COMPTON EFFECT IS A RAMAN WAVE EFFECT

UNMODIFIED RAYS NOT DUE TO COLLISIONS PHOTONS VS. NUCLEI

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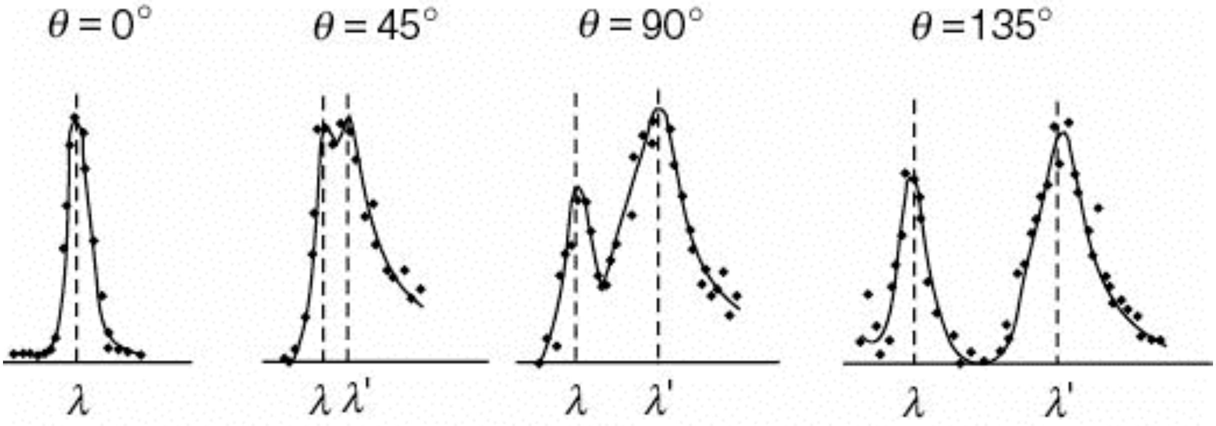
Introduction

Today's explanation of the Compton effect consists of
1) the treatment of the X-rays as photon bullets rather than as waves and
2) that these photon bullets strike the loosely bound valence electrons and the relatively weakly bound non-valence electrons.
3) It is supposed furthermore that the photon bullets strike also the nuclei of the atoms.
4) A material bombarded with X-ray photons gave off primary and secondary photon rays.

Compton attempted to show that the secondary rays (or modified rays in his words) were the result of scattering of the incident photons from quasi-free electrons. The photon wavelength undergoes a shift, dependent on angle.
The wavelength of photons that strike the nuclei of the target undergoes no shift and we see an unshifted peak in the spectrum. This is the primary or unmodified ray. Take for example carbon, then Brandl explains:
An X-ray photon passing through a graphite target could strike either a lightly bound ("free") electron, an electron bound tightly to its carbon atom, or conceivably even the nucleus of a carbon atom. In the last two cases, the photon would be colliding with the entire carbon atom, whose mass is considerably greater than the mass of a single electron... Some wavelength shift would be predicted in this case; its form would be identical to that of Eq. (23), but with the electron mass me being replaced by the mass of the carbon atom, $m_C = 2 \times 10^4\ m_e$. The wavelength shift caused by x-rays scattering from carbon atoms in a graphite target is therefore about four orders of magnitude smaller than the shift caused by scattering from free electrons in the same target.
Regarding the collisions between X-ray photons with non-valence electrons we can treat them also as quasi not bound electrons because X-rays have energies in a range of $10^3 – 10^4$ eV. Therefore Brandl did not realize that the non-valence electrons could be treated also as quasi-free electrons because the electron binding energies are negligible when compared with X-ray energies. Take for instance carbon. The second ionization energy is 24,38 eV; this is the energy required for the liberation of a second electron. There are also calculated electron binding energies for **carbon:**
Binding energies quoted in electron-volts (eV)
Electron
Identity
1s: 288.23; 2s: 16.59; 2p: 11.26;
Source Dan Thomas,
http://www.chembio.uoguelph.ca/educmat/atomdata/bindener/grp14num.htm

Here we are not concerned with the discrepancies between the experimental ionization energies and the calculated binding energies of the electrons.

