

# On Anthropomorphic Principles and the Planck Fine-structure Constant

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*In this paper I introduce a new Planck unit - the Planck fine-structure constant –. Then, from the relativistic model of the hydrogen atom I prove that this new constant is consistent with the existence of the hydrogen atom. Therefore, it seems natural to extend this concept to the rest of the laws of physics stating that the laws of physics are consistent with the appearance of life in the universe.*

**Keywords:** *Planck's constant, Fine-structure constant, electromagnetic coupling constant, atomic constant, Planck charge, Planck fine-structure constant, Planck electromagnetic coupling constant, Planck atomic constant.*

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## 1. Introduction

The fine structure constant, commonly denoted  $\alpha$ , was introduced by the German physicist Arnold Sommerfeld in the year 1916. This constant is one of the most enigmatic constants of nature. The American physicist Richard Feynman referred to this constant with these words:

*"It's one of the greatest damn mysteries of physics: a magic number that comes to us with no understanding by man. You might say the "hand of God" wrote that number, and "we don't know how He pushed his pencil." We know what kind of a dance to do experimentally to measure this number very accurately, but we don't know what kind of dance to do on the computer to make this number come out, without putting it in secretly!" [1]*

The Austrian-born physicist Wolfgang Pauli also referred to this constant as follows:

*“The theoretical determination of the fine structure constant is certainly the most important of the unsolved problems of modern physics.” [2]*

The American physicist John Wheeler quoted:

*“But some numbers, called dimensionless numbers, have the same numerical value no matter what units of measurement are chosen. Probably the most famous of these is the ‘fine-structure constant,’ .... Physicists love this number not just because it is dimensionless, but also because it is a combination of three fundamental constants of nature.” [3]*

The British mathematician and physicist Roger Penrose quoted:

*“There are considerable mysteries surrounding the strange values that Nature’s actual particles have for their mass and charge. For example, there is the unexplained ‘fine structure constant’ ... governing the strength of electromagnetic interactions, ...” [4]*

The American physicist Frank Wilczek quoted:

*“QED reduces ... ‘all of chemistry and most of physics,’ to one basic interaction, the fundamental coupling of a photon to electric charge. The strength of this coupling remains, however, as a pure number, the so-called fine-structure constant, which is a parameter of QED that QED itself is powerless to predict.” [5]*

Despite the fact that, so far, no theory has been successful enough to predict the value of the fine-structure constant, QED has achieved a great success in explaining the electromagnetic interactions. In section 3 I shall define another constant with a remarkable property that will give us a better understanding of the universe.

## 2. The Planck Fine-structure Constant

The fine-structure constant is defined by the following formula

$$\alpha = \frac{e^2}{2\epsilon_0 h c} \quad (2.1)$$

The Planck charge is defined by

$$Q_P = \sqrt{2\epsilon_0 h c} \quad (2.2)$$

Now let me define the Planck fine-structure constant, that I shall denote  $\alpha_P$ , as

$$\alpha_P = \frac{Q_P^2}{2\epsilon_0 h c} \quad (2.3)$$

Where I have replaced the elementary charge,  $e$ , with the Planck charge,  $Q_P$ . From equations (2.2) and (2.3) we get

$$\alpha_P = \frac{(\sqrt{2\epsilon_0 h c})^2}{2\epsilon_0 h c} \quad (2.4)$$

Which gives

$$\alpha_P = \frac{2\epsilon_0 h c}{2\epsilon_0 h c} \quad (2.5)$$

Finally

$$\text{Planck fine-structure constant} \quad \alpha_P = 1 \quad (2.6)$$

Thus, we find that the value of the Planck fine-structure constant is 1. But what does this value mean? In other words, what is the physical meaning of this constant or unit? To answer this question we need additional knowledge. The reader may ask: where can we find this knowledge? in the relativistic model of the hydrogen atom. The reader may also ask: isn't the Bohr model enough to answer this question? Unfortunately, the answer is no. The Bohr model's equations are very nice and simple but they don't show the role of the fine-structure constant simply because the model is not relativistic. In the remainder of this article I shall find the meaning of this new Planck constant by looking at the formula for the radius of the hydrogen atom.

