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# A CALCULATION ABOUT PHOTON EMISSION INSIDE SPACE-TIME GEOMETRY FOR A HYDROGEN ATOM

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## Abstract

The aim of this paper is try to calculate photon emission inside Space-Time Structure, using as starting point the Rydberg equation and the Balmer and Lyman Series. From previous calculations, we are going to establish four premises as basis for calculations:

1. The Space-Time is quantized in energy linked equidistant vertices, separated by the Compton electron wavelength [1] and frequency in Space and Time $(X, Y, Z, t)$, forming the fourth dimensions described by Relativity [2], acquiring the following values $\lambda_{ce} = 2.42 \times 10^{-12}\text{m}$ and $t_{ce} = 8.09 \times 10^{-21}\text{s}$ or $f_{ce} = 1.236 \times 10^{20}\text{s}^{-1}$.

2. Therefore, the Space-Time would be an omnitensional Structure [3] with the capability to hold the energy and mass, allowing atoms and photons quantized movement from vertex to vertex. The Space-Time curvature would be produced by an angle change between Structural vertices.

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3. The inverse of the Fine Structure Constant 137.035 [4], would be related to the same Space-Time Structure, associated to the electron movement, in its minimum energy state.

4. Our Physics could be translated to what we call, Structural or Space Time units, where eliminated the arbitrariness of our System of units (S.I.), would arise the connections between the different Universal Constants and a more clear vision of the equations found.

## 1. Rydberg Equation, Electron Movement inside Space-Time Structure

The equation that describes the wavelength emitted by the different excited levels of hydrogen atom, was discovered empirically by Balmer in 1885, later improved in 1889 by Rydberg [5], following the expression:

$$\frac{1}{\lambda} = R_H\left(\frac{1}{n_1^2} - \frac{1}{n_n^2}\right), \tag{1}$$

where $\lambda$ is the photon wavelength, $R_H$ the Rydberg Constant whose value is $1.097 \times 10^7\,\mathrm{m}^{-1}$, $n_1$ and $n_n$ are the main Quantum Numbers that depends on the photon energy absorbed/emitted by the electron.

Making an energy balance, it could be derived this formula:

$$h \times f_n = \frac{1}{2} \times h \times f_2 + h \times f_f, \tag{2}$$

where $f_2$ represents the minimum electron frequency, $f_f$ the photon frequency and $f_n$ the whole energy acquired by the electron, using this expression, we can begin to introduce Structural Units, where the frequency is the speed of the electron $(v_{e2} = c/137.035)$, $c$ being the speed of light and $137.035$ the inverse of Fine Structure constant, divided by the Bohr diameter [6] and $\lambda_{ce} \times N$ represents the times that the Bohr diameter grows when a photon is absorbed:

$$f_2 = \frac{v_{e2}}{\lambda_{ce} \times 137.035}, \tag{3}$$

$$f_n = \frac{v_{en}}{\lambda_{ce} \times N}. \tag{4}$$

From the formula (2) making the full transformation to Structural Units we obtain:

$$\frac{1}{N_f^2} = \frac{1}{2 \times 137.035^2} - \frac{2}{N^2}, \tag{5}$$

where $N_f^2$ is the number of Space-Time units that characterizes a photon, and can be translated as:

$$\lambda = \lambda_{ce} \times N_f^2. \tag{6}$$

As we established in the four premises, the Space-Time would be formed by equidistant energy vertex separated by $\lambda_{ce}$, then the wavelength of a photon divided by the vertex separation or Compton electron wavelength, would give a square of $N_f$ vertices side, translated to Structural Units and emitted as a Space-Time area.

Also, these two formulas are derived:

$$N_f^2 = \frac{m_e \times c^2}{h \times f_f}, \tag{7}$$

$$2 \times 137.035^2 = \frac{m_e \times c^2}{h \times f_e}, \tag{8}$$

where it can be seen more clearly, the possible relationship between squares of Space-Time Structure and photon emission.

## 2. Integer Quantum Numbers in the Balmer Series

Although, it is established that the Quantum numbers in Rydberg equation are integer numbers, because the energy is quantized, it remains a mystery how the Quantum Numbers are related to the only allowed photon wavelengths, in other words, why the photon emission is only produced at this determinate energies. This Space-Time interpretation tries to answer this question.