Compton’s experimental set up and his outcomes are easily available at
http://nobelprize.org/physics/laureates/1927/compton-lecture.html
Compton's results at the scattering angles, 0, 45, 90 and 135˚, are shown in the following figure. Each graph represents the intensity of X rays (ordinate) as a function of wavelength (abscissa).



The unshifted peak is interpreted to occur due to a collision of the X-ray photon with the nucleus. [bra]

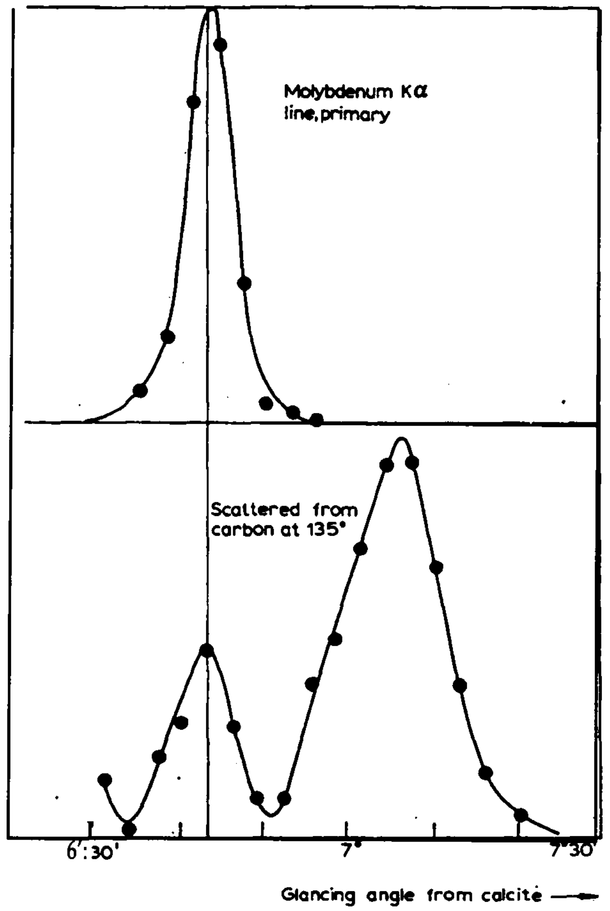
Theses:

1) There is no possibility to explain the occurrence of unshifted peaks in the spectra due to collisions of photons with nuclei.
2) The relative intensities of shifted and non-shifted peaks are not explicable on the assumption that the energy of an EM ray is E = hν. The Compton effect is another indication that this formula is a flaw. See the article on the *Photoelectric effect* where it is shown that this formula cannot be inferred neither from the supposed QM interactions nor from the underlying measurement technique.

Interpretation of the Compton effect in terms of QM

For angles greater than 0˚ there are shifted and unshifted peaks. The shifted peaks are due to inelastic collisions of photon packets with loosely bound valence electrons and relatively weakly bound non-valence electrons. All electrons are treated as free.
If one treats the 2p electrons of graphite as quasi-unbound electrons then one must do so also for the 2s electrons because the relation of the photon energy to the electron binding energy is in the same order of magnitude, see above.
Therefore we must calculate two collisions: photon vs. 2p electrons and photon vs. 2s electrons. For both we get around the same energy of the scattered photon. The two peaks are not distinguishable.
The famous Compton formula for the wavelength shift is roughly in agreement with experiments and can be explained due to an inelastic collision photon versus electron. But the unmodified rays are not explicable analogously.

