Why a photon is not a particle

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Abstract – The variables and parameters of the presented model for the generation of an arbitrary photon fit like the pieces of a jigsaw puzzle and therefore justify the conclusion that the model eliminates the wave-particle duality of the photon by explicitly excluding the possibility that it can be a (massless) particle too.

Introduction
Considering a photon as an (extremely) short pulse with an electro-magnetic wave as carrier, eliminates the so-called wave-particle duality. This article shows how the origin of such a pulse can be explained by applying Ampère’s and Faraday’s law in Bohr’s atomic model. Using the Rydberg formula and the assumed energy E=hf, the expected pulse durations and their related EM-powers are presented.

Bohr’s atomic model
In Bohr’s atomic model, in case of a stable atom, an equal number of electrons revolve around the nucleus, as there are protons in this nucleus. These electrons can rotate in orbits with different distances with respect to the nucleus. These distances are discreet. In other words: an electron will never orbit in between the determined circles.

The generally accepted concept is that a photon is emitted if an electron jumps out of an inner orbit into a more outer orbit. The question is: how is such a photon precisely generated?

Forces holding the electron in its orbit

An electron is held in its orbit by three forces:
- the centrifugal force trying to eclipse the electron out of its orbit.
- the centripetal gravitational force between nucleus and electron
- the centripetal Coulomb force between nucleus and electron

with:
- \( r \) radius of the orbit of the electron \( m \)
- \( v_e \) velocity of the electron along its orbit \( m/s \)
- \( Z \) atom number
- \( m_e \) mass of the electron \( 9.1*10^{-31} \) kg
- \( m_p \) mass of proton \( 1.7*10^{-27} \) kg
- \( m_n \) mass of the nucleus \( 2Zm_p \) kg
- \( G \) gravitational constant \( 6.7*10^{-11} \) Nm²kg⁻²
- \( k_e \) Coulomb’s constant \( (1/4\pi\varepsilon_0) \) \( 8.99*10^9 \) Nm²C⁻²
- \( q_e \) electric charge of the electron \( 1.6*10^{-19} \) C

The mathematical descriptions of the mentioned forces are:

Centrifugal force: \( F_{cf} = m_e v_e^2 / r \)
Gravitational force: \( F_G = Gm_m m_e / r^2 \)
Coulomb force: \( F_C = k_e q_e^2 / r^2 \)
Remarks:
- $r$ has the discreet values $n^2a_0$, with $a_0$ so called Bohr radius, and $n=1, 2, 3......$
- The mass of a proton is about equal to the mass of a neutron.
- The number of neutrons is taken equal to the number of protons.
- $F_G \sim 10^{-67}Z/r^2$ and $F_C \sim 10^{-28}Z/r^2$, with as expected result that $F_G$ is incomparably small compared to $F_C$.

So, the real number of neutrons does not play any role in this article, neither does $F_G$ anymore.

As a result, the electron is held in its orbit by:

\[ F_{cf} = F_C \]

So:
\[ m_e v_e^2 / r = k_e Z q_e^2 / r^2 \]

from which it follows that:
\[ v_e = \left\{ k_e Z q_e^2 / (m_e r) \right\}^{1/2} \]

The basic idea behind the generation of a photon

The fundamental part of the investigated model is the assumption that the orbit of an electron around the nucleus of an atom is equivalent to a circular shaped electric current, creating a magnetic field.

Suppose the “round trip” of an electron is $s_e$ seconds and its electric charge is represented by the symbol $q_e$. Then the first approximation of the meant electric current is $q_e / s_e = i_e$ ampere. The mentioned “round trip” is equal to $2\pi r / v_e$, with $r$ the radius of the orbit of the electron and $v_e$ the velocity along that orbit.
Such an electric current causes a straight-lined magnetic field $H_e$, perpendicular to plane of the orbit and enclosed by the orbit of the electron.

\[ H_e = i_e / 2r = q_e v_e / 4\pi r^2 = q_e^2 (k_e Z / m_e) \frac{1}{r^2} / 4\pi r^{2.5} \]

As soon as the electron eclipses its orbit, $r$ changes, so the strength of this magnetic field changes. And a change of a magnetic field causes a change of an electric field.

