Photons:
Explained and Derived by Energy Wave Equations

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May 2, 2018

Summary

Photons are curious packets of energy that exhibit particle-like behavior but they are also known for their wave behavior as the source of light, radio waves, microwaves and other waves in the electromagnetic spectrum. They are known to be created by atoms and then absorbed by these particles but the mechanism for this transfer is unknown. They are believed to have no mass yet they can create matter.

The photon is demystified in energy wave theory as a transverse wave packet of energy, resulting from the vibration of particles that are responding to waves that naturally travel the universe. In earlier works in the theory, the photon was accurately modeled mathematically with the same wave properties that govern the creation of particles and their forces. These properties are: 1) wave amplitude, 2) wave speed, 3) wavelength, and energy is measured in a given volume in a medium with a known 4) density. These four constants form the equations for particles and their interactions with photons.

Earlier works accurately modeled photon behavior in atoms from hydrogen to calcium using wave equations and applying the conservation of energy principle to calculate photon wavelengths and energies. Photoelectric behavior was assumed without consideration of photon angles emitted or absorbed by the atom.

In this paper, the photon's behavior is further explained to match various photon experiments, describing the mechanism for the creation and absorption of transverse waves.

1. Introduction

The Standard Model of Elementary Particles lists the photon as one of the elementary particles – as the carrier of the electromagnetic force.[1] The photon is said to have both particle and wave features. It was determined to be a *quantized* packet of energy – a particle – following experiments that produced the photoelectric effect. Albert Einstein would later receive a Nobel prize for his explanation of this effect.[2] It is also known to have wave features, producing different types of waves (e.g. radio, microwave, light, x-rays) based on the frequency of the wave.[3] Furthermore, the wave properties of the photon have both an electrical and magnetic component and is often illustrated in physics textbooks and papers like the following:

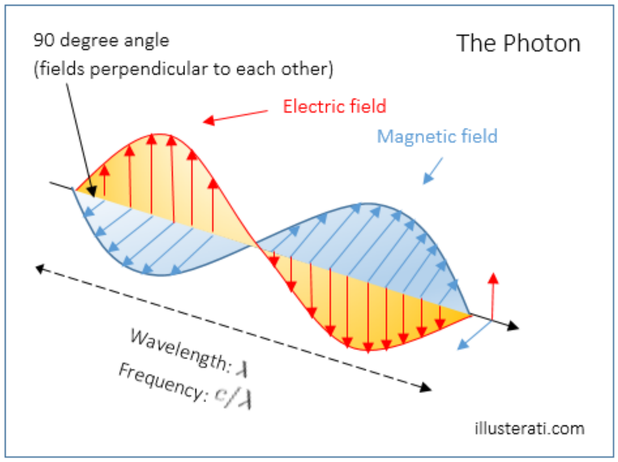


Fig 1.1 – The Photon's Electric and Magnetic Field[4]

Energy Wave Explanation

The photon is a packet of energy as a result of particle vibration. The known aspects of the photon are satisfied by the principles of energy wave theory of a particle that reflects longitudinal waves and may vibrate for a brief period of time before coming to rest.

- Particle behavior – the photon is a result of a vibration of an electron, positron, proton, neutron or other particle that contains wave centers (reflects waves). This creates a discrete packet of energy and appears like a particle. *Note for terminology, a photon is not considered a "particle" in energy wave theory as it does not contain wave centers nor standing waves.*
- Electric field – the vibration of a particle will produce a transverse wave with a frequency that matches the speed and duration of the particle's vibration. Electron vibrations in an atom will be short-lived as the electron eventually comes to rest in an orbital. Vibrations of entire atoms may last much longer as the atoms have kinetic energy – measured as temperature.
- Magnetic field – a particle is constantly reflecting longitudinal waves, with or without particle vibration. During particle vibration, the magnetic component will be combined with the electric component in the wave packet.

A visual of the photon using this definition of energy wave theory is found in Fig 1.2:

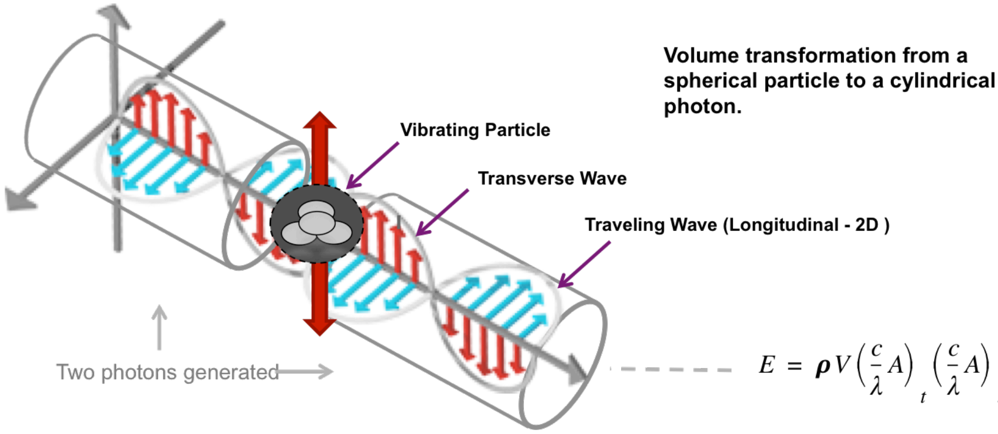


Fig 1.2 – Creation of the Photon from Particle Vibration – Energy Wave Theory

In the *Particle Energy and Interaction* paper, this model of the photon resulted in a transverse equation that is able to correctly derive or calculate:[5]

- Planck relation (E=hf)
- Transverse wavelengths for hydrogen (Lyman, Balmer, Paschen, etc series)
- Transverse energies for the first twenty elements (hydrogen to calcium)

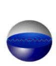
Matching Theory to Experimental Evidence

While the *Particle Energy and Interaction* paper was able to derive equations to match experimental evidence for photon wavelengths and energies, it did not discuss the angles of photons nor provide an explanation of why one photon appears as an output in some experiments.

A comprehensive view of the photon and its interactions with electrons, positrons and atoms is provided in this paper as a supplement to *Particle Energy and Interaction*. The detailed mathematics and equations are reserved for the other paper. Instead, this paper will provide an explanation of how photons interact with particles and the mechanism of energy transfer from transverse waves to longitudinal waves and vice versa.

1.1. Icons

The following icons are used throughout this paper to describe particles and waves.

Icon	Name	Comment
	Particle wave centers	Core of particles
	Electron	Electron particle

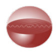
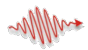
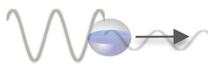
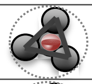
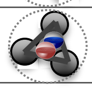
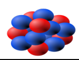
	Positron	Positron (phase shift of electron)
	Photon	Transverse wave packet
	Wave Amplitude	Particle movement to minimal amplitude
	Nucleon (proton)	Nucleon structure with positron in center
	Nucleon (neutron)	Nucleon structure with positron and electron
	Atomic nucleus	Protons and neutrons

Table 1.1 – Icons

1.2. Transfer of Energy Wave Form

The interaction of a photon with a particle is a transfer of energy. Energy is always conserved, yet it may change forms. The two types of wave forms are: longitudinal waves and transverse waves. From *Particle Energy and Interaction*, particles such as the electron were described as a collection of wave centers reflecting longitudinal waves. The result is standing (longitudinal) waves until the particle's perimeter, where it transitions back to traveling (longitudinal) waves. At its core are the wave centers that reflect these waves and are constantly shifting to be at the node of a standing wave, causing motion. This is the electron's spin as illustrated in Fig. 1.2.1.

