The Fine Structure Constant and the Scale Principle

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Earlier this year I wrote a paper entitled Scale Factors and the Scale Principle. In that paper I formulated a new law which describes nature at both quantum and cosmic scales. This paper shows that the fine structure constant is a special case of the abovementioned formulation.

***Keywords**: Fine structure constant, Planck scale, Planck length, Planck mass.*

1. Introduction

In a previous article [1] I introduced the scale principle or scale law through the following mathematical relationship

(1)

Scale principle or scale law
$\left(\frac{Q_1}{Q_2}\right)^n \left[\leq \mid = \mid \geq\right] S \left(\frac{Q_3}{Q_4}\right)^m$

Where

a) Q_1, Q_2, Q_3 and Q_4 are physical quantities of identical dimension (such as Length, Time, Mass, Temperature, etc), or

b) Q_1 and Q_2 are physical quantities of dimension 1 or dimensionless constants while Q_3 and Q_4 are physical quantities of dimension 2 or dimensionless constants. However, if Q_1 and Q_2 are dimensionless constants then Q_3 and Q_4 must have dimensions and vice versa.
The physical quantities can be variables, constants, dimensionless constants, differentials, etc.
(e.g.: Q_1 and Q_2 could be quantities of Mass while Q_3 and Q_4 could be quantities of Length).

c) The relationship is one of three possibilities: **less than or equal to** inequation ($\leq$), or an equation (=), or a **greater than or equal to** inequation ($\geq$).

d) S is a dimensionless scale factor (this factor could be real numbers, complex numbers, a real function or a complex function)

e) n and m are integers 0, 1, 2, 3,… (In general these two numbers are different, e.g. 1: n =1 and m = 1. e.g. 2: n = 1 and m = 2. n and m cannot be zero in the same relationship.)

2. The Fine Structure Constant

I shall show that the fine structure constant (also known as the electromagnetic coupling constant) given by

$$\alpha = \frac{e^2}{2\varepsilon_0 h c} \qquad (2)$$

obeys the scale principle. Let us start with the scale table given below

Fundamental Constant *(exponent = 1)*	Charge (Planck Scale) *(exponent = 2)*	Charge (electron/proton) *(exponent = 2)*	Constant (real number 1) *(exponent = 1)*
α	Q_P	e	1

α	Q_P^2	e^2	1

TABLE 1*: This simple scale table is used to show that the formula for the fine structure constant obeys the scale law.*

Where

α = fine structure constant.
Q_P = Planck charge
e = electron charge

According to the above scale table we write the following relationship

$$\alpha\ Q_P^2 = S e^2 \times 1 \qquad (3)$$

As always we have introduced the scale factor S.
Equation (2) can be rewritten in the form of the scale principle

$$\frac{\alpha}{1} = S\left(\frac{e}{Q_P}\right)^2 \tag{4}$$

Thus equation (3) has the form of the scale principle (relationship 1)

$$\frac{Q_1}{Q_2} = S\left(\frac{Q_3}{Q_4}\right)^2 \tag{5}$$

Where

$n = 1$
$m = 2$
$Q_1 = \alpha$ (dimensionless)
$Q_2 = 1$ (dimensionless)
$Q_3 = e$ (Coulombs)
$Q_4 = Q_P$ (Coulombs)
$S =$ to be determined by a separate analysis.

If we take a scale factor of 1 then we can rewrite equation (4) as follows

$$\alpha = \frac{e^2}{Q_P^2} \tag{6}$$

Taking into account the definition of Planck charge

$$Q_P = \sqrt{2\varepsilon_0 h c} \tag{7}$$

And substituting Q_P in equation (6) with the second side of equation (7) we get

$$\alpha = \frac{e^2}{2\varepsilon_0 h c} \tag{8}$$

Thus we have proved that the expression for the fine structure constant is a special case of the scale principle. This result suggests that when we apply the scale principle to find the expression for a fundamental constant such as the fine structure constant, the scale factor is always one. However we don't have a valid proof about this conjecture.

3. Conclusions

Taking into consideration that the scale law describes several known laws of physics as I have shown both on previous papers [1, 2, 3] and on this paper, we can consider the scale law as a more general law than the specific laws it describes.

It is worthy to remark that some Planck units or constants such as the Planck mass, the Planck charge and the Planck acceleration are not found in nature. They are Meta constants. Therefore it is reasonable to consider the scale principle as *a Meta law* or *hyper law (a law model)* nature applies to a wide range of phenomena. Meta laws, if there is more than one, are an integral part of nature and are as real as any other physical law.

REFERENCES

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