312(3): Estimate of Photon Rest Mass by Comparison of Dipole Radiated Flux Density and the Planck / Rayleigh Law.

Reference: Google "Dipole radiation" and fourth site, "Electric Dipole Radiation".

The classical flux density magnitude radiated by an electric dipole $\underline{\mu}$ is:

$$\Phi = \frac{\omega^2 \mu^2 \sin^2\theta}{32\pi^2 \epsilon_0 c^3 r^2} \quad -(1)$$

in S.I. units, where:

$$\epsilon_0 = 8.854188 \times 10^{-12} J^{-1} C^2 m^{-1} \quad -(2)$$

Units check

$$\Phi = \frac{s^{-2} C^2 m^2}{J^{-1} C^2 m^{-1} m^3 s^{-3} m^2} \quad -(3)$$

$$= J s m^{-2} = \text{watts } m^{-2} \checkmark$$

The power in watts generated by Φ is:

$$P = \frac{\omega^2 \mu^2}{32\pi^2 \epsilon_0 c^3} \int_0^{2\pi} d\phi \int_0^{\pi} \frac{\sin^2\theta}{r^2} r^2 \sin\theta \, d\theta$$

$$= \frac{\omega^2 \mu^2}{12\pi \epsilon_0 c^3} \text{ watts} \quad -(4)$$

Therefore for a mains frequency of 60 Hz

2) and a given power in watts = volts × amps the dipole moment μ can be found.

Now set up a radiation source consisting of a mains wire of given ω and P. Given an angle θ and distance r from the source the flux density Φ of the radiation can be calculated classically.

From the quantum theory with finite photon mass the flux density is:

$$\Phi = \frac{\hbar\omega}{3c^2\pi^2} \frac{(\omega^2 - \omega_0^2)^{3/2}}{e^y - 1} \quad -(5)$$

where

$$y = \frac{\hbar\omega}{kT} \quad -(6)$$

and

$$\omega_0 = \frac{m_0 c^2}{\hbar} \,. \quad -(7)$$

Here m_0 is the rest mass of the photon.

From eqs. (1) and (5):

$$\frac{\omega^2 \mu^2 \sin\theta}{32\pi^2 \epsilon_0 c^3 r^2} = \frac{\hbar\omega}{3c^2\pi^2} \frac{(\omega^2 - \omega_0^2)^{3/2}}{e^y - 1} \quad -(8)$$

From eq. (4):

$$\mu^2 = \left(\frac{12\pi \epsilon_0 c^3}{\omega^2} \right) P \quad -(9)$$

Therefore from eqs. (8) and (9):

$$\frac{3}{8\pi} \frac{\sin\theta}{r^2} P = \frac{\hbar (\omega^2 - \omega_0^2)^{3/2}}{3c^2\pi^2 (e^y - 1)} \quad -(10)$$

Therefore:

$$P = \frac{8\pi}{3} \left(\frac{r^2}{\sin\theta} \right) \cdot \frac{\hbar}{3c^2\pi^2} \frac{(\omega^2 - \omega_0^2)^{3/2}}{e^y - 1} \quad -(11)$$

This equation for the irradiated power in watts is derived from the quantum / classical equivalence of eq. (8).

At visible frequencies:

$$\omega \gg \omega_0 \quad -(12)$$

so to an excellent approximation:

$$P = \frac{8\pi}{3} \left(\frac{r^2}{\sin\theta} \right) \frac{\hbar \omega^3}{\left(\exp\left(\frac{\hbar\omega}{kT} \right) - 1 \right)} \quad -(13)$$

at a distance r and angle θ from the source. However at the 60 Hz frequency of the mains it is thought that ω is not much greater than ω_0, so eqn. (11) applies, so:

4)

$$P(\text{watts}) = \frac{8\pi}{3}\left(\frac{r^2}{\sin\theta}\right)\frac{\hbar}{3c^2\pi^2}\left(\frac{\left(\omega^2-\omega_0^2\right)^{3/2}}{\exp\left(\frac{\hbar\omega}{kT}\right)-1}\right) \quad -(14)$$

At the point:

$$\omega = \omega_0 \quad -(15)$$

the power falls to zero:

$$\underline{P \longrightarrow 0} \quad -(16)$$

Therefore the suggested experiment consists of tuning the extremely low frequency from an alternating current in a wire or devices to the rest frequency ω_0 of the photon. At this point the irradiated power in watts falls to zero.