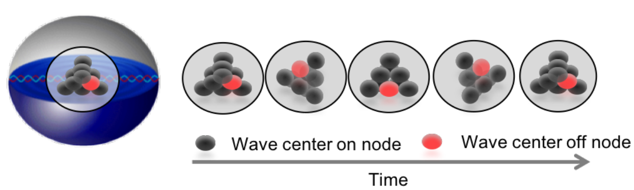


Fig 1.2.1 – Electron consisting of wave centers that cause spin.

From the *Atomic Orbitals* paper, it was found that the electron's orbit can be accurately modeled as the sum of the forces of an attractive core of the proton and a repelling force that is further described in that paper.[6] The paper calculates the orbital distance of the first twenty elements, from hydrogen to calcium. The icons for the proton and neutron in Section 1.1 reflect the view of a common nucleon structure that contains the repelling force, a positron in the center of the proton, and a positron-electron combination in the center of the neutron. This structure is consistent with beta decay experiments as explained in the *Forces* paper and will also be consistent with the upcoming section on pair production.[7]

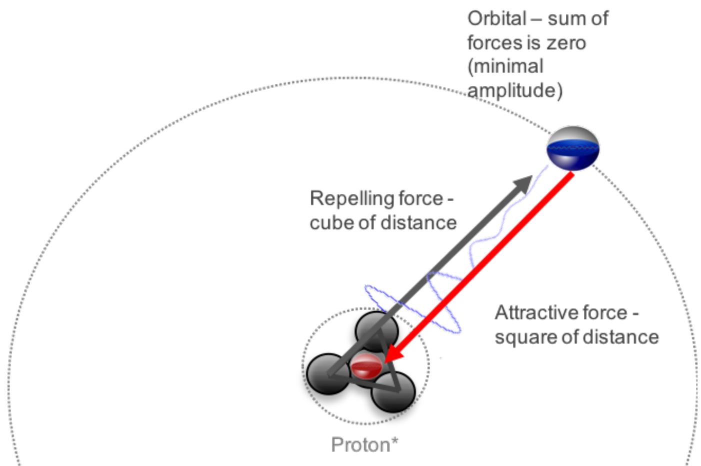


Fig 1.2.2 – Electron's position from the proton creates an orbital due to attractive and repelling forces.

To explain the photon's interaction with particles, an example will be provided of a water wave. In the case of this wave, the medium is water, or more specifically water molecules. As the wave travels in Fig 1.2.3, it has both a transverse and a longitudinal wave component. The molecule highlighted in yellow takes a circular path going both up-and-down (transverse direction) and left-to-right (longitudinal direction). This visual will also be used to understand the interaction between a photon and an electron.

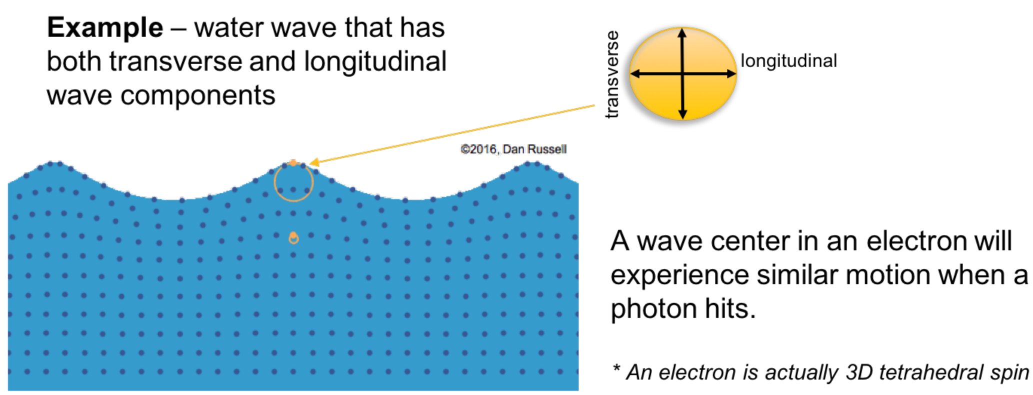


Fig 1.2.3 – Water Wave Analogy of Transverse and Longitudinal Components of a Wave.

In Fig. 1.2.4, the same concept of a photon is now applied to the electron. The interaction is between the photon and wave centers within the electron. The same motion of the water molecule in a water wave now takes place within the electron. If it were only a single wave center in a two-dimensional world, it would take a circular path. However, the electron is calculated to consist of multiple wave centers (10) in *Particle Energy and Interaction* and therefore would rotate in a manner suggested earlier in Fig. 1.2.1 as a potential tetrahedral structure. Regardless, it is expected to now be converting transverse energy to longitudinal energy as a result of this individual wave center motion inside the electron.

An increase in longitudinal energy now increases the wave amplitude between the atomic nucleus and the electron. This has an effect on the electron because the primary rule of all motion is for the particle to move to the point of minimal wave amplitude. This causes the electron to move away from the atomic nucleus, as illustrated in the next figure.

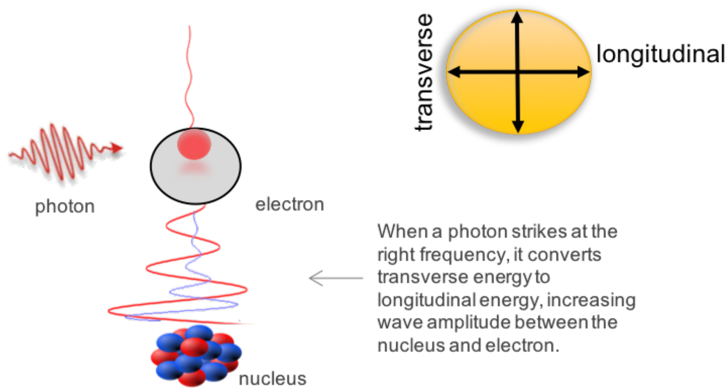


Fig 1.2.4 – Conversion from Transverse Energy to Longitudinal Energy.

Not all photons will transfer energy from transverse to longitudinal wave energy. It depends on the frequency of the photon and the electron. To understand the potential scenarios, the details of the photon also need to be described. Similar to a water wave that contains water molecules, the photon must have components. In energy wave theory, the components of the aether have been given the name *aether granules*. This is what transfers energy, like two water molecules colliding, or two billiard balls colliding. The granule is represented in Fig. 1.2.5 as a dot, and the arrow signifies its direction of motion. In this example, the photon is moving from left-to-right.

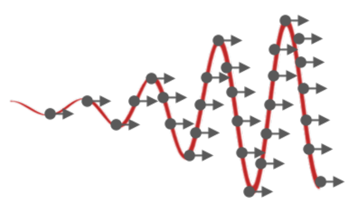


Fig 1.2.5 – Photon Components (movement is from left-to-right).

To understand the photon and electron interaction, the components of each need to be considered. An individual view of aether granules colliding with an electron's wave center is illustrated. In Fig 1.2.6, three examples are provided:

- Photon Misses – The individual granule misses the wave center in its rotation. The photon will pass through the electron.
- Photon Single Hit – An individual granule is timed correctly to hit the wave center in its rotation. As it transfers its forward momentum, the wave center now spins faster. The photon is now absorbed.
- Photon Multiple Hits – Individual granules are timed to correctly hit the wave center in its rotation. The increased energy now spins the wave center faster, or some granules may continue past the electron, depending on the amount of energy absorbed.

