Where Do the Laws of Physics Come From?

This paper investigates the origins of the fine-structure constant and the laws of physics. Evidence strongly suggests that there is a common origin behind all of them. The most striking evidence is perhaps the Lorentz transformations which are mentioned here and analysed in a separate paper. The author presents a new perspective about the laws of Nature through a new theory called: ***the theory of the pre-universe*** *and proposes an answer to the question: where do the laws of physics come from?*

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1. Introduction

Physical systems exhibit symmetry if they are unchanged under certain transformation. In his book "Cosmic Impressions" the physicist Walter Thirring [1] defines symmetry as follows:

"We say that a given space exhibits symmetry when observed from different points of views appears always the same."

I shall begin by defining symmetry as follows

Definition of Symmetry
We say that an object and/or its behaviour is symmetrical under certain transformation when the transformation causes no change in the appearance or in any other property of the object and/or its behaviour.

The object can be either a three-dimensional object such a book, an electron, an atom, a ball, etc., or a two-dimensional object such as a drawing, a photograph, or any other image. The transformation can be a translation of the object, a rotation of the object, the reflection of the object in a mirror (parity transformation or P-symmetry), make the object to go back in time (T-symmetry), a charge conjugation of the object

(C-symmetry), the reflection of the object in a mirror and the substitution of one or more properties of the object with another one, the translation of the object in time, a Lorentz transformation, a gauge transformations, a combination or two or more transformations given above, etc.

To illustrate this point, let us consider the combination of three different transformations or operations a) an operation that exchanges a particle with its antiparticle (Charge conjugation operation or C-operation). b) a mirror reflection (Parity operation or P-operation), and c) an operation that replaces t by $-t$ (time reversal operation or T-operation). This combined transformation is known as CPT. One of the reasons CPT symmetry is significant, is because all interactions exhibit this type of symmetry. Thus, as far as we know, the Universe shows symmetry under a CPT transformation.

Symmetries have been classified into two mayor types:

a) **Continuous symmetries**
There is a finite number of transformations that leave a measurable quantity unchanged. These symmetries lead, for example, to energy and linear momentum conservation.

b) **Discrete symmetries**
There is an infinite number of transformations that leave a measurable quantity unchanged. These symmetries lead, for example, to parity and charge conservation laws.

From the physical system's point of view, symmetries can be classified as

a) **External symmetries**
These are symmetries external to the physical system and comprise spatial and temporal transformations. Examples of external symmetries are: spatial translations, spatial rotations, time translations, Poincare transformations and Lorentz transformations.

b) **Internal symmetries**
These are symmetries internal to the physical system. Examples of internal symmetries are: parity transformations, charge conjugation, time reversal, isospin symmetry and gauge transformations.

There are other classifications we shall not discuss here.

As the German mathematician Emmy Noether [2] showed every continuous symmetry yields a conservations law and for every conservation law there is a continuous symmetry.

It is worthy to remark that symmetries generate conservation laws, but not all laws of physics are conservation laws. For example, the Heisenberg uncertainty principle or the Lorentz transformations are not conservation laws. This means that Nature must invoke other higher order laws or Meta-laws to deal with all the laws of physics (with no exceptions).

The idea of the existence of Meta-laws is not new. Einstein invoked a Meta-law to formulate his two most important theories: The special theory of relativity and the general theory of relativity. The former incorporated the Lorentz covariance principle, or simply Lorentz covariance, and the latter the general covariance principle (which we shall not discuss here).

The special theory of relativity requires that all laws of Nature to be the same in all inertial reference systems. This means that the laws of physics must be invariant with respect to the Lorentz transformations. This is what Einstein quoted:

"The so-called special or restricted relativity theory is based on the fact that Maxwell's equations (and thus the law of propagation of light in empty space) are converted into equations of the same form, when they undergo Lorentz transformation. This formal property of the Maxwell equations is supplemented by our fairly secure empirical knowledge that the laws of physics are the same with respect to all inertial systems.
...The content of the restricted relativity theory can accordingly be summarized in one sentence: all natural laws must be so conditioned that they are covariant with respect to Lorentz transformations." [3]

"Nature must be covariant relative to Lorentz transformations; the theory thus provides a criterion for general laws of Nature. It leads in particular to a modification of the Newtonian point motion law in which the velocity of light in a vacuum is considered the limiting velocity, and it also leads to the realization that energy and inertial mass are of like nature." [4]

In his book: Relativistic Physics [5], McCrea quotes:

"... the laws of nature have to verify when the variables space and time undergo a Lorentz transformation. Because of this we say that they are relativistically invariant. Physics must present clearly its laws in ways that incorporate such invariance; any principle or statement that fails in this regard cannot be a general law."