### 3. The Relativistic Atomic Model

The relativistic model of the hydrogen atom that I formulated in 2014 [6], predicted that the radius of the hydrogen atom is a function of the quantum number  $n$  and the fine-structure constant (let me put it this way although the fine-structure constant is not a variable). According to this formulation the atomic radius turned out to be

$$r_n = \left( n \sqrt{\frac{n^2}{\alpha^2} - 1} \right) \frac{h}{2\pi m_0 c} \quad (3.1)$$

$n = 1, 2, 3, 4 \dots$

Where  $n$  is the quantum number that takes integers values. From this formula we deduce that the hydrogen atom can exist, if and only if, the square root yields a positive number. Then, the condition for the existence of hydrogen is

$$\frac{n^2}{\alpha^2} - 1 > 0 \quad (3-2)$$

which means that

$$\alpha < n \quad (3-3)$$

The lowest value of the second side of inequation (3-3) occurs when  $n = 1$  (the lowest quantum number). Thus, we can rewrite the condition for the existence of hydrogen as

$$\text{Condition for the existence of hydrogen} \quad \alpha < 1 \quad (3-4)$$

But because the fine-structure constant is defined as

$$\alpha = \frac{e^2}{2\epsilon_0 h c} \quad (3-5)$$

Then we can write

$$\frac{e^2}{2\epsilon_0 h c} < 1 \quad (3-6)$$

Solving this inequation for the speed of light, we get

$$c > \frac{e^2}{2\epsilon_0 h} \quad (3-7)$$

Now we define the constant  $c_H$  as

$$c_H \equiv \frac{e^2}{2\epsilon_0 h} \quad (3-8)$$

$$c_H = 2\,187\,691.266 \frac{m}{s}$$

$c_H$  is the speed of the electron in its fundamental or lowest energy level. This velocity is also known as  $v_1$ . However, since this constant is a threshold for the speed of light (in vacuum) to ensure the existence of the hydrogen atom, we shall use a new nomenclature,  $c_H$ , to indicate that this constant is a new constant of nature. Now inequation (3-7) can be rewritten as follows

$$c > c_H \quad (3-9)$$

This inequation reveals one of the most important conditions for the existence of hydrogen in the universe

*A necessary condition for the existence of hydrogen atoms is that the fine-structure constant to be less than 1:*

$$\text{Condition for the existence of hydrogen} \quad \alpha < 1 \quad (3-10 = 3.4)$$

Since  $\alpha = 0.007\,297\,352\,57$ , this condition is satisfied.

Comparing eq. (2.6) with the last inequality, ineq. (3.4), we find out that the Planck fine-structure constant represents the limit for the existence of the hydrogen atom. In other words, if the fine-structure constant were greater or equal than the Planck fine-structure constant, then hydrogen wouldn't have formed. In turn, this means that water wouldn't have formed either. And without water life wouldn't have arisen, at least, as we know it.

## 4. Conclusions

As a result of the discussions of the previous sections we may write

$$\alpha < \alpha_p \quad (4.1)$$

This expression is telling us that the universe “knows” what the condition for the existence of life is. This condition is written in the value of the Planck fine-structure constant:

$$\text{Planck fine-structure constant} \quad \alpha_p = 1 \quad (4.2)$$

This is a remarkable result that I did not see when I wrote the relativistic model of the hydrogen atom. The following table summarizes the findings of this paper.

CONDITION	Would hydrogen have formed?	Would life have arisen? (as we know it)
$\alpha < \alpha_p$ or, equivalently $\alpha < 1$	Yes	Yes
$\alpha \geq \alpha_p$ or, equivalently $\alpha \geq 1$	No	No

**Table 1:** The necessary condition for the formation of hydrogen atoms and for life to arise.

In summary, the formation of hydrogen atoms requires that the fine-structure constant to be less 1. As we all know, nature satisfies this condition beautifully since the value of this constant is, approximately,  $0.007\,297\,352\,57$ . However, and more importantly, nature showed us, in a very simple mathematical form, that the value of the Planck fine-structure constant is 1, exactly the boundary that separates universes with life forms from universes

without them (at least as we know it). What a fantastic coincidence! How did nature know what the limit for the existence of life was? I think, this would indicate that the idea of an anthropomorphic principle, dictating the laws of physics, could be correct.

## Appendix 1

### Nomenclature

I shall use the following nomenclature for the constants and variables used in this paper

- $\alpha$  = fine-structure constant (electromagnetic coupling constant, atomic structure constant)
- $c$  = speed of light in vacuum
- $h$  = Planck's constant
- $e$  = elementary charge
- $\epsilon_0$  = permittivity of vacuum
- $c_H$  = speed of the electron in its fundamental or lowest energy level
- $Q_p$  = Planck electric charge
- $\alpha_p$  = Planck fine-structure constant
- $QED$  = quantum electro-dynamics

For the rest of the symbol please refer to reference [6]

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