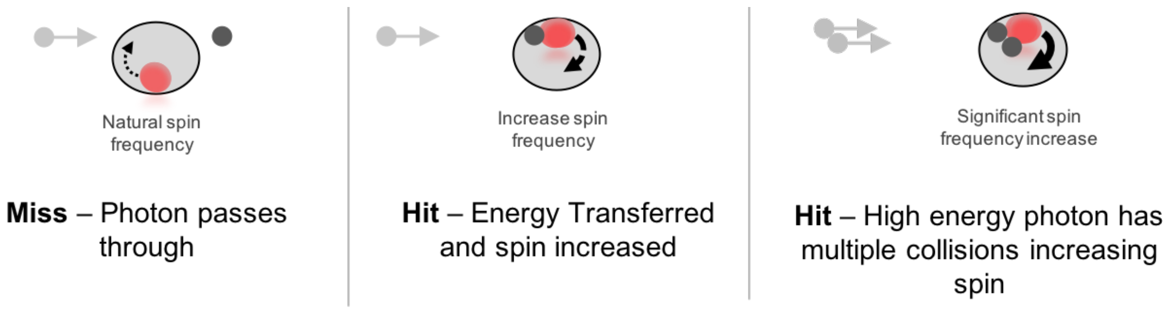


Fig 1.2.6 – Photon Interactions with Electron Wave Centers.

In the previous example, the photon must match the frequency of wave centers spinning in the electron to transfer transverse energy to longitudinal energy. It is a resonant frequency. In physics, *resonance* is defined as a phenomenon in which a vibrating system or external force drives another system to oscillate with greater amplitude at specific frequencies.[8]

Resonance is often described in terms of a swing. A swing will have a natural frequency where an object moves back-and-forth. The amplitude is the height at which the object might reach. Now, imagine a man pushing on the kid (object) on the swing. If he pushes too late or too early, his hands push into empty space. If this were a photon, it would pass right through. If he pushes at just the right time, with minimal energy expended, the swing reaches its greatest amplitude. With a stronger push, at the right time, the kid moves faster and reaches even greater amplitudes. This is an appropriate analogy to understand resonance and the interactions with photons.

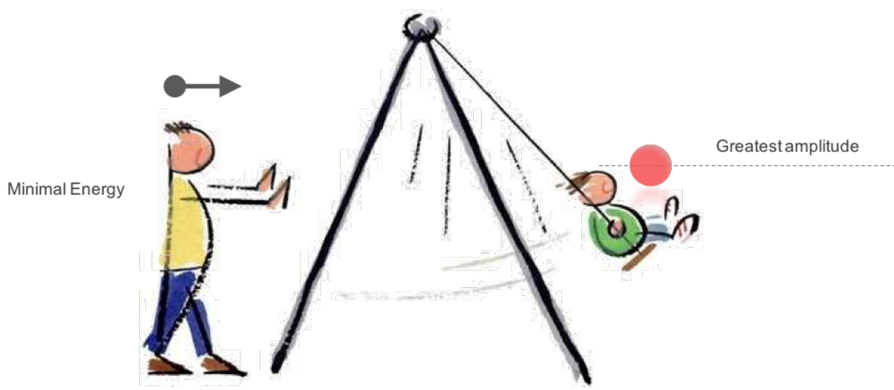


Fig 1.2.7 – Resonance Example.

1.3. Summary of Photon Interactions

In Sections 2 (Emission) and 3 (Absorption), various types of particle interactions with photons are considered to match and explain experiments. A summary of the experiments that will be discussed, and the before-and-after picture is described in Table 1.3

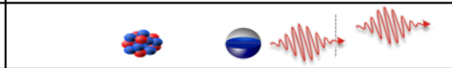
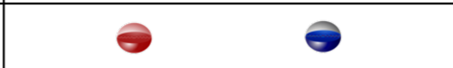
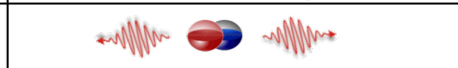
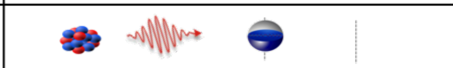
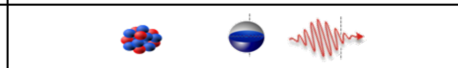
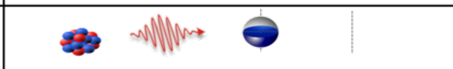
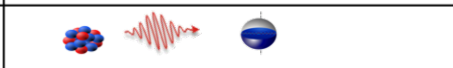
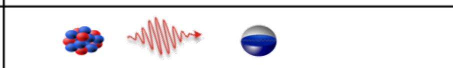
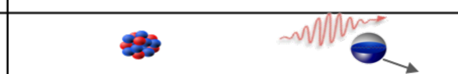
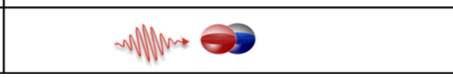
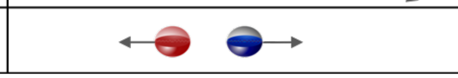
	Before	After	EWT Equation
Emission (Spont.)			$\frac{1}{2}E_l = E_t$
Emission (Stim.)			$E_t + \frac{1}{2}E_l = 2E_t$
Annihilation			$2E_l = 2E_t$
Non-Absorb (Pass)			$E_t = E_t$
Absorb (Orbital)			$E_t = \frac{1}{2}E_l$
Absorb (PhotoElec)			$E_t = \frac{1}{2}E_l + KE$
Absorb (Compton)			$E_t = \frac{1}{2}E_l + KE + E_{t2}$
Pair Production			$E_t = 2E_l + 2KE$

Table 1.3 – Summary of Photon Interactions.

In the right column of Table 1.3 is the Energy Wave Theory (EWT) equation for the equivalent of what is measured outside of the atomic nucleus as a conservation of energy. The left side of each equation is the energy before the event; the right side of the equation is the energy after the event. The one exception is that the equations do not consider the recoil energy of the atomic nucleus. The symbols represent:

- E_l – Longitudinal energy
- E_t – Transverse energy
- KE – Kinetic energy

The equations for longitudinal and transverse energy are found in *Particle Energy and Interaction*. The equation for kinetic energy is the commonly used KE=½mv^2. Many of the calculations for these examples were found mathematically in *Particle Energy and Interaction*. The remaining details of each of these experiments is now considered in the next sections of this paper.

2. Emission

The three scenarios covered in this section include interactions with electrons that produce a photon that did not previously exist. It does not include the vibration of atoms which may also produce photons. Temperature is the average kinetic energy of molecules, so when atoms within these molecules are vibrating with kinetic energy, a transverse wave may be created. For example, the hotter the object, the faster the vibration and the shorter the wavelength of the photon being generated.

However, only experiments involving an electron and photon are considered here. The experiments discussed in detail in this section are: 1) spontaneous emission, 2) stimulated emission, and 3) annihilation.[9] [10]

2.1. Spontaneous Emission

In spontaneous emission experiments, an electron moves to an orbital closer to the atomic nucleus, generating a photon. This may occur for an electron that drops from a higher-level orbital, such as Fig. 2.1, or it may also occur for an electron that is outside of the atom and is captured into an orbital.