A source of an electro-magnetic wave shows up!

The purpose of this analysis is to investigate whether this idea makes sense or not in relation to the available information about photons.
The conception of “potential energy”

There exists quite a lot of confusion regarding the conception of “potential energy”. It doesn’t concern the related expression, but whether this expression has to be presented as negative or not. In order to avoid this confusion in this article a fundamental explanation of this phenomenon will be presented here. Two situations will be considered: a static and a dynamic one.

Static situation

The static situation is defined as two masses \( m_1 \) and \( m_2 \) at a distance \( r \) in rest with respect to each other. This situation itself is impossible in reality, because the masses will immediately move to each other if they would not be held in that position by an external force. For the ease of discussion it is assumed that some mystique force \( F(r) \) is holding the masses at the mentioned distance \( r \).

It is generally accepted that \( F(r) = Gm_1m_2/r^2 \), with \( G \) the so-called gravitational constant (6.7*10^{-11} \text{ Nm}^2\text{kg}^{-2}). \( F(r) \) will be shortly written as \( C/r^2 \).

Based on the relation “energy equals force multiplied by distance” the potential energy \( E_p \) of the example under consideration is defined as: \( E_p = \int F(r) \, dr = -C/r \).

So, in first instance, a negative sign shows up! However to get a better understanding of the concept of potential energy, the boundaries of this integral have to be considered.

Suppose these boundaries to be \( r_1 \) resp. \( r_2 \), with the result that \( \Delta E_p = +C(1/r_1 - 1/r_2) \).

If \( r_2 > r_1 \) the masses have been towed away from each other and \( \Delta E_p > 0 \), meaning that the system absorbed energy.

If \( r_2 < r_1 \) the masses moved towards each other and \( \Delta E_p < 0 \), meaning that the system released energy.

These conclusions don’t contradict with our expectations.

If \( r_2 \) is chosen \( \infty \), \( \Delta E_p = +C/r_1 \), a result that might lead to confusion, given the above mentioned \( E_p = -C/r \). If \( r_1 \) is chosen \( \infty \), \( \Delta E_p = -C/r_2 \), in accordance with \( E_p = -C/r \).

The confusion about potential energy is made even stronger due to the expression \( mgh \) for gravitational potential energy, with \( h \) the height above the surface of the earth and \( g \) the constant of gravity: 9,81 \text{ m/sec}^2.

If \( r_1 \) is chosen as the radius \( r_e \) of the earth and \( r_2 \) as \( r_e + h \), with \( h \ll r_e \), then \( C(1/r_1 - 1/r_2) \) can be approximated by \( Ch/r_e^2 = G.m_e.m.h/r_e^2 = mgh \), with \( g = G.m_e/r_e^2 \).

Dynamic situation

In this situation the mass \( m_1 \) orbits around \( m_2 \) at distance \( r \). The mystique force, as introduced in the static situation, is now replaced by the real centrifugal force.

Besides that nothing changes in the considerations as shown under “static situation”.
The kinetic and potential energy of an orbiting electron

The kinetic energy $E_k$ of an electron in orbit $r$, versus its potential energy $E_p$ is:

$$E_k = \frac{1}{2}m_e v_e^2 \quad \text{versus} \quad E_p = k_e Z q_e^2 / r$$

(for the moment neglecting the sign of $E_p$)

Applying the above found expression $v_e^2 = k_e Z q_e^2 / (m_e r)$ in $E_k$ results in:

$$E_k = \frac{1}{2}m_e k_e Z q_e^2 / m_e r = \frac{1}{2}k_e Z q_e^2 / r = \frac{1}{2}E_p$$

This compared to the situation of a mass $m_e$ orbiting around a mass $m_n$ shows a gravitational potential energy $E_g = G m_n m_e / r$ versus the kinetic energy $\frac{1}{2}m_e v_e^2$.

Based on $F_C = F_G$ or $G m_n m_e / r^2 = m_e v_e^2 / r$ it follows that $v_e^2 = G m_n / r$.

This applied to the kinetic energy results in $E_k = \frac{1}{2}G m_n m_n / r$, so the kinetic energy in a gravitational situation also equals half the potential energy!