The Balmer series is defined by the following wavelengths and Quantum Numbers, being 2 the minimum energy state:

$$3 - 2 = 656.3\,\text{nm},$$

$$4 - 2 = 486.1\,\text{nm},$$

$$5 - 2 = 434.1\,\text{nm},$$

$$6 - 2 = 410.2\,\text{nm},$$

$$7 - 2 = 397\,\text{nm},$$

$$8 - 2 = 388.9\,\text{nm},$$

$$9 - 2 = 383.5\,\text{nm}.$$

The frequency of the minimum electron energy, can be defined as the half of its speed divided by Bohr diameter:

$$f_e = \frac{v_{e2}}{2 \times \lambda_{ce} \times 137.035} = 3.29 \times 10^{15}\,\text{s}^{-1}. \tag{9}$$

And the photon frequency can be calculated as:

$$f_f = \frac{c}{\lambda}. \tag{10}$$

Then, it can be checked this relationship between Quantum Numbers and the electron and photon frequencies:

$$\frac{f_f}{f_e} = \left(\frac{1}{n_1^2} - \frac{1}{n_n^2}\right). \tag{11}$$

Translating it to Structural Units, using the formula, $\lambda = \lambda_{ce} \times N_f^2$

$$\frac{N_e^2}{N_f^2} = \left(\frac{1}{n_1^2} - \frac{1}{n_n^2}\right), \tag{12}$$

where $N_e^2 = 2 \times 137.035^2$ is the minimum electron energy in Structural units and $n_1^2 = 4$ is the minimum Quantum Number, clearing $n_n^2$, we obtain:

$$n_n^2 = \frac{N_f^2}{0.25 \times N_f^2 - 2 \times 137.035^2}. \tag{13}$$

We have provided different photon wavelengths in Table 1. We have put intentionally not allowed wavelengths in black. In red there is the Balmer series allowed wavelengths, we can see that the photon emission seems to be admitted when the quotient between the Space-Time photon square is an integer number of the little square derived from the difference between minimum energy electron and $1/4$ of Space-Time photon square area, a geometrical relationship with a mathematical equation, as this condition is not accomplished for the other wavelengths, the emission would not be allowed.

**Table 1.**

| Wavelength | Square area | Square side | Quantum number squared | Quantum number | Little square area | Large square side/Little square side |
|---|---|---|---|---|---|---|
| 7.00E–07 | 288503.9422 | 537.1256298 | 8.34578916 | 2.888907953 | 34568.8031 | 2.888907953 |
| 6.56E–07 | 270493.0532 | 520.0894666 | 8.996618299 | 2.99943633 | 30066.08086 | 2.99943633 |
| 5.00E–07 | 206074.2444 | 453.9540114 | 14.76030767 | 3.841914583 | 13961.37866 | 3.841914583 |
| 4.861E–07 | 200345.3804 | 447.599576 | 15.9903248 | 3.998790418 | 12529.16266 | 3.998790418 |
| 4.50E–07 | 185466.82 | 430.6585887 | 21.0529934 | 4.588354105 | 8809.522546 | 4.588354105 |
| 4.341E–07 | 178913.659 | 422.9818661 | 24.94880258 | 4.994877634 | 7171.232303 | 4.994877634 |
| 4.25E–07 | 175163.1078 | 418.5249189 | 28.09985603 | 5.300929733 | 6233.594491 | 5.300929733 |
| 4.102E–07 | 169063.3101 | 411.1730902 | 35.90487437 | 5.992067621 | 4708.645082 | 5.992067621 |
| 4.00E–07 | 164859.3955 | 406.0288112 | 45.07228815 | 6.713589811 | 3657.666436 | 6.713589811 |
| 3.97E–07 | 163622.9501 | 404.5033375 | 48.86374771 | 6.990260918 | 3348.555069 | 6.990260918 |
| 3.93E–07 | 161974.3561 | 402.4603783 | 55.16073871 | 7.427027582 | 2936.40658 | 7.427027582 |
| 3.889E–07 | 160284.5473 | 400.3555261 | 63.75793795 | 7.98485679 | 2513.954379 | 7.98485679 |
| 3.86E–07 | 159089.3167 | 398.8600214 | 71.81886189 | 8.474600987 | 2215.146725 | 8.474600987 |
| 3.84E–07 | 1.58E+05 | 3.98E+02 | 8.07E+01 | 8.99E+00 | 1.96E+03 | 8.985715694 |

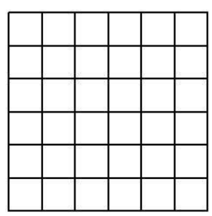

**Figure 1.** A representation of a photon emitted with Quantum number $= 6$ where each small square is the denominator of the formula (13).