An electron and proton are attractive due to destructive wave interference from the positron at the proton's core. This attractive force decreases at the square of the distance from the proton. Yet, a repelling force that decreases at the cube of the distance keeps the electron in orbit. The details of these calculations were provided in *Atomic Orbitals*. In this model, the electron will always be attracted to the nucleus and move to the point of the ground state orbital, but within this perimeter, it is repelled due to the stronger repelling force. The orbital is the point where the sum of forces is zero (the attractive force and repelling force are equal).

An electron in a higher orbital or outside of the electron will be attracted to and move to the orbital where the sum of forces is zero. Before stopping, it will vibrate and produce two photons. The vibration converts longitudinal wave energy to transverse energy, the opposite of what is shown in Fig. 1.2.4. It vibrates perpendicular to the direction between the electron and the nucleus as it reaches the orbital and begins to spin synchronous to the proton.

The temporary vibration of the electron as it settles into position creates two transverse waves traveling in opposite directions. One travels away from the nucleus and is measured in experiments. The other photon travels to the proton and is absorbed by the massive nucleus as the recoil energy.

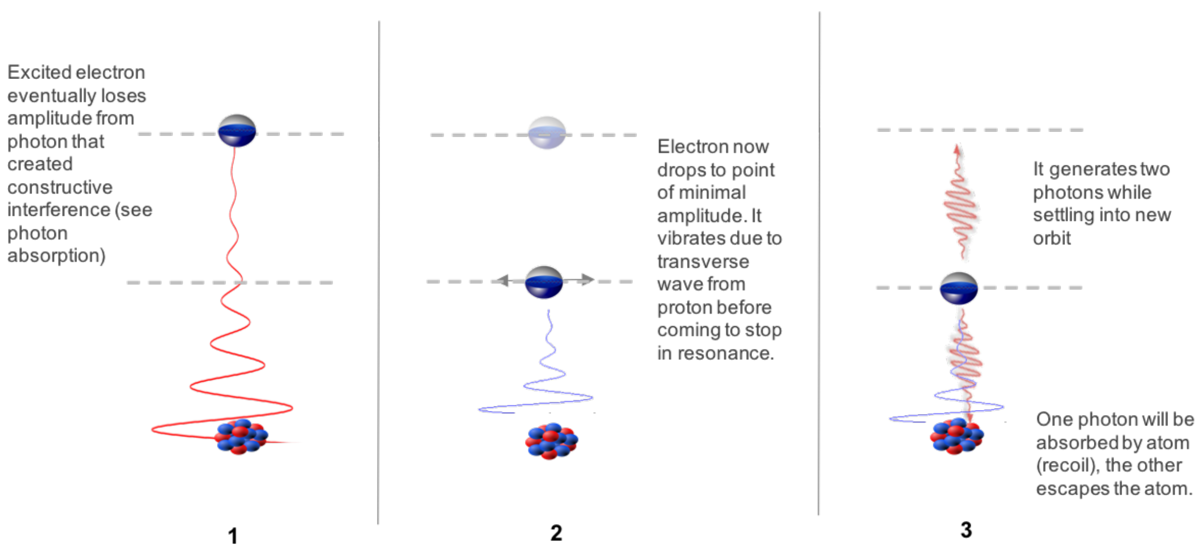


Fig 2.1 – Spontaneous Emission.

2.2. Stimulated Emission

In stimulated emission, an electron is first excited to a higher level. While excited, a second photon is used to excite the electron further. In experiments, this results in two photons being generated that leave the atom. The two photons will be identical in energy, spin and polarization.

Fig. 2.2. illustrates the process for stimulated emission. Starting with #1, an already-excited electron is struck by a photon. This excites the electron momentarily and then it returns to the excited orbital, which still temporarily has increased amplitude (see Section 3 for details). Upon reaching this orbital, where the sum of forces is temporarily zero, it vibrates and creates two photons traveling in opposite directions. Similar to spontaneous emission, one photon will leave the atom and one will reach and be absorbed by the nucleus as recoil.

Finally, the temporary increased amplitude between the electron and nucleus disappears. Once it disappears, the electron is attracted again to the nucleus and moves to the ground state where amplitude is minimized (sum of forces is again zero). Upon reaching this point, it vibrates again, generating two photons. One will leave the atom and one will reach the nucleus and be absorbed as recoil.

The two photons from #2 and #3 that leave the atom travel in the same direction and have the same spin and polarization since they originate from the same electron.

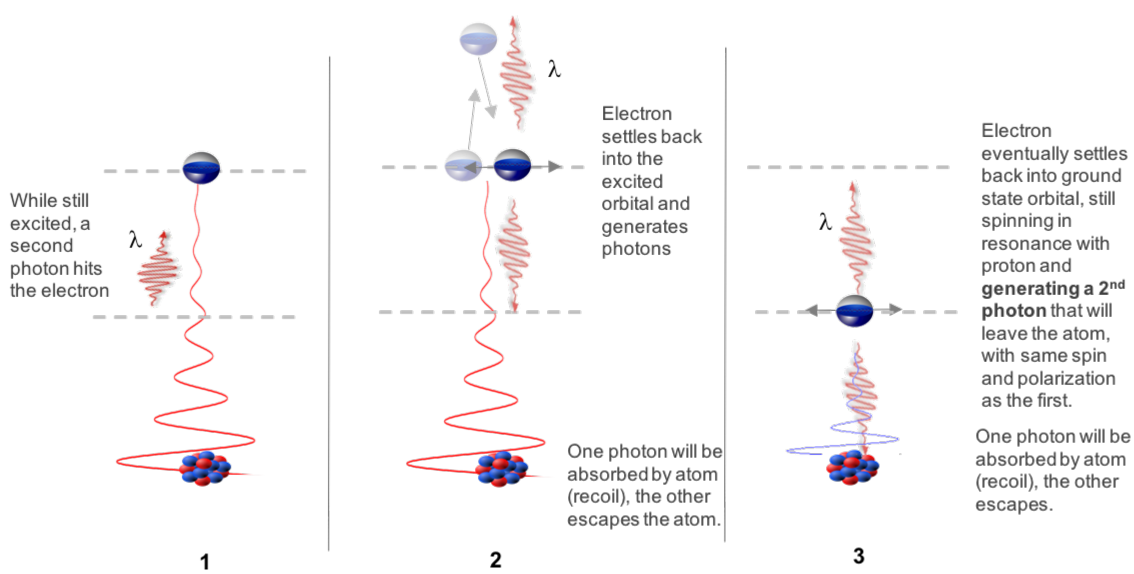


Fig 2.2 – Stimulated Emission.

2.3. Annihilation

An electron and a positron are known to annihilate in experiments, seemingly disappear and produce two photons (gamma rays) traveling in opposite directions.

Similar to the proton, the electron is attracted to the positron due to destructive wave interference that causes particles to be attractive to minimize wave amplitude. Unlike the proton, it is only attractive. There is no repelling force to create an orbital so the electron and positron will be attracted until the particles meet – destructive wave interference affects the standing wave structure too. The particles no longer have mass (standing waves) and are not detected by electromagnetic apparatus (due to wave cancellation). Yet the wave centers still remain.

Before coming to rest, both particles transfer longitudinal energy to transverse, vibrating perpendicular to the direction between the particles. This process is illustrated in Fig. 2.3.