The expressions above show that in both situations the kinetic as well as the potential energy of an orbiting object is proportional to $1/r$.

The obvious conclusion thus is: the larger the orbit, the smaller both kinds of energy.

This conclusion however contradicts the prevailing conception.


**Orbital energy**

In atoms with a single electron (hydrogen-like atoms), the energy of an orbital (and, consequently, of any electrons in the orbital) is determined exclusively by $n$. The $n=1$ orbital has the lowest possible energy in the atom. Each successively higher value of $n$ has a higher level of energy, but the difference decreases as $n$ increases. For high $n$, the level of energy becomes so high that the electron can easily escape from the atom.

As shown in the previous paragraph the system, called atom, absorbs potential energy when an electron jumps to an outer orbit. That means that $\Delta E_p > 0$.

Regarding the kinetic energy the atom releases energy ($v_e$ decreases) so $\Delta E_k < 0$.

Given the fact that $|E_p| = 2|E_k|$, the net result is that the atom absorbs energy, explaining the apparent contradiction.

The electron will not jump to an outer orbit without an outside force that compelled the electron to do so.

Besides that, we know that the atom emits a photon when an electron jumps to an outer orbit.

The end result must be an energy-neutral balance.

It is assumed that the energy from outside the atom will equal $\Delta E_p$, while the released energy $\Delta E_k$ will equal the energy of the photon, as motivated in the next chapter.
Background of the Rydberg expression

Citation from Wikipedia:
“The Planck constant $h$ has been introduced to express the relation between frequency $f$ and energy $E$ for a light quantum (photon) as: $E=hf$.”

Another description shows:
“The Planck constant was first described as the proportionality constant between the energy ($E$) of a photon and the frequency ($f$) of its associated electromagnetic wave.”

The formula $E=hf$ is a non-physical equation, because it suggests that the energy of a photon is proportional to the frequency of its carrier. It is well known that this can, physically speaking, not be true. Only the amplitude of the electro-magnetic wave can be related to its power, thus to its energy, of the photon. Seemingly there is relation between the frequency and the amplitude of the carrier of a photon.

It is generally accepted that the orbits of an electron are discrete. However, up to now nothing in Bohr’s model forces us to such a hypothesis. For whatever radius $r$, the balance between the Coulomb and the centrifugal force is, by definition, perfect. But that would also mean that an arbitrary small orbit radius would be possible, or even worse: that an electron would melt together with a proton to a neutron, resulting in the elimination of the atom. Based on this proof by contradiction it is indeed logical to assume only discrete orbits.

The discrete radii are mathematically represented by $r_n = n^2 a_0 / Z$, with $n$ is an integer. The radius $a_0$ is the so-called Bohr’s radius, the smallest in the neutral hydrogen atom.

The mathematical expression for $a_0$ is found as follows.

The idea behind the quantitative presentation of the discrete radii is based on the assumption, for whatever reason, that the angular momentum $m_e v e r_n$ of the electron is quantized, expressed as:

$$m_e v e r_n = n h / 2\pi$$

Applying this to the relations:

$$F_{cf} = m_e v e^2 / r = F_C = k_e Z q_e^2 / r^2$$

it follows that:

$$r = n^2 h^2 / (4\pi^2 k_e Z q_e^2 m_e)$$

$r$ is defined as $a_0$ for $n=1$ and $Z=1$, so:

$$a_0 = h^2 / (4\pi^2 k_e q_e^2 m_e)$$

The difference in kinetic energy of the electron orbiting in $n_1$ respectively $n_2$, is represented by:
\[ \Delta E_{kn} = \frac{1}{2} m_e (v_{e1}^2 - v_{e2}^2), \quad \text{with: } v_{e2}^2 = k_e Z q_e^2 / m_e r \quad \text{resulting in:} \]
\[ \Delta E_{kn} = (k_e Z q_e^2 / 2) (1/r_{n1} - 1/r_{n2}) = (k_e Z q_e^2 / 2a_0 / Z) (1/n_{12} - 1/n_{22}) \]