The problems to interpret are the *unshifted peaks*.
The current interpretation claims that the unshifted peaks are due to collisions of photons with nuclei. (Compton himself did not consider these peaks as a result of a collision photon versus nucleus!) It is assumed that the nucleus is at rest. Because the momentum of the photon in comparison with the mass of the atom is minute, so, the collision can be regarded as a perfect elastic one. Therefore the incident photon and the scattered photon must have the same energy and frequency for all scattering angles.
Compton's results are not in agreement with this requirement; the intensities of the unshifted peaks vary with scattering angle. See the graph above. The graph from Compton's Nobel lecture (on the right hand) for the 135° scattering angle shows that the unmodified ray has intensity, which is 50% of the intensity of the modified ray. QM asserts that there is an elastic collision between the X-ray photon and the nucleus. In that case the scattered photon undergoes no energy loss, therefore the intensity of the scattered (unmodified) ray should be greater then the intensity of the modified ray because for the modified ray there is an energy loss due to the inelastic scattering with the electron. Regarding the experimental results, this is obviously not the case.



A typical spectrum of scattered X-rays, showing the splitting of the primary ray into a modified and an unmodified ray.

Compton himself refuted unconsciously the possibility of an elastic collision: X-ray-photon versus nucleus. The situation is hopeless: When the collision is assumed to be inelastic, then the wavelength changes. This disagrees with the experimental outcomes...

A special case is the angle 0°. Here we would expect a sum of intensities: the intensity of electron scattering (that is unshifted at 0°) and the intensity of the atom scattering. Compton's result does not show an increase for the intensity due to electron + atom scattering.

Again:
1) The intensities of the unshifted peaks are different, this is not in agreement with the supposed elastic scattering. For some angles the intensities of the unshifted peaks are smaller than the intensity of the shifted peaks, this is also not in agreement with elastic scattering.
2) The assumed elastic scattering implies that there is no absorption of radiation. But *graphite*

for instance absorbs a part of the radiation. Therefore, collisions of photons with nuclei cannot be totally elastic.

3) Compton himself remarked in his Nobel lecture another relation for the intensities of electron scattering and atom scattering which is not explicable in terms of QM:

The relative intensity of the two components changes. For the longer wavelengths the unmodified ray has the greater energy, while for the shorter wavelengths the modified ray is predominant.

Then Compton himself unconsciously refuted photon theory a second time:

In fact, when hard γ rays are employed, it is not possible to find any radiation of the original wavelength.

A hard γ ray photon strikes a nucleus, there is allegedly an elastic collision, but the scattered photon is missing!

One and the same Nobel lecture describes the rise and fall of QM!

Compton investigated a Raman effect

(For more details see the article:
Raman atomic spectra...

Description of the Raman scattering effect

When EM radiation with exciting frequency ν_0 enters a medium it is part reflected part refracted part scattered and part absorbed. The scattered radiation can have a change of frequency, because not only scattered rays of the exciting frequency are observed (Rayleigh scattering), but also some weaker bands of shifted frequency are detected.

The shifted bands of lower frequency $\nu_0 - \Delta\nu_I$ are the so-called Stokes bands, whereas these at higher frequency, $\nu_0 + \Delta\nu_i$ are the so-called anti-Stokes bands.

The shifting pattern of the satellite Raman lines is independent of the frequency of the monochromatic incident ray but is the characteristic fingerprint of the scattering substance.

X ray spectra can be interpreted as Raman shifting of incident ray

The results that Mosely obtained for *The High Frequency Spectra of the Elements* indicate that the square root of frequency is a linear function of the atomic number. Moseley observed in 1913 that the line spectrum of elements due to incident X rays could be described in the analogous way to the series describing the hydrogen spectrum.

In terms of QM, for every element there are K, L and M-lines where K, L, M denote the shells for the principal quantum numbers n = 1, n = 2, n = 3, respectively.

The frequencies of the K_α-, L_α- and M_α-lines can be expressed by the empirical formulas

$$\nu (K_\alpha) = R_f (Z - X_K)(1/1^2 - 1/2^2)$$
$$\nu (L_\alpha) = R_f (Z - X_L)(1/2^2 - 1/3^2)$$
$$\nu (M_\alpha) = R_f (Z - X_M)(1/3^2 - 1/4^2)$$

where Z is the atomic number of the element and X_K, X_L, X_M are empirical constants.