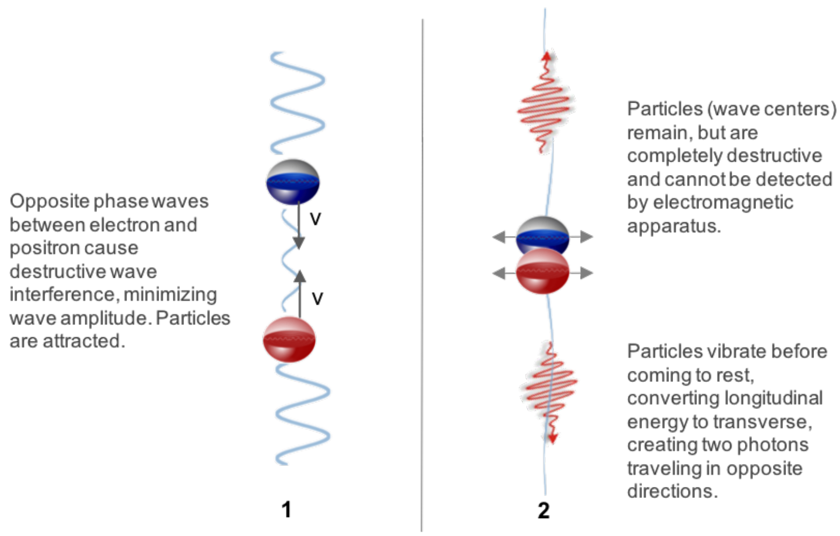


Fig 2.3 – Annihilation of Electron and Positron.

3. Absorption

The scenarios in this section involve the process of a photon being absorbed by an electron, where transverse energy is converted to longitudinal energy. The following experiments are explained: 1) Non-absorption (photon pass through), 2) orbital transition, 3) photoelectric effect, 4) Compton scattering effect, 5) pair production. [9] [11] [12] [10]

3.1. Non-Absorption (Pass Through)

Photons may pass through an atom and maintain the same energy and direction, even if it appears to coincide with the electron's path. In this case, the photon is not absorbed by the electron.

As illustrated in Section 1, the photon should match the frequency of the electron to exchange energy. In the example of the swing in Fig. 1.2.7, the man could miss the chance to push the kid if the frequency does not match, similar to the photon's *granule* missing the chance to push the electron's *wave center*. This results in the photon passing through the atom unless it matches a resonating frequency.

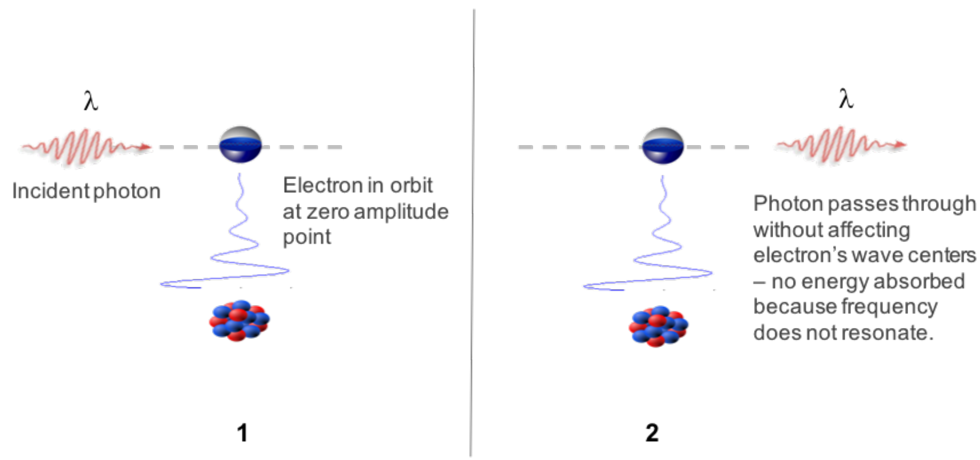


Fig 3.1 – Photon Passes Through Atom (non-absorption).

3.2. Orbital

A photon may be absorbed by an electron and change to a higher energy level orbital, which is further from the nucleus. Unlike spontaneous emission, which is when an electron moves closer to the nucleus and emits a photon, to move an electron further from the nucleus requires the absorption of a photon. However, there are defined orbitals that are possible, resulting in *quantum* jumps.

Fig. 3.2 explains the process. An incident photon strikes an electron which is at a lower energy level orbital. In this case, the photon frequency matches the electron's spin frequency of the wave centers, causing a temporarily faster spin. This transfer of transverse energy to longitudinal energy increases the wave amplitude between the electron and the nucleus, forcing the electron away to the new point of minimal amplitude – a new orbital.

The photon must match (resonate) with the spin of the electron for this to occur, but there are multiple frequencies that allow the collision of the photon with the wave centers in the electron. With more energy in the photon, at the correct frequency, the electron spins faster, creating more wave amplitude. These photon frequencies convert transverse energy to longitudinal energy, and these cause distinct repelling wave amplitudes cause different orbitals.

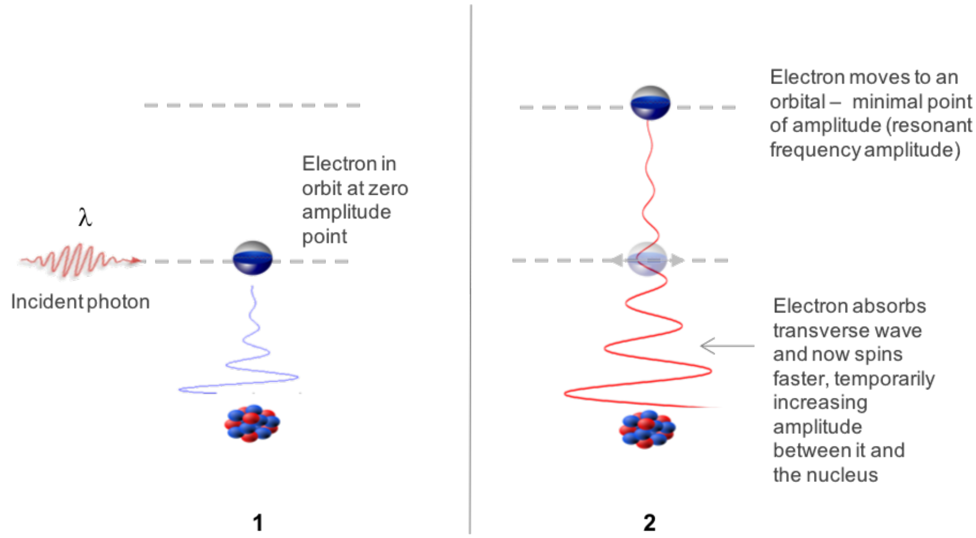


Fig 3.2 – Photon Causes Electron to Change Orbital.

3.3. Photoelectric Effect

As photon energies get bigger (compared to orbital transitions from the previous section) it can cause the electron to escape the atom. When the electron leaves the atom without a photon being produced, it is referred to as the photoelectric effect. In the remaining three sections on photon absorption, the photoelectric, Compton effect and pair production experiments are discussed. The difference is based on the energy of the photon that strikes the electron and also the number of protons (Z) in the atom, which affects the electron density in the atom. This is described in Fig. 3.3.1.