Applying the expression for \( a_0 \):
\[ \Delta E_{kn} = \left\{ k_e Z^2 q_e^2 / (2h^2 / (4\pi^2 k_e q_e^2 m_e)) \right\} (1/n_{12} - 1/n_{22}) \]
\[ \Delta E_{kn} = h^2 k_e Z^2 q_e^4 / (4\pi^2 m_e) * (1/n_{12} - 1/n_{22}) \]

With: \( k_e = 1/4\pi \varepsilon_0 \)
\[ \Delta E_{kn} = Z^2 m_e q_e^4 / (4\pi^2 \varepsilon_0^2 h^3 c) * (1/n_{12} - 1/n_{22}) \]

The Rydberg expression is:
\[ 1/\lambda = R_\infty (1/n_{12} - 1/n_{22}) \]

with the following parameters:

| \( \lambda \) | wavelength of the carrier | m |
| \( R_\infty \) | Rydberg’s constant \( (Z^2 m_e q_e^4) / (8\varepsilon_0^2 h^3 c) \) | 1.097*10^7 m^-1 |
| \( h \) | Planck’s constant | 6.626*10^-34 kg m^2 s^-1 |
| \( \varepsilon_0 \) | dielectric permittivity | 8.854*10^-12 A^2 s^4 kg^-1 m^-3 |
| \( \mu_0 \) | magnetic permeability | 4\pi*10^-7 NA^-2 |
| \( c \) | velocity of light in vacuum | 2.999*10^8 m/s |

With: \( hc/\lambda = hf \):
\[ hf = hc * R_\infty (1/n_{12} - 1/n_{22}) \]

Given the experimental evidence of the Rydberg expression it is indeed likely that the assumption, formulated at the end of the previous chapter, is correct: the energy of an emitted photon equals the difference in kinetic energy of the orbiting electron.
Further elaboration of the model

The basic idea behind the generation of a photon is that an orbiting electron is equivalent to a circular shaped electric current. Such an electric current causes a magnetic field \( H_e \), with \( H_e = \frac{q_e^2(k_e Z/m_e)}{4\pi r^2} \), perpendicular to the plane through the orbit of the electron. So, as soon as the electron eclipses its orbit, \( r \) changes, and the strength of this magnetic field changes. A change of a magnetic field causes a change of an electric field, resulting in an EM-field, propagating with velocity \( c \) with respect to the nucleus of the atom.

**Step 1: the eclipse of an electron from n=1 to n=2 in the neutral hydrogen atom**
The value of \( Z \) of this atom is 1. The two radii therefor are: \( r_1 = a_0 = 5.29*10^{-11} \) m and \( r_2 = 2.12*10^{-10} \) m. The magnetic field strengths related to the two equivalent electric currents are calculated as follows:

\[
\begin{align*}
    r_1 &= 0.53*10^{-10} \text{ m} \\
    r_2 &= 2.12*10^{-10} \text{ m} \\
    v_e &= 2.19*10^6 \text{ m/s} \\
    v_e &= 1.09*10^6 \text{ m/s} \\
    s_e &= 1.52*10^{-16} \text{ s} \\
    s_e &= 1.22*10^{-15} \text{ s} \\
    i_e &= 1.05*10^{-3} \text{ A} \\
    i_e &= 1.32*10^{-4} \text{ A} \\
    H_e &= 9.97*10^6 \text{ A/m} \\
    H_e &= 3.11*10^5 \text{ A/m}
\end{align*}
\]

The amplitude of the sinusoidal shaped magnetic field of the carrier of the photon will be represented by \( A_{H_e} \), like \( A_{E_e} \) will be the amplitude of its sinusoidal electric field. The relation between \( A_{H_e} \) and \( A_{E_e} \) is:

\[
A_{E_e} = Z_e A_{H_e} \quad \text{V/m}
\]

where \( Z_e \) is the so called characteristic impedance for vacuum.

\[
Z_v = (\frac{\mu_0}{\varepsilon_0})^{\frac{1}{2}} = 377 \quad \Omega
\]

Based on these two amplitudes the power density of the EM-field is:

\[
P_d = A_{E_e}\sqrt{2} * A_{H_e}/\sqrt{2} = Z_v A_{H_e}^2/2 \quad \text{VA/m}^2
\]

