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EQUIVALENCE OF COMPTON EFFECT AND DOPPLER EFFECT

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Abstract: The Compton collision of photons and electrons is another form of the Doppler effect. The actual experimental evidence on Compton effect for bound electrons is inconclusive as is the qualitative experimental evidence on inverse Compton recoil of photons from highly energetic electrons.

An examination of the Ives-Stilwell types of experiments on the Einstein-Doppler formula in the preceding article has led to the conclusion that the experimental results are inconclusive contrary to the usual belief of favorable corroboration. The experiments on Compton effect are not well appreciated as also representative of Doppler effect. It has been shown by Nielson and Olsen[1,2] that the Compton effect, for the scattering of x-rays from electrons assumed to be free (unbound) and stationary, can be expressed in the form of the Einstein-Doppler formula.

Reference to Figure 1 suggests that it is possible to express energy and momentum conservation in the form:

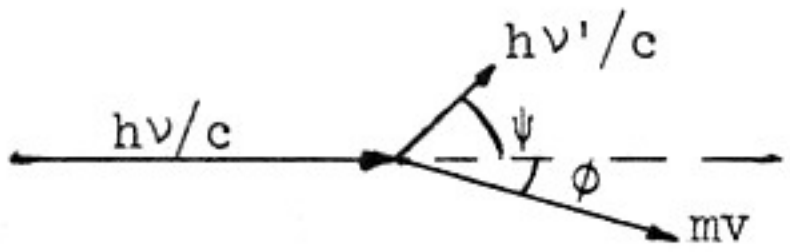

FIG 1 Momentum Diagram

$$k(1 - \epsilon) = \gamma - 1 \qquad (1a)$$

$$\gamma\beta\sin\phi = k\epsilon\sin\psi \qquad (1b)$$

$$k - \gamma\beta\cos\phi = k\epsilon\cos\psi \qquad (1c)$$

where $k = h\nu/m_o c^2$, $\epsilon = \nu'/\nu$, $\beta = v/c$, and $\gamma = 1/\sqrt{(1 - \beta^2)}$. Eliminating ψ in (1b,c) yields

$$\epsilon^2 = 1 - (2\gamma\beta\cos\phi/k) + \gamma^2\beta^2/k^2. \qquad (2)$$

Expressing $\underline{k}$ from (1a) into (2) led to a solution for ϵ so that the Einstein-Doppler formula for frequency was obtained,

$$\nu' = \nu\gamma(1 - \beta\cos\phi). \qquad (3)$$

This is a different mode of the usual expression for the Compton formula for frequency obtained by eliminating ϕ in (1b, c);

$$\nu - \nu' = (h/m_o c^2)(1 - \cos\psi)\nu\nu'. \qquad (4)$$

The Compton formula owes its relative simplicity to the idealistic assumption that the electron is free (unbound) and motionless. These conditions are not actually met in experimental situations, with the consequence that certain modifications have to be introduced for the Compton formula or the equivalent Doppler formula to obtain agreement with experiment. The modifications which take account of the electron binding energy and momentum effects have been obtained both Einstein relativistically and classically and suffer from many restrictions concerning the binding energy. Veigele, Tracy, and Henry[3] note that: "Therefore comparison of prediction with experiment is unsatisfying. More detailed and careful experiments would be useful."

The current experiments[4,5] on inverse Compton recoil of photons from free energetic (5.5 Gev) electrons are also unsatisfying as a test of the Einstein-Doppler formula (3) or the Compton formula (4) due to the broad qualitative results obtained, rather than definitive quantitative data. The basic process of the inverse Compton experiment on the conversion of visible light photons to γ-ray photons by head-on collision of visible light photons with high speed electrons is equivalent to the usual Compton effect relative to the electron regarded as stationary. The electron speed in these experiments is not directly measured. Instead, the speed is inferred on the basis of the special theory of relativity so that there is an inherent circular and ambiguous logic in the significance of these experiments as an independent test of the special theory of relativity.

It seems to be almost unknown that the Compton effect has been described rather accurately by C. V. Raman[6] without recourse to the special theory of relativity. Aside from the lack of experimental confirmation of the "Compton-Einstein" formulae, the differing theoretical approaches deny a comfortable and compelling basis for regarding these formulae as theoretically unique.

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