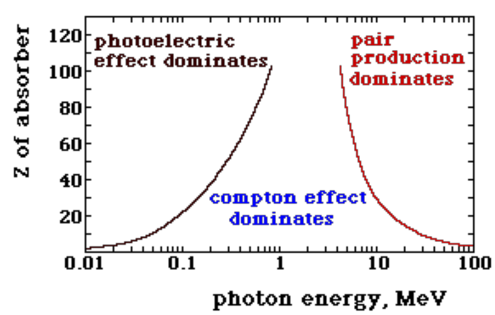


Fig 3.3.1 – Photoelectric vs Compton vs Pair Production Effects.[13]

When photon energies are very low (not pictured in the above figure), the electron will not move. When more energy is added to the photon, and at the right frequency, the electron begins to move and transition to higher energy level orbitals but it does not leave the atom. With even more energy added, the electron will leave the atom. Extra energy from the difference between the photon energy and the atomic binding energy is converted to kinetic energy of the electron leaving the atom. In other words, the electron will exit with a faster velocity with more energy. This is the photoelectric effect. Continuing to add more energy to the photon results in the Compton effect (Section 3.4) and then even more energy results in pair production (Section 3.5).

Fig. 3.3.2 explains the process for the photoelectric effect. Similar to the absorption of the photon in the previous scenario for orbitals, transverse energy is converted to longitudinal energy, temporarily increasing wave amplitude between the electron and nucleus. This time, the energy that repels the electron exceeds the attractive, binding energy. The electron will escape the atom. Due to the conservation of energy, any additional energy from the repelling force is converted to kinetic energy – ½ mv^2, where m is the mass of the electron and v is the exit velocity.

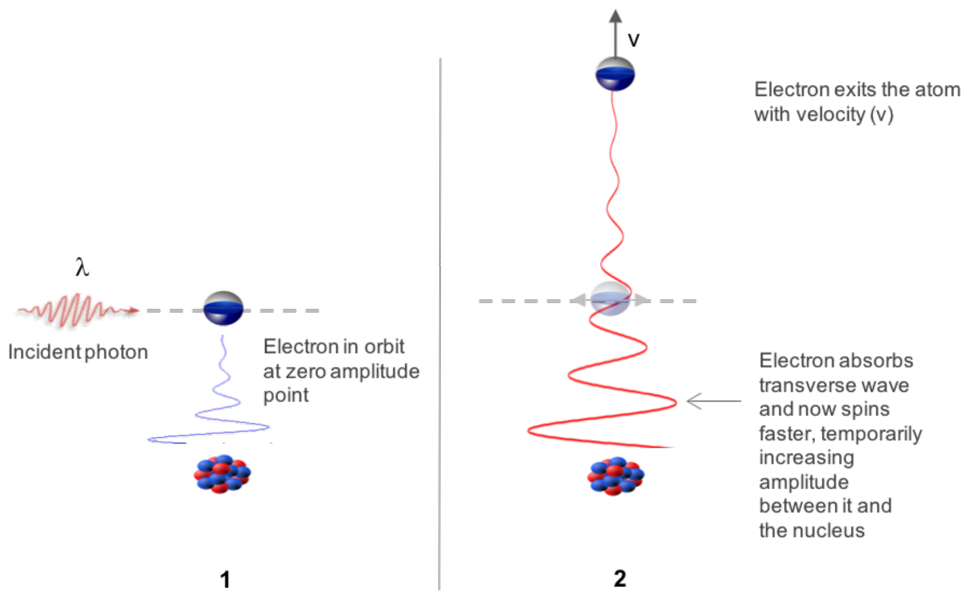


Fig 3.3.2 – Photon Causes Electron to Leave Atom (Photoelectric Effect)

3.4. Compton Effect

From Fig. 3.3.1, it is shown that photons that strike the electron not only eject the electron from the atom, but now also produce a photon that leaves the atom, which may leave at a different angle than the incident photon. This is referred to as the Compton scattering effect. In Compton scattering experiments, the angle and energy of the incident photon is compared to the angle and energy of the new, scattered photon.

When the angle of the incident photon is the same as the scattered photon (0°), the photon's energy (wavelength) remains the same. The electron exits the atom with zero energy, which means that it has just enough energy to match the binding energy to leave the atom. When the scattered photon returns backwards relative to the incident photon, (180° backscatter), it transfers maximum energy to the electron, which then exits the atom at its greatest velocity. The experimental results are shown below in Fig. 3.4.1 – the exchange in photon energy to electron energy is based on the angle of the incident photon to the angle of the scattered photon. Illustrations of incident and scattered photon angles are coming up later in Fig. 3.4.4.

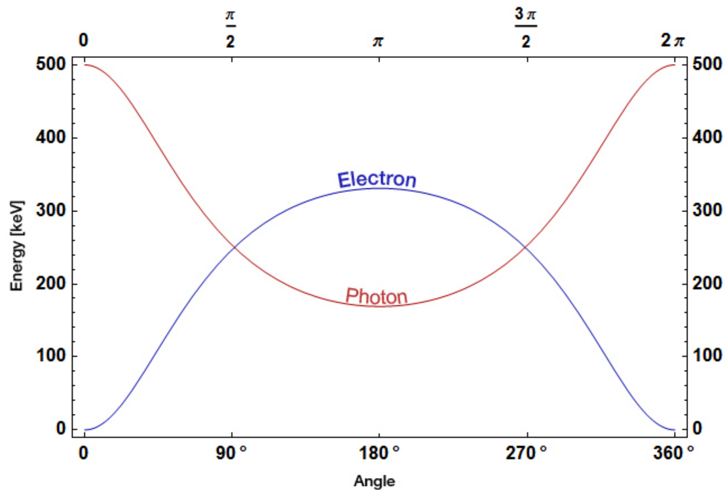


Fig 3.4.1 – Compton effect photon angles to electron energy transfer values. [12]

One of the differences between the Compton effect and the photoelectric effect is the electron density in the atom. This is seen in Fig. 3.3.1 as the Z number (protons) increases in the nucleus. As more electrons are added to the atom, there are more repelling forces from other electrons, and at various angles. The orbital remains the point where the sum of forces is zero from the attractive nucleus and all of the repelling forces.

Fig. 3.4.2 illustrates an incident photon that strikes the electron and is scattered in the same direction (0°). At this angle, the scattered photon has the same energy as the incident photon. The photon's energy resonates with the electron's spin energy, causing the greatest amplitude (resonance), and the electron leaves the atom with zero energy – just enough to match the attractive, binding energy.

Using the swing example, from Fig. 1.2.7, imagine a wind that blows in the same direction as the man, also blowing at a given frequency. When the man pushes at the same frequency as the wind, he is aided by it, increasing amplitude with no effort. In an atom with two or more electrons, there would be the equivalent of one or more "winds" that are repelling the electron struck by the photon. The photon is aided by these electrons. A lot of the photon's energy does not need to be absorbed, and therefore some of the energy, if not all, can continue.