It is assumed that this power density, related to this power density, is constrained by the orbit of the electron from which it eclipses, so the power \( P \) of the photon in this example is:

\[
P = Z_v A_{H_e}^2/2 * \pi r_1^2 \quad \text{W}
\]

This assumption will be argued under: “Intermediate conclusions regarding step 1”

In order to be able to calculate the energy of the photon, with the model under consideration, this power has to be multiplied with the duration of the photon. This duration will be represented by the name pulse width, abbreviated as plsw. In this sense the calculated energy of the photon is mathematically represented by:

\[
E_e = \text{plsw} * Z_v A_{H_e}^2/2 * \pi r_1^2 \quad \text{Joule}
\]

Both the parameters plsw and \( A_{H_e} \) are yet unknown.
Estimation of the pulse width of the photon

It is assumed that the minimum value of the pulse width is one period of the carrier of the photon, because if it would be less it is difficult to imagine that it would be possible to find the energy of the photon to be $E = hf$.

The maximum value is certainly constrained by the round trip time of the orbit to which the electron has been eclipsed, because after that time period the magnetic field is completely stabilized. Applying the Rydberg expression $f$ in this example is calculated as:

$$f = \frac{c}{\lambda} = 2.999*10^8 * 1.097*10^7 \ (1-1/4) = 2.47*10^{15}$$

resulting in $T = 4.05*10^{-16}$

So $4.05*10^{-16} < \text{plsw} < 12.2*10^{-16}$ s

The estimation for the pulse width in this example is that it equals 2 times a period of the carrier: $8.1*10^{-16}$ s. It is considered unlikely that the carrier stops abruptly at an arbitrary moment within such a period.

The power density of the photon in this example can now be calculated as:

$$P_d = \frac{hf}{(plsw*\pi r_1^2)} = 6.626*10^{-34} * 2.47*10^{15} / (8*10^{-16} * \pi * (0.53*10^{-10})^2)$$

$$P_d = 2.29*10^{17}$$

W/m$^2$

So: $Z_w A_H^2/2 = 2.29*10^{17}$ W/m$^2$

Resulting in:

$$A_H = 3.49*10^7$$

A/m

N.B.
This magnetic field strength is of the same order of magnitude as the field strength $H_{e1}$!

In order to obtain more reliance (or maybe not) in the validity of the model, the variable $dH_e/dt$, at the moment of the eclipse, is analysed.

It is assumed that $dH_e/dt$ has its maximum value at the moment the electron eclipses.

At a certain moment the magnetic field strength $H(t)$, belonging to the EM field that will be generated, can be represented by: $H(t) = A_H \sin(\omega t)$ and the next assumption is that this sinusoidal function starts also at the moment the electron eclipses. So, the maximum value of $dH_c/dt$ is assumed to be at $t=0$. This maximum value thus is represented mathematically by $A_H \omega$, with $\omega$ the radial frequency of the carrier of the photon.

The first approximation of $dH_c/dt$ is $\Delta H_c/\Delta t$, with $\Delta H_c = H_{e1} - H_{e2}$ and $\Delta t$ a yet to find appropriate value.

$$A_H \omega = A_H * 2\pi f = 3.49*10^7 * 2\pi * 2.47*10^{15} = 5.41*10^{23}$$

A/ms

Applying $\Delta H_c = H_{e1} - H_{e2} = 9.65*10^6$, leads to $\Delta t = 9.65*10^6 / 5.41*10^{23} = 1.78*10^{-17}$ s
This value for $\Delta t$ is an order of magnitude smaller than the round trip time of the orbit from which the electron eclipses. That doesn’t feel unrealistic and it means that the magnetic field $H_{e1}$, created by the equivalent electric current due to the circular movement of the electron, instantly decreases to a negligible value, compared to this initial field, because $H_{e2} << H_{e1}$.

