

$$\left(4\cos^2\theta_3-1\right)x^2 + \left(4\cos^2\theta_3 - 1\right)\omega^2\omega_1^2 - 4\left(\omega^2+\omega_1^2\right)x\cos^2\theta_3 = 0 \quad -(19)$$

or

$$x^2 + \omega^2\omega_1^2 - \frac{4\left(\omega^2+\omega_1^2\right)x\cos^2\theta_3}{4\cos^2\theta_3 - 1} = 0 \quad -(20)$$

Eq. (20) can be denoted:

$$x^2 + Bx + C = 0 \quad -(21)$$

where

$$B = \frac{4\left(\omega^2+\omega_1^2\right)\cos^2\theta_3}{1-4\cos^2\theta_3} \quad -(22)$$

and

$$C = \omega^2\omega_1^2 \quad -(23)$$

Therefore:

$$x = \left(\frac{nc^2}{\hbar}\right)^2 = \frac{1}{2}\left(-B \pm \left(B^2 - 4C\right)^{1/2}\right) \quad -(23)$$

$$\geq 0$$