'Simulation of the Compton effect by reflection from a moving mirror': a reply to a comment by McFarlane and McGill

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COMMENT

'Simulation of the Compton effect by reflection from a moving mirror': a reply to a Comment by McFarlane and McGill

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I restricted the title of my paper (Ashworth 1978) to 'An analogy between the Compton effect and reflection from a moving mirror', and no claim was made to have simulated the effect that the wave has on the electron, only to have simulated the effect that the electron has upon the electromagnetic radiation. The wording of the paper was carefully chosen. I stated that '... if the scattering electron is *replaced* by a perfectly reflecting mirror which moves with a *constant* velocity...' then the '... perfectly reflecting moving mirror has the same effect on a photon as that produced by the scattering electron in the Compton effect in the two cases depicted in figure 3 and 4'. In other words, the mirror is constrained to move, by an external agency (not shown in the figures), in a direction parallel to the x axis. Nowhere is it stated that the electron is replaced by a mirror of equal mass; in fact, the mass of the mirror does not figure in the calculation at any stage and could therefore be of any arbitrary magnitude. It is not claimed that the velocity of the mirror is produced by the mirror recoiling under radiation pressure, nor is it claimed that the mirror can be replaced by the original electron. I agree that momentum is not conserved '... if the mirror (in figure 3) is replaced by the original electron moving parallel to the x axis throughout...', but no such substitution was ever referred to in my paper. The analysis was carried out to investigate the phenomenon of angular scattering from the viewpoint of electromagnetic waves rather than particles. The fact that McFarlane and McGill can derive a similar solution to my own by considering particle collisions is of little surprise, since Compton's original work involved the photon–particle concept. What my paper shows is that these results may be obtained, without invoking photon–particle concepts, by considering the scattering of electromagnetic radiation.

The validity of the second solution (equation (13) of my paper) can be verified by substituting equations (9) and (13) into equation (7), thereby giving

$$\cos \phi_2 = -\frac{\cos \psi - V/c}{1-(V/c)\cos \psi};$$

this, by comparison with equation (5), gives $\cos \phi_2 = \cos(\phi + \psi)$, which, as well as having the solution $\phi_2 = -(\psi + \phi)$, as given by McFarlane and McGill, also has the solution $\phi_2 = +(\psi + \phi)$. The solution given by equation (13) is therefore correct for a mirror which is constrained to move with velocity v in a direction parallel to the x axis. I agree with McFarlane and McGill that it does not represent a recoiling electron, but this is not relevant in the context of the solution to the mirror equation.

In their final sentence McFarlane and McGill claim that nothing in my analysis 'appears to suggest that the Compton effect might be explicable in classical terms not involving the photon hypothesis'. This is incorrect; the analysis is consistent with and complements the classical treatment of the Compton effect given by Jennison (1978). Jennison shows that the same velocity v corresponds to the velocity of the node during the precisely limited capture time of a phase-locked cavity. This does not require quantisation of the illumination, as the quantisation arises from the way in which a phase-locked cavity interacts with radiation in a step-like manner and acquires precise increments or 'quanta' of momentum proportional to the applied frequency of radiation.

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References

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