The Einstein's Lorentz covariance is a Meta-law. But a Meta-law of a different kind.

2. What are exactly the Laws of Physics?

The laws of physics are not written anywhere however they are real. Nature does not write its laws in papers or books like humans do. Nature "writes" its laws in more subtle way: as behaviour or, in other words, as relationships among things. Nature is made of physical entities (electrons, protons, neutrons, photons, etc.) and the behaviour that govern the interactions among those physical entities. The latter is what we call the laws of physics.

There are two types of observations that lead to the discovery of the laws of physics:

a) ***Qualitative observations***.

This is simple observation without doing any measurements or mathematical work. For example when we observe an apple falling from a tree we say that there must be a law that dictates apples what to do: they must fall to the ground. Based on observations we say that this behaviour is compulsory and unavoidable. Then we go further by saying that the reason apples fall to the ground is because of the force Earth exerts on all objects such as apples (and apples on all other bodies). We call this force gravity.

b) ***Quantitative observations (Measurements).***

Measurement is the basic process humans use to read or discover the existing laws of Nature. We make measurements on a number of different dimensions and we call them quantities of that dimension. When we find a relationship among these quantities we say that we have discovered a physical law. The way we use to record a law is to assign a symbol for each quantity (for example: F, G, M, m, r); and then we relate these symbols through mathematical operations such as multiplications, divisions, etc. In this case we have to use the inverse square law to obtain the correct classical relationship. That way we have created or invented a mathematical representation (equation) for a given law of physics. Finally we give it a name such as the *law of gravity* and we proceed to write this law as

$$F = \frac{GMm}{r^2} \qquad \text{(Approximate description of a natural law)}$$

This is a law of physics because whenever there exists such a pair of massive bodies (Earth and apple), there exists such a force between them. This force between two masses is not an accident but it is inevitable, it is compulsory, it is reproducible; and therefore it is a law.

We, humans, did not and do not create the laws of Nature. The best we can do is to discover relationships or behaviours that we call laws. What we invent is a representation for the law we have discovered. As a consequence, the laws of physics come from discoveries and not from human invention.

We cannot find natural relationships if the relationships are not there. In that regard the laws of physics are as solid as a rock. However we normally find approximations to the law we are studying. Whether we are smart enough to discover the exact representation of the law is irrelevant. If we are smart enough we shall find the correct equation (an equation whose accuracy cannot be improved any further), if we are not smart enough we shall find an approximate description of the law. For example when Newton discovered the law of universal gravitation he found an approximate and very useful description of one of the most important laws of Nature. In this respect Albert Einstein quoted:

"Maybe, though Newton's ideas seem to work in the everyday world, they are actually approximations of something else that works in all conditions!"

In 1915 Einstein developed a geometric theory of gravitation known as general relativity (GR). Thus, according to Einstein, the gravitational force between two objects is due to a geometric distortion of spacetime produced by the presence of matter (and matter is a form of energy). The American physicist J. Wheeler quoted:

"space-time tells matter how to move; matter tells space-time how to curve."

GR is described by a system of ten, coupled non-linear partial differential equations known as Einstein's field equations:

$$R_{\alpha\beta} - \frac{1}{2} g_{\alpha\beta} R + \Lambda g_{\alpha\beta} = \frac{8\pi G}{c^4} T_{\alpha\beta}$$ (Approximate description of a natural law)

Considering the expression for the Planck force, F_P

$$F_P = \frac{c^4}{G}$$

the Einstein's field equations can be written in terms of this force as follows

$$R_{\alpha\beta} - \frac{1}{2} g_{\alpha\beta} R + \Lambda g_{\alpha\beta} = \frac{8\pi}{F_P} T_{\alpha\beta}$$

The improvement over Newton's law is impressive. Einstein was able to explain several phenomena that Newton's theory couldn't explain (e.g. the advance of Mercury's perihelion, the bending of light grazing massive celestial bodies, the gravitational redshift, the existence of black holes, etc.). Einstein also showed that the force of gravity was a much more complex force than scientists previously thought. However, because general relativity does not include any generalized uncertainty principle [19] (an extension of the Heisenberg uncertainty principle), Einstein's theory is also an approximation (a much better one than Newton's law of gravity).