**Intermediate conclusions regarding step 1**

The model applied to the neutral hydrogen atom where an electron eclipses from the most inner orbit ($n=1$) to the next outer orbit ($n=2$), learns that:

- The length of the photon has to be at least one period of the frequency of its carrier and will certainly be not longer than 3 of these periods.
- Dividing the energy of the photon by the length of the photon the power $[VA]$ of the photon is found. To find a value for the strength of the magnetic, resp. electric field, of the carrier of the photon, $[A/m]$ resp. $[V/m]$, this power has to be divided by the surface to which it belongs. Up to this moment all variables were found to be strongly related to the orbit from where the electron eclipses, so the most likely surface is assumed to be the surface of the orbit from where the electron eclipses: $\pi r_1^2$ in this example.
- Application of these variables shows that the magnetic field strengths of the EM carrier of the photon varies from 4.94 to $2.47*10^7$ A/m, all three of the same order of magnitude as the linear magnetic field strength, generated by the orbiting electron in orbit $n=1$: $7*10^7$ A/m.
- These conclusions justify analyses of other photon emissions, based on the model under consideration.

**Step 2: The eclipse of an electron from n=1 to n=n2 in the neutral hydrogen atom**

In step 1 it is assumed that the length of the photon is two times the period of its carrier, also based on the assumption that it will certainly not be longer than $s_{e2}$. In this step the round trip time $s_m$, with $n \geq 3$, will be much larger than $s_{e2}$. Notwithstanding that feature pls w will, as a first estimate, be taken two times the period independent of $n_2$.

The frequency of the carrier is calculated by means of the Rydberg expression, resulting in as well the length of the photon as $2/f$, as in its energy $E=hf$.

The power of the photon now equals $hf/\pi r_1^2$ (= $\frac{1}{2}hf^2$).

This result divided by the surface $\pi r_1^2$ equals the power density of the photon.

The magnetic field strength $A_H$ is calculated from: $A_H = (2P_d/Z_0)^\alpha$ and $\Delta t$ from: $\Delta t = \Delta H/(A_H \omega)$. This last calculation learned that $\Delta H$ has to be interpreted as: $\Delta H = H_1 - H_{n2}$ and not as $H_1$ notwithstanding the fact that $H_{n2} << H_1$.

The relatively small error in the calculation of $E_c$ for $n_2 \geq 3$, in case $\Delta H$ is chosen to be $H_1$, is completely eliminated for $\Delta H = H_1 - H_{n2}$!
Effectively I found this remarkable result in step 3, due to the fact that the error in $E_n$ grew explosively to > 100% in the Brackett series.

The importance of the correct calculation of $\Delta t$ will be shown later.

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Intermediate conclusions regarding step 2

- The presented values don't show any abnormality, as could be expected, because only the orbit to which the electron eclipses has been changed, while the orbit from where it eclipses proved to be the most important parameter for the quantification of the variables (see step 1).
- $\Delta H$ in the expression $\Delta t = \Delta H/(A_H \omega)$, has explicitly to be interpreted as: $\Delta H = H_1 - H_{n2}$ and not as: $\Delta H = H_1$.
- The results of the calculations justify analyses of other photon emissions, based on the model under consideration.

Step 3: The eclipse of an electron from $n=n_1$ to $n=n_2$ in the neutral hydrogen atom

The related frequencies to these eclipses, as mathematically presented by the Rydberg formula, have been measured by and named after the shown scientists.

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<th>wave length</th>
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<tr>
<td>6</td>
<td>7</td>
<td>Humphreys</td>
<td>12363.5*10^{-9}</td>
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</tbody>
</table>

The table shows that the Lyman series has been analysed under step 2

For all series the relation $hf = \frac{1}{2}m_e(v_{n1}^2-v_{n2}^2)$ has been checked and found to be valid.
The most important conclusion is that the magnetic fields $A_{\text{H}(n_1+1)}$, relative to the magnetic field generated by the orbit of the electron from where it eclipses, increase from a factor 3 to about a factor 7, along the series, if plsw = 2/f.

If plsw is taken $(n_1+1)/f$, this ratio varies over all series from 3.5 to 4.3.

If it is taken $(n_1+2)/f$ this range becomes 2.9 to 3.9.