## 3. Lyman Series

In a similar derivation, it can be found the Structural units formula for Lyman Series, starting from the known equation:

$$\frac{1}{\lambda} = R_H\left(1 - \frac{1}{n_n^2}\right). \tag{14}$$

It can be obtained:

$$n_n^2 = \frac{N_f^2}{N_f^2 - 2\times 137.035^2}. \tag{15}$$

Lyman Series is provided in Table 2, where it can be checked the relation between squares, also as in Balmer Series.

**Table 2.**

| Wavelength | Square area | Square side | Quantum number squared | Quantum number | Little square area | Large square side/Little square side |
|---|---|---|---|---|---|---|
| 1.216E–07 | 50117.256 | 223.86883 | 3.99020 | 1.99754 | 12560.0738 | 1.99754 |
| 1.025E–07 | 42245.220 | 205.53642 | 9.01128 | 3.00187 | 4688.0376 | 3.00187 |
| 9.72E–08 | 40060.833 | 200.1520 | 16.300096 | 4.00096 | 2503.6506 | 4.00012 |
| 9.49E–08 | 39112.891 | 197.76979 | 25.14151 | 5.01413 | 1555.7091 | 5.01413 |
| 9.37E–08 | 38618.313 | 196.51542 | 36.39354 | 6.03270 | 1061.1309 | 6.03270 |
| 9.30E–08 | 38329.967 | 195.78040 | 49.59978 | 7.04271 | 772.7849 | 7.04271 |

We also could derive that as much energy has a photon, less Space-Time area would occupy.

## 4. Conclusions

Once established the four starting premises, it could be derived a calculation that seems to give an explanation of why the Quantum numbers are integer numbers, being the Space-Time Geometry the possible responsible of photon quantized emission, as it seems to point the calculations in hydrogen atom.

It can be useful to translate our Physics to Structural Units, where it would be easier to understand that Physics could be the result of Geometrical and Mathematical relationships.

The photon would be transmitted from vertex to vertex of Space-Time Structure forming squares in proportions of electron minimum energy.

### 5. Experimental Implications, Double Slit Experiment

When Eddington demonstrated the General Relativity Theory described by Einstein in 1919 [7], also established the strong relation between photons and Space-Time, photons follow the curved Space-Time shape. The calculations done in this manuscript seems to point, that photons in a hydrogen atom are emitted forming determined energy Space-Time squares. We are going to try to relate the Double-slit experiment [8] to this calculation. When a beam of photons has to pass through a narrow hole it is observed a change in emission pattern, after the hole the beam is transformed into separated waves, defining the photon duality between particle and wave. Following the calculations done in this paper, we propose that what is happening after the narrow hole is a Space-Time adjustment, when the photon flux arrives to the narrowing, its spatial area does not allow it to momentarily go to the other side, but the flexibility of the Space-Time Structure would allow its curvature to maintain the flow, as this adjustment would has a time delay, the photons would be emitted by wave pulsations after the hole. The conclusion would be that photons could also change Space-Time Structure, as we know that acceleration is produced by Space-Time bending, the experimental proof of this paper would be to produce acceleration narrowing a photon flux.

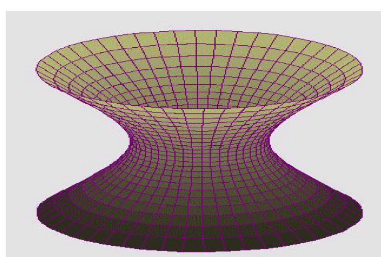

**Figure 2.** A proposition of Space-Time shape during Double-slit experiment as a hyperboloid.

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