159(5): Hypothetical Case of Compton Scattering with Stopped Photon.

In this case the photon loses all of its velocity and momentum when it collides with an object of mass M, for example an H atom. In the Einstein theory the photon of energy $\hbar\omega$ is absorbed:

$$E_2 - E_1 = \hbar\omega \quad -(1)$$

and the energy of the electron in the atom is increased by $E_2 - E_1$ from one orbital 1 to a second orbital 2. In the Einstein theory there is no photon mass and no exchange of momentum. This well known theory was considered by Einstein to be heuristic, i.e. guesswork that happened to work.

If an attempt is made to consider eq. (1) with the correct equations of relativistic transfer of energy and momentum, the resulting equations are:

$$\gamma mc^2 + Mc^2 = mc^2 + (M^2c^4 + c^2p'^2)^{1/2} \quad -(2)$$

and

$$\hbar \underline{\kappa} = \underline{p}' \quad -(3)$$

Eqs. (2) and (3) are respectively conservation of total energy and conservation of total momentum. In eq. (2) the initial energy of the photon is:

$$E = \hbar\omega = \gamma mc^2 \quad -(4)$$

where

$$\gamma = \left(1 - \frac{v^2}{c^2}\right)^{-1/2} \quad -(5)$$

Here v is the initial velocity of the photon and m is the mass of the photon, which should be constant if the photon is an elementary particle. The photon collides with an object of mass M which is initially at rest, so its energy

2) is the rest energy of special relativity:

$$E_0 = \underline{M} c^2 \quad -(6)$$

After collision, the photon is considered to have been stopped, i.e. <u>absorbed</u>. Its energy after collision is:

$$E(\text{photon}) = mc^2 \quad -(7)$$

The object $\underline{M}$ gains momentum $\underline{p}'$ and its total energy after collision is

$$\left.\begin{aligned} E^2 &= c^2 p'^2 + m^2 c^4 \\ E &= (c^2 p'^2 + m^2 c^4)^{1/2} \end{aligned}\right] -(8)$$

The Einstein / de Broglie theory states that:

$$\left.\begin{aligned} E &= \hbar\omega = \gamma mc^2 \; ; \quad \hbar\omega_0 = mc^2 \\ p &= \hbar\kappa = \gamma mv \; ; \quad \hbar\kappa_0 = 0. \end{aligned}\right\} -(9)$$

From eq. (3):

$$p'^2 = \hbar^2 \kappa^2 \quad -(10)$$

So in eq. (2):

$$\underline{M}^2 c^4 + \hbar^2 c^2 \kappa^2 = \left[(\gamma - 1) mc^2 + \underline{M} c^2\right]^2 \quad -(11)$$

From eqs. (9):

$$\kappa = \frac{\omega v}{c^2} \quad -(12)$$

From eqs. (11) and (12):

$$\frac{v^2}{c^2} = \left(\frac{c^2}{\hbar\omega}\right)^2 \left[(\gamma - 1)^2 m^2 + 2m\underline{M}(\gamma - 1)\right] \quad -(13)$$

Now use:

$$\frac{1}{\gamma^2} = 1 - \frac{v^2}{c^2} = \left(\frac{mc^2}{\hbar\omega}\right)^2 \quad -(14)$$

i.e.

$$\frac{v^2}{c^2} = 1 - \left(\frac{mc^2}{\hbar\omega}\right)^2 \quad -(15)$$

3) Therefore:

$$\frac{v^2}{c^2} = 1 - \frac{1}{\gamma^2} = \frac{1}{m^2\gamma^2}\left[(\gamma-1)^2 m^2 + 2mM(\gamma-1)\right] \quad -(16)$$

i.e. $$\gamma^2 - 1 = (\gamma+1)(\gamma-1) = (\gamma-1)^2 m^2 + 2\frac{M}{m}(\gamma-1) \quad -(17)$$

i.e. $$\boxed{m = M} \quad -(18)$$

Therefore if a photon is stopped by a mass M, eq. (18) is the result. This is a hypothetical result which attempts to introduce momentum conservation into the heuristic eq. (1) of Einstein. Experimentally, it is observed that the photon is always scattered.

A more realistic treatment consists of assuming that the mass m is captured by the mass M in the process of absorbing a photon. The final object of mass $m + M$ acquires a momentum p'. This momentum is not considered at all in eq. (1). In this case:

$$\gamma m c^2 + M c^2 = \left((m+M)^2 c^4 + c^2 p'^2\right)^{1/2} \quad -(19)$$

$$\hbar \underline{\kappa} = \underline{p}' \quad -(20)$$

The next note will solve this system of equations.

<u>Overall Conclusion</u>

The fundamentals of twentieth century physics are surprisingly uncertain. As soon as the photon mass is considered severe internal inconsistencies appear. The Einstein suggestion (1) is heuristic.