For all three values of plsw the absolute value of $A_{\text{H}n_2}$, within each series, shows, as function of $n_2$, an increase varying from 1.3 in the Lyman series up to 2.7 in the Humphreys series

Based on this information it is considered more likely that plsw $\approx (n_1+1)/f$.

The model under investigation doesn't give a decisive answer.

Only measurements of the length of the photon will give it.

For all series the same table as presented under step 2 has been calculated and shown in the attachment. N.B. The pulse width in these calculations is $(n_1+1)/f$!

**Final step: The eclipse of an electron from $n=n_1$ to $n=n_2$ in an arbitrary ion**

An arbitrary ion in this study is meant to be a nucleus with Z protons around which one electron is orbiting.

The only basic parameters that change in such a situation are the radii of the orbits, because these are represented by $r_n = n^2a_0/Z$.

So, in fact nothing changes fundamentally, by altering the value of Z.

The Excel spread sheets (not included in this article), that have been used for the calculations for the series mentioned under step 3, indeed don't show any abnormalities by changing Z.

As an example: the length of the photon for $n_1=1$ and $n_2=2$ is $\approx 0.01$ femtosecond for $Z = 9$, while for $Z = 1$ this length is $\approx 1$ femtosecond.
The characteristics of the photon expressed mathematically

In order to understand in detail how a photon looks like, the calculation of the energy is build up by four characteristics of the pulse: frequency, length, power density and surface related to this power density:

\[ E_c = Z_v A_H^2 / 2 * \pi r_1^2 * \text{plsw}(f) \]

With \( A_H = (\Delta H / \Delta t) / 2\pi f \) and \( \text{plsw} = (n_1+1) / f \) this can also be written as:

\[ E_c = \{Z_v \Delta H^2 \Delta t^{-2} (2\pi f)^{-2}\} / 2 \pi r_1^2 * (n_1+1) / f \]

The analyses described under step 2 and 3 proved that \( \Delta H = H_{n1} - H_{n2} \), from now on presented as \( \Delta H_{n1,n2} \). \( \Delta t \) will be presented as \( \Delta t_{n1,n2} \), \( f \) as \( f_{n1,n2} \) and \( r_1 \) as \( r_{n1} \).

As a result \( E_c \) will be presented as \( E_{n1,n2} \) and can be written as:

\[ E_{n1,n2} = \{Z_v \Delta H_{n1,n2}^2 \Delta t_{n1,n2}^{-2} (2\pi f_{n1,n2})^{-2}\} / 2 \pi r_{n1}^2 * (n_1+1) / f_{n1,n2} \]

If \( \Delta t_{n1,n2} \) is now considered as an unknown variable and \( E_{n1,n2} \) is replaced by the known variable \( hf_{n1,n2} \), then:

\[ \Delta t_{n1,n2}^{-2} = hf_{n1,n2} * \{Z_v^{-1} \Delta H_{n1,n2}^{-2} * (2\pi f_{n1,n2})^{-2}\} * 2 \pi r_{n1}^{-2} * f_{n1,n2} / (n_1+1) \]

This equation applied in the formula for power density: \( Z_v \{(\Delta H / \Delta t) / 2\pi f\}^2 / 2 \) leads to:

\[ P_d = (hf_{n1,n2}^2 / \pi r_{n1}^2) / (n_1+1) \]

thus \( E_{n1,n2} \) presented as: “power density * surface * pulse width” to:

\[ E_{n1,n2} = (hf_{n1,n2}^2 / \pi r_{n1}^2) / (n_1+1) * \pi r_{n1}^2 * (n_1+1) / f_{n1,n2} \]

Presented as: “power * pulse width”:

\[ E_{n1,n2} = (h f_{n1,n2}^2) / (n_1+1) * (n_1+1) / f_{n1,n2} \]

Presented as generally accepted:

\[ E_{n1,n2} = h f_{n1,n2} \]

The magnetic resp. electric field strength of the carrier of the photon can, based on the presented model, thus be calculated from an expression that only consists of the Rydberg parameter \( f_{n1,n2} \) and the atom parameters \( n_1 \) and \( r_{n1} \), assumed that the length of the photon is \( (n_1+1) / f_{n1,n2} \).

\[ A_H = hf_{n1,n2}^2 / \pi r_{n1}^2 / (n_1+1) \] A/m

\[ A_E = Z_v A_H \] V/m

This proves that the particle-wave duality of a photon has been eliminated by this model, because what might yet be the reason to qualify a photon as a particle (too)?
Conclusions

The study has proven that the generation of a photon can be explained by considering an orbiting electron in an atom as an electric current. This current causes a straight-lined magnetic field, perpendicular to plane of the orbit and enclosed by the orbit of the electron. As soon as the electron eclipses to a more outer orbit, this magnetic field decreases rapidly and cause through this an electric field. A source of an EM filed has been created.