Two Different Mathematical Descriptions for the Same Law

What Newton and Einstein have done is to invent two mathematical descriptions for the same law of Nature – gravity.

However it is worthy to emphasize that we didn't invent the laws of physics as some people have suggested; we invented mathematical descriptions of the laws of Nature. The laws of Nature are real even if we were unable to find any representation or description for them. Thus it is important to differentiate between a **law of Nature** and the **mathematical description** of it.

Even if we found that a law we discovered in the past suddenly changes or ceases to exist (which has never been observed) is irrelevant. This is so because new measurements would reflect these changes or the non-existence of the law.

Now we can ask a question: if the laws of physics are real, as we proved they are, what are they made of? The laws of physics are certainly not made of matter (including anti-matter) or energy. The laws of physics are simply behaviour.

When people say "the laws of physics" they refer to one of two meanings: the behaviour of a physical body or the mathematical description of the behaviour of the physical body. It is important to differentiate these two meanings:

(Meaning 1) The behaviour of the body

This is the most important meaning of the two. For example, when a net force is exerted on a body, the body will accelerate. The fact that the body accelerates when a force is exerted on it is a behaviour.

The behaviour of particles can be illustrated through the two classes of fundamental particles: *fermions* and *bosons*. Fermions are the matter constituents. Bosons, on the other hand, are force carriers: they are messengers of the forces of Nature.

Fermions can be divided into *leptons* (electron, muon, tau particle, their corresponding neutrinos and their antiparticles) and *quarks* (up, down, strange, charm, bottom, top and their antiparticles). Fermions are particles whose spins are half-integer multiples of the reduced Planck's constant: $(\hbar/2, 3\hbar/2)$. Fermions obey the Pauli exclusion principle. Basically this means that they cannot be grouped together when they are in the same quantum state.

Bosons are particles whose spin are integer multiples of the reduced Planck's constant $(0, \hbar, 2\hbar)$. The Standard Model requires several force carriers to explain all physical interactions: the photon, the graviton (which has never been observed), the W^-, W^+ and Z^0 particles, also known as intermediate vector bosons, and the Higgs boson. The Higgs boson is believed to give particles their masses. Bosons do not obey the Pauli exclusion principle. This means that they can be grouped together when they are in the same quantum state. Thus fermions (matter) and bosons (force carriers) exhibit a completely different behaviour.

(Meaning 2) The mathematical description of the behaviour of the body

This is the equation (formula, expression, or relationship) that we use to represent the behaviour of the body. For the above behaviour the relativistic mathematical description is:

$$\mathbf{F} = \frac{d\mathbf{p}}{dt} = \frac{d(m\mathbf{v})}{dt}$$

which is the Newton's second law of motion (bold letters are vectors). The corresponding classical description (where the mass, *m,* of the body is constant) is

$$\mathbf{F} = m\mathbf{a}$$

Fermi and Dirac developed the so called Fermi-Dirac distribution function which is a mathematical description of the behaviour of large quantities of fermions:

$$p_{FD}(E) = \frac{1}{Fe^{(E/k_B T)} + 1}$$

On the other hand Bose and Einstein developed the Bose-Einstein distribution function which is a mathematical description of the behaviour of large quantities of bosons:

$$p_{BE}(E) = \frac{1}{Be^{(E/k_B T)} - 1}$$

The reason these two distribution functions are different is because the behaviour of fermions and bosons is different and that is exactly what these distribution functions reflect. While the Fermi-Dirac distribution, $p_{FD}(E)$, function gives the probability of finding a fermion in a given energy state, *E*, for a given absolute temperature, *T*, the Bose-Einstein distribution function, $p_{BE}(E)$, gives the probability of finding a boson in a given energy state, *E*, for a given absolute temperature, *T*.