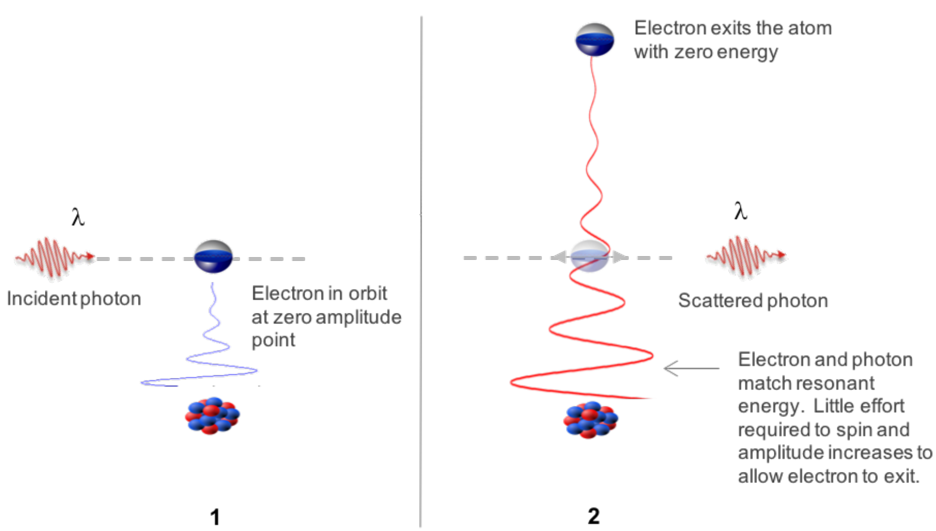


Fig 3.4.2 – Photon Causes Electron to Leave Atom (Compton Scattering)

As the photon's energy increases, the angle of the electron that leaves the atom begins to change. It has an angle of 90° from the incident photon when the scattered photon is 0° and leaves the atom with the zero energy (left example of Fig. 3.4.3).[14] According to experiments, as the energy of the photon increases, the exit velocity of the electron begins to increase and the angle changes closer to 0° (same direction as incident photon), as shown in Fig. 3.4.3.

The explanation of this process is based on constructive wave interference. With minimal energy at resonance, the longitudinal wave amplitude is increased between the nucleus and electron, and the exit is in this direction (parallel to the line between the electron and nucleus). As the photon energy increases, constructive wave amplitude from the photon is also considered, changing the angle as shown in the middle example of Fig. 3.4.3.

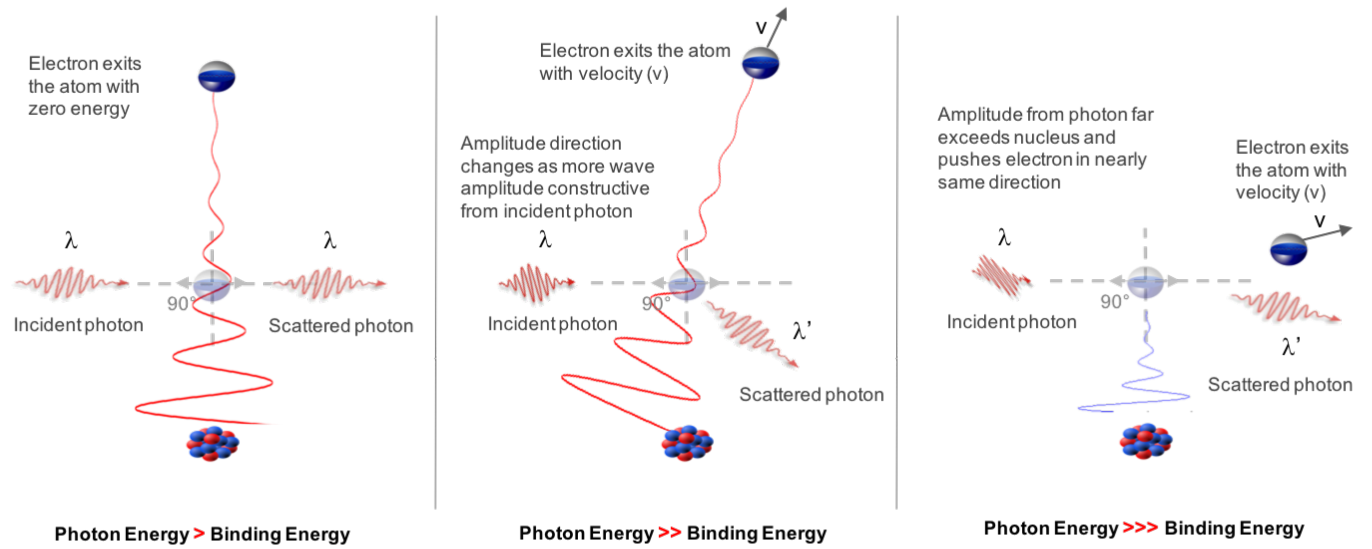


Fig 3.4.3 – Compton Scattering – Change in Photon Energy

Another consideration of the Compton scattering effect is the angle at which the incident photon and scattered photon are measured. Although the position of the electron relative to the proton is not known in these experiments, it can be deciphered from knowing and understanding these interactions. From experiments, it is known that a scattered photon that travels in the same direction as the incident photon transfers the least amount of energy and the backscattered photon transfers the most amount of energy to the electron (from Fig. 3.4.1).

In Fig. 3.4.4, the angles may be explained by the position of the electron relative to the nucleus. The electron and proton in the nucleus contain destructive wave interference. The angle at which the incident photon approaches the electron adds constructively to the repelling force of the proton. This causes the maximum constructive interference when the photon approaches from the same angle as the nucleus and has the least effect when it approaches from a right angle.

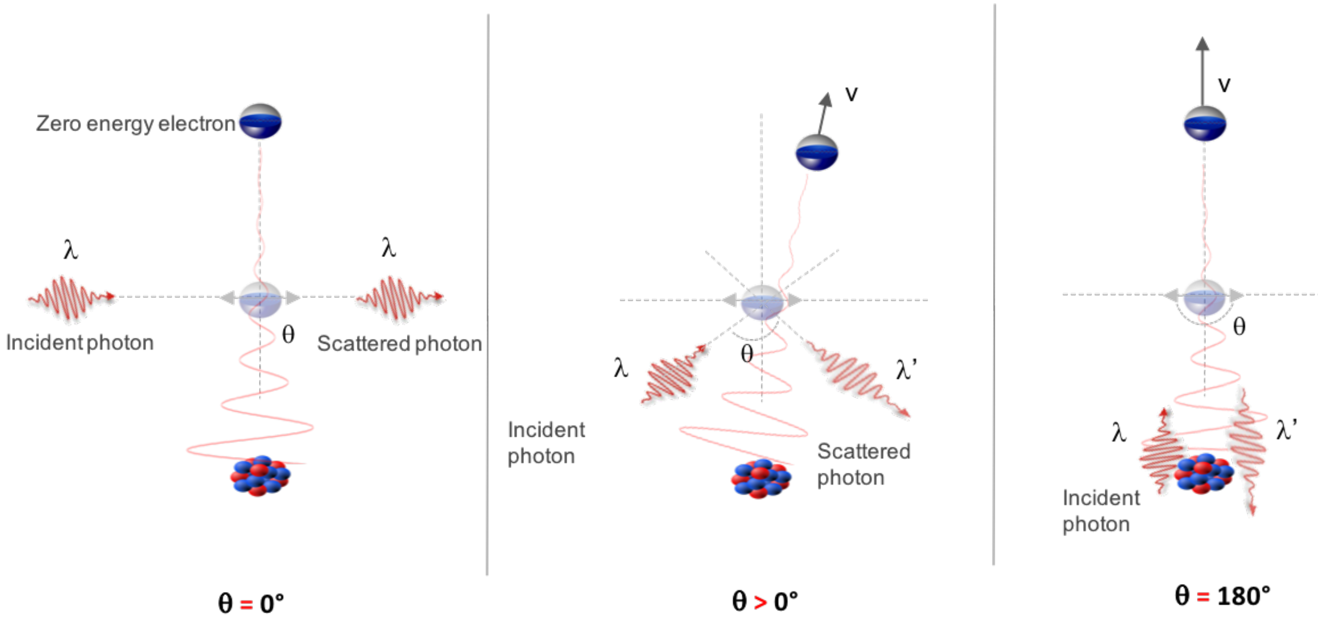


Fig 3.4.4 – Compton Scattering – Change in Photon Angle

3.5. Pair Production

An electron and a positron are known to appear in space, where they did not previously exist, after a high-energy photon (gamma ray) disappears. This process is known as pair production. This process may also occur when a gamma ray strikes the nucleus of an atom (see Fig. 3.3.1).