Calculations, carried out on this model, proved that this principle indeed works, but above all it also gives an impression of the length of the photon. Real values have to be gained by measurements.

Based on the educated estimates of the length of the photon, the power of the photon can be calculated and as a result the strength of the magnetic and electric field of the carrier of the photon.

As a result it can be concluded that this model eliminates the wave-particle duality.

Einstein wrote about this duality the following;
"It seems as though we must use sometimes the one theory and sometimes the other, while at times we may use either. We are faced with a new kind of difficulty. We have two contradictory pictures of reality; separately neither of them fully explains the phenomena of light, but together they do".

My words:
Nature doesn't deal with dualities, paradoxes or contradictions. Judgments like these are created by mankind, not understanding a certain phenomenon. Physical science should not accept these kinds of judgements.

See the ‘Encore’ on the next page too.
Encore

The presented model of the generation of a photon is based on Ampère’s and Faraday’s law, bound together in the Maxwell laws, normally called Maxwell’s equations. By working out Maxwell’s equations, the velocity of light in vacuum is calculated as \( c \).

N.B. Maxwell lived in the century that the ether-model was generally accepted within the scientific community. As a result the reference for \( c \) was by definition this ether.

The Principle of Relativity states: all physical laws are the same in all inertial systems.

The inner part of an atom and its direct surrounding is by definition vacuum. Applying the Principle of Relativity in the presented model leads to the conclusion that a photon, generated by an atom, based on the mentioned physical laws, must have a propagation velocity \( c \) w.r.t. this atom, \textit{whatever the velocity of this atom might be}.

Effectively this is the so-called emission theory, vigorously rejected by the community of physicists.

To quote Wikipedia:

“Emission theories obey the principle of relativity by having no preferred frame for light transmission, but say that light is emitted at speed “\( c \)” relative to its source instead of applying the invariance postulate.”

Einstein’s Special Theory of Relativity is based on the hypothesis of a system “in rest” w.r.t. which the velocity of light in vacuum would be \( c \).

The community of physicists realized that this system “in rest” is equivalent to the, by Einstein himself, abandoned ether-model and therefore slinky changed his hypothesis in: \( c \) w.r.t. any inertial system, known under the expression: “invariance postulate”.

In this way a “not-Einstein” Special Theory of Relativity has been created, of which the hypothesis is fundamentally contradictory with Einstein’s hypothesis!

N.B.

\[ A \text{ postulate is an assumption, so self-evident that further evidence, if it would be possible to deliver it at all, is not required. } \]
\[ A \text{ hypothesis is an assumption that needs yet to be proven. } \]

One of the consequences of the invariance hypothesis is that the velocity of light in vacuum is also \( c \) w.r.t. its source, \textit{whatever the speed of that source might be}!

But that same community of physicists seemingly excludes this inertial system from all the “any inertial systems”, as put forward in the invariance hypothesis!

This inconsequence, the contradiction between Einstein’s hypothesis and the invariance hypothesis and the contradiction of both these hypotheses with the Principle of Relativity, leads to the unavoidable conclusion that the Special Theory of Relativity has to be rejected.

Regarding the velocity of light: only the emission theory can be valid.
It is indeed a \textit{theory}, not a hypothesis.

See also: http://vixra.org/abs/1504.0234 and http://vixra.org/abs/1502.0080
Attachment

**Lyman series**

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# Pfund series

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<th>(1/\omega T)</th>
<th>(plsw)</th>
<th>(hf/plsw)</th>
<th>(P_d)</th>
<th>(A_H)</th>
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# Humphreys series

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