The Heisenberg Uncertainty Principle and the Scale Principle

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Earlier this year I wrote a paper entitled Scale Factors and the Scale Principle. In this paper I formulated a new law which describes a number of fundamental quantum mechanical laws. This paper shows that the Heisenberg Uncertainty Principle obeys this new formulation.

Keywords: *Heisenberg Uncertainty Principle, Planck mass, Planck length.*

1. Introduction

This paper investigates the relationship between the *Heisenberg Uncertainty Principle* and the Scale Law.

2. The Scale Principle or Scale Law (Summary)

In May 2014 I published a paper entitled the Scale Factors and the Scale Principle. In that paper this principle was called the *Quantum Scale Principle*. However after finding that Einstein's relativistic energy also obeys this Law, I changed its name to the *Scale Principle* (or Scale Law). Since the first version the principle has evolved to the present form given by the following relationships:

(1)

Meta Law: *Scale Principle* or *Scale Law*	
(1a) Implicit form (exponents and scale factor)	(1b) Explicit form (ratio, exponents and scale factor)
$D_1^n \left[< \vert \le \vert = \vert \ge \vert > \right] S \; D_2^m$ D_1 = Dimensionless quantity D_2 = Dimensionless quantity	$\left(\frac{Q_1}{Q_2} \right)^n \left[< \vert \le \vert = \vert \ge \vert > \right] S \left(\frac{Q_3}{Q_4} \right)^m$ (See details below)

The above symbols stand for

a) Quantities:
(i) Q_1, Q_2, Q_3 and Q_4 are physical quantities of identical dimension (such as Length, Time, Mass, Temperature, etc), or
ii) 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 viceversa.
(e.g.: Q_1 and Q_2 could be quantities of Mass while Q_3 and Q_4 could be quantities of Length).
The physical quantities can be variables (including differentials, derivatives, Laplacians, divergence, integrals, etc.), constants, dimensionless constants, any mathematical operation between the previous quantities, etc.

b) Relationship type: The relationship is one of five possibilities: **less than or equal to** inequation ($\leq$), or **less than** inequation (<), or **equal to** - equation (=), or a **greater than or equal to** inequation ($\geq$), or a **greater than** inequation (>).

c) Scale factor*:* S is a dimensionless *scale factor*. This factor could be a real number, a complex number, a real function or a complex function (strictly speaking real numbers are a particular case of complex numbers). The scale factor could have more than one value for the same relationship. In other words a scale factor can be a quantum number.

d) Exponents: n and m are integer exponents: 0, 1, 2, 3, …
Some examples are:
example 1: $n = 0$ and $m = 1$;
example 2: $n = 0$ and $m = 2$;
example 3: $n = 1$ and $m = 0$;
example 4: $n = 1$ and $m = 1$;
example 5: $n = 1$ and $m = 2$;
example 6: $n = 2$ and $m = 0$;
example 7: $n = 2$ and $m = 1$;
It is worthy to remark that:
i) The exponents, n and m, cannot be both zero in the same relationship.
ii) The number n is the exponent of both Q_1 and Q_2 while the number m is the exponent of both Q_3 and Q_4 regardless on how we express the equation or inequation (1c). This means that the exponents will not change when we express the relationship in a mathematically equivalent form such as

$$\left(\frac{Q_4}{Q_3}\right)^m \left[< \middle| \leq \middle| = \middle| \geq \middle| > \right] S \left(\frac{Q_2}{Q_1}\right)^n$$

iii) So far these integers are less than 3. However we leave the options open as we don't know whether we shall find higher exponents in the future.

The scale law (1b) can also be written (mixed form) as

$$Q_1^n Q_4^m \left[< \middle| \leq \middle| = \middle| \geq \middle| > \right] S\, Q_2^n\, Q_3^m$$

The Scale Law describes fundamental laws such as the Heisenberg's uncertainty principle, the black hole entropy, the fine structure constant, Einstein's relativistic energy equation, the formula for the Schwazschild radius, the Bohr Postulate, the De Broglie wavelength-momentum relationship, Newton's law of universal gravitation, the Schrödinger equation, the Friedmann equation, and maybe many others.

References [1] and [2] provide a more complete explanation on the Scale Law.

3. The Heisenberg Uncertainty Principle

I shall show that the *Heisenberg uncertainty principle* is a special case of the Scale Principle. I must clarify that this analysis is not the derivation of the uncertainty principle. To find the scale factor in this special case we need to do a much deeper investigation (exactly what Heisenberg did). However the point here is not to prove that the Heisenberg principle's scale factor can be found through the Scale Law, but to prove that the *uncertainty principle* is a special case of the more general formulation presented here.

Length *(Exponent = 1)*	**Momentum** *(Exponent = 1)*	**Momentum** (Planck Scale) *(Exponent = 1)*	**Length** (Planck Scale) *(Exponent = 1)*
Δx	Δp	$M_P c$	L_P

TABLE 1: *We don't label the columns as Generations because we are not dealing with particles*.

From Table 7 we establish the relationship

$$\Delta x \Delta p = S\, M_P c\, L_P \qquad (2)$$

Where

Δx = uncertainty in the position of the particle
Δp = uncertainty in the momentum of the particle
c = speed of light in vacuum
S = scale factor

$$M_P \equiv \sqrt{\frac{hc}{2\pi\, G}} \qquad \text{(Planck mass)} \qquad (3)$$

$$L_P \equiv \sqrt{\frac{hG}{2\pi\, c^3}} \qquad \text{(Planck length)} \qquad (4)$$

Equation (2) can be re-written in the form of the scale principle

$$\frac{\Delta p}{M_P c} = S \frac{L_P}{\Delta x} \tag{5}$$

It is easy to show that

$$M_P c\, L_P = \hbar \tag{6}$$

Thus equation (2) transforms into

$$\Delta x \Delta p = S \hbar \tag{7}$$

Substituting the equal sign with a greater than or equal to (≥) and the scale factor, *S*, with ½ , we get the *Heisenberg uncertainty principle*

$$\Delta p\, \Delta x \geq \frac{\hbar}{2} \tag{8}$$

Although we have not found the exact expression of the principle, we have proved that the *Heisenberg uncertainty principle* is a special case of the *Scale Law*.

4. Conclusions

This paper shows that the *Heisenberg uncertainty principle* obeys the present formulation: the Scale Law.

5. Notes

This investigation was published on line for the first time in May 2014 as part of another paper. Now it is published separately for clarity reasons.

REFERENCES

[1] R. A. Frino, *Scale Factors and the Scale Principle*, viXra:1405:0207, (2014) (Version 1 was published on May 2014).
[2] R. A. Frino, *Where Do the Laws of Physics Come From?*, viXra: xxxx.xxxx, (2014)