From the Section 2.1 on Annihilation, the combination of a positron and electron produces destructive waves that collapse the standing wave structure of both particles. The particles have no mass and are not detected by electromagnetic apparatus but the wave centers remain. When a gamma ray strikes these wave centers, they will increase amplitude, causing separation of the particles just like the process in which an electron leaves the atom. In this case, there is not a large nucleus mass to absorb a recoil and so the positron also exits, in the opposite direction of the electron. Once separated, the wave centers continue to reflect longitudinal waves. The reflected out-waves now combine again with in-waves to form the standing wave structure of the particles. Mass has been recreated by this effect of separating the two particles' wave centers.

The same process occurs in an atomic nucleus. From the *Forces* paper, the neutron is a composite particle that contains a positron and an electron in its center. This is also the reason for electron capture that converts a proton (which has a positron in its center) to a neutron. It also matches beta decay experiments, as shown in the same *Forces* paper. With this structure of the neutron, a gamma ray hitting the positron-electron combination would have the same effect of pair production – forcing an electron and a positron from the nucleus. The neutron in the nucleus would still be neutral but it would now be an empty shell of a nucleon. This is described in Fig. 3.5.

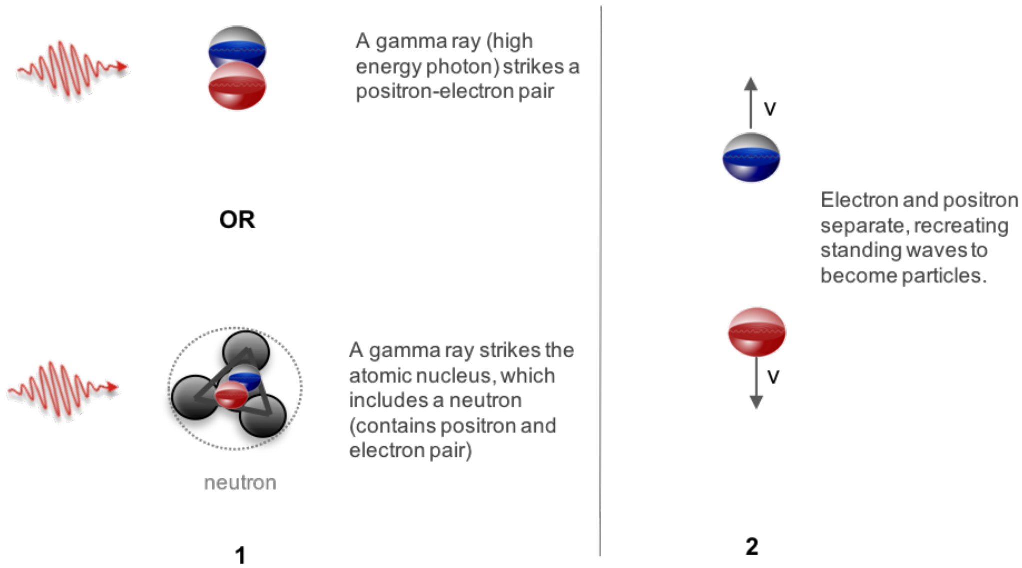


Fig 3.5 – Pair Production of Electron and Positron

4. Conclusion

The photon is a packet of wave energy as a result of a vibration of a particle. A particle – or more specifically its wave centers – are constantly reflecting longitudinal waves which are responsible for the particle's mass and forces. When the particle vibrates, it adds a transverse component to the wave perpendicular to the direction of vibration. In the case of an electron in an atom, it eventually come to rest. The vibration is short-lived and two wave packets flow in opposite directions. A photon contains both a transverse and longitudinal component within the packet, responsible for the electric and magnetic fields.

A photon can be created by the vibration of a particle and it can also be absorbed by the spin of a particle to end the photon's energy. The spin reconverts transverse energy back to longitudinal energy. This behavior is seen in an electron leaving an atom and also when an electron and positron are produced in pair production.

The various scenarios for photon emission were described and match experimental results for spontaneous and stimulated emission from atoms and annihilation for electrons and positrons. The mechanism is similar except the proton is replaced with a positron in the latter case. Likewise, various scenarios were provided for photon absorption, including a transition to higher level orbitals, the photoelectric effect, Compton effect and pair production.

Mathematically, the calculations of photons for emission and absorption energies match experimental evidence when using the energy wave equations. This was shown in previous works, including *Particle Energy and Interaction*. Now, the mechanism for energy transfer can be explained. Likewise, the expected photon and electron angles can be explained against experimental evidence. The photon does not need to be a mysterious entity that exhibits particle-like or wave-like behavior at its own choosing.

Acknowledgements

These findings would not be possible without the research of the late Dr. Milo Wolff, Gabriel LaFreniere and Xavier Borg from whom this theory is based upon as a derivative of the Wave Structure of Matter (WSM). Special thanks to Oyvind Liberg for the assistance with photons. Lastly, my sincere appreciation to my family, who were considerably patient and understanding while I worked on this paper.

References

[1] Wikipedia, *Standard Model*, Online: https://en.wikipedia.org/wiki/Standard_Model (Accessed May 2, 2018).

[2] NobelPrize.org, *The Nobel Prize in Physics 1921*, Online: https://www.nobelprize.org/nobel_prizes/physics/laureates/1921 (Accessed Nov, 2017).

[3] NASA, *The Electromagnetic Spectrum*, Online: https://imagine.gsfc.nasa.gov/science/toolbox/emspectrum1.html (Accessed October, 2017).

[4] Illusterati, *The Photon*, Online: https://commons.wikimedia.org/wiki/File:The_Photon.png (May 2, 2018).

[5] Yee, J., Particle Energy and Interaction, Vixra.org 1408.0224 (2018).

[6] Yee, J., Zhu, Y. and Zhou, G., Atomic Orbitals, Vixra.org 1708.0146 (2018).

[7] Yee, J., Forces, Vixra.org 1606.0112 (2018).

[8] Wikipedia, *Resonance*, Online: https://en.wikipedia.org/wiki/Resonance (Accessed May 2, 2018).

[9] Hyperphysics, *Quantum Processes*, Online: http://hyperphysics.phy-astr.gsu.edu/hbase/mod5.html (Accessed May 2, 2018).

[10] Hyperphysics, *Positron Annihilation*, Online: http://hyperphysics.phy-astr.gsu.edu/hbase/Particles/lepton.html#c5 (Accessed May 2, 2018).

[11] Wikipedia, *Photoelectric Effect,* Online: https://en.wikipedia.org/wiki/Photoelectric_effect (Accessed May 1, 2018).

[12] Wikipedia, *Compton Scattering,* Online: https://en.wikipedia.org/wiki/Compton_scattering (Accessed May 1, 2018).

[13] NuclearPower.Net, *Linear Attenuation Coefficient,* Online: https://www.nuclear-power.net/nuclear-power/reactor-physics/interaction-radiation-matter/interaction-gamma-radiation-matter/gamma-ray-attenuation/linear-attenuation-coefficient/ (Accessed May 1, 2018).

[14] Gunderson, L. and Tepper, J., *Clinical Radiation Oncology* (Elsevier, 2016).