The X ray spectra can be interpreted as a wave Raman effect, moreover:

We can interpret all Rydberg-type frequencies formulas

$$\nu = \nu_{Atom} \left| 1/n^2 - 1/m^2 \right|$$

as frequencies of a forced vibration of two coupled oscillators: the first term represents the eigenfrequencies of the excited specific crystal.
The second term represents the resonance frequencies of a transmitting EM medium. The difference frequency (the difference „tone“) is the produced frequency of the transmitter that we observe as a spectral line.
An incident X ray causes an excitation of the crystal. The crystal is coupled with an electromagnetic medium that works as a transmitter. The Raman-like frequencies shifts that we observe are the eigenfrequencies oft that medium. This EM medium „waves“. A vacuum cannot wave.

QM description of the Raman effect: Who interacts with whom?
There are explanations of the Raman effect in terms of QM. As mentioned above, the explanation of the energy balance for the Compton-Raman effect is impossible, when the formula E = hν is the base for a comparison of intensities.
Nevertheless see for example Illia Marderfeld’s attempts to enlighten on QM interactions:
physics.technion.ac.il/~illia/ qunstr2/Meni-Raman%20Effect53.ppt
The oscillating crystal is artificially separated and treated as a product of electron states and phonon states. Phonon-photon interaction is weak. (The phonon is a revival of the phlogiston, the atom of temperature...)
Incoming photon interacts with an electron .The photon is annihilated and the electron is excited to an intermediate virtual state |b>. The excited electron interacts with a phonon, and returns to the electronic ground state creating a scattered photon.
See this author or any textbook for additional QM subtleties…

Recoiling electrons
When Compton proposed his theory, no electrons of this type were known; but they were discovered by Wilson and Bothe within a few months after their prediction. Now we know that the number, energy, and spatial distribution of these recoil electrons are roughly in accord with the predictions of the photon theory. But the collision theory does not work for nuclei!

Conclusion
The experimental results of the Compton effect are not explicable in terms of QM, which presupposes a X-ray photon that carry energy E =hν. Therefore, QM is inherently flawed.
The Compton effect can be interpreted to be a Raman effect. The Raman effect can be interpreted in terms of wave theory.
An incident X ray causes an excitation of the crystal. The crystal is coupled with an electromagnetic medium that works as a transmitter. The Raman-like frequencies shifts that we observe are the eigenfrequencies oft this medium.

Planck's formula E = hν cannot represent a natural law

It was shown here over that the so-called Compton effect cannot be an empirical confirmation for the existence of a photon that carry an energy packet E = hν. Moreover, the argument is that the energy of an electromagnetic wave is not truly expressed by E = hν because the amplitude is ignored.
There are many empirical indications that the energy of EM radiation is not E = hν. Recall the Raman anti-Stokes scattering effect, where the produced wave has a greater frequency as the incident wave. An energy balance according to the formula E = hν is impossible.
Then consider the ontological status of E = hν. The formula represents not a natural law.
In natural laws the constants are constants of proportionality only that have no dimensions.
The Planckian h has the dimension energy times time.

References and notes

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[sch] Schrödinger. E., Über den Comptoneffect, *Ann. Phys.*, **82**, p. 257-264, (1927).

http://home.tiscali.nl/physis/HistoricPaper/HistoricPapers.html

Compton effect due to wave mechanics, *which delivers all except for intensities*.

(determination of intensities is *tedious* and *complicated*..)

[han] Hanson, N. F., Verification of the Compton effect, Phys.Dep. College of Wooster, Ohio

44691, www.wooster.edu/physics/JrIS/Files/Nick.pdfC

Conclusion: In examination of the 180° scattering

angle for ^{137}Cs and ^{22}Na radioactive sources, the backscatter energy peaks were found to be 0.196 ± 0.026 MeV and 0.190 ± 0.044 MeV respectively. The ^{137}Cs peak had a 6.5% error while the ^{22}Na peak had a 10% error. The error found in the experimental value for E_{Na} is certainly systematic and can be attributed to a limitation in the MCA used to isolate the backscatter energy. The digital method of measuring the energy should be used in future runs of this experiment due to its superior accuracy in comparison to the analogous method. This experiment verified Compton's theory that photons do indeed possess energy and momentum.

This experiment investigated only the presupposed collisions of photons and electrons. It is

not a verification of E = hν.