It is worthy to remark the subtle difference between the two meanings. The behaviour of particles (the way they interact with other particles) is something that exists even if we had no mathematical description of it. When we say that we have discovered a physical law we are saying that we have discovered a natural behaviour and, eventually, we propose an equation (or inequation) to describe such behaviour. However the equation/inequation is normally a mere approximation to the real behaviour of the particles or bodies under study.

Particles and behaviour were born simultaneously during the Big Bang. The behaviour exhibited by particles is what we call the laws of physics (**Meaning 1**). Since matter cannot be separated from its behaviour, we cannot separate matter from natural laws. But where did this behaviour (the laws of physics) come from?

3. The Theory of the Pre-Universe

The theory presented in this paper is *the theory of the pre-universe*. This theory is based on the following 5 postulates:

Postulate 1) Nothingness does not exist (see section 4).

Postulate 2) There exists a pre-universe or meta-universe which had no beginning.

Postulate 3) The fundamental properties or elements of this meta-universe are: meta-time, meta-energy and meta-space. These properties did not have a beginning either.

Postulate 4) Matter was created during the Big Bang and there was no matter before that time.

Postulate 5) Meta-space has, at least, 4 (spatial) dimensions (our universe has 3 spatial dimensions).

When normal time was created, part of the pre-universe or Meta-universe transformed into our Universe. Matter along its behaviour was spawned from Meta-energy and its Meta-behavior (Meta-laws). We then can say that

Preliminary Definition of the Big Bang

our Universe is a result of a Meta-transformation known as the Big Bang.

This, of course, was not the end of Meta-time. Meta-time goes on and it will go on forever. It is reasonable to think that if energy transforms into matter and vice versa (in our Universe), then both energy and matter must come from Meta-energy. But what is Meta-energy? Meta-energy is primordial energy, or in other words the "thing" that created our Universe.

Symmetry Differences

Because of the non-existence of Meta-matter (Meta-mass) it follows that the Meta-Universe is more symmetrical than our Universe.

The famous Einstein's equation

$$E = m c^2$$

does not apply to the Meta-universe. This equation is valid in our Universe only (or in any other similar parallel Universe). In fact if we write this equation as follows:

$$m = \frac{E}{c^2}$$

we observe that the existence of matter (mass is one of the properties of matter) depends on the existence of energy, space and time (light can propagate through spacetime if and only if there exist spacetime). Energy, space and time are all ingredients spawned during the Big Bang.

The above mass-energy formula indicates that energy was created first (from Meta-energy) followed by the creation of spacetime. Finally, after energy and spacetime were created matter was created. This primary process is shown in Diagram 1

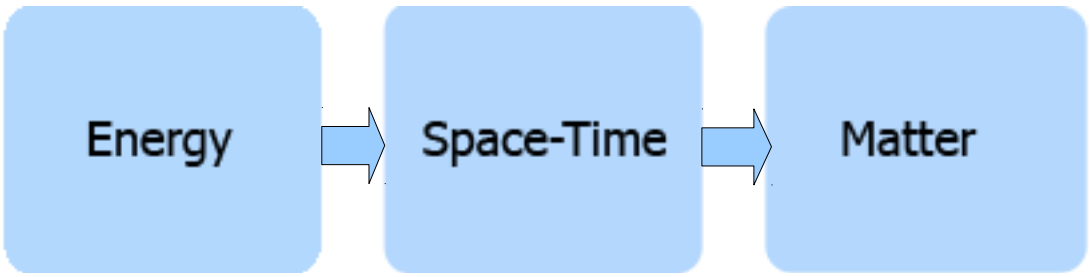

Diagram 1: *This diagram shows the order of creation: (1) energy, (2) spacetime and (3) matter.*

We do not know the exact difference between Meta-energy and energy. However since we have postulated that there is no Meta-matter (and therefore there is no Meta-mass), one difference could be that Meta-energy to be truly massless. This means that its rest mass should be zero. On the other hand, energy (photons), must have non-zero rest mass. Having say that, however, if Meta-energy and energy were different, there could be other unknown differences that would make them even more different than we suppose they are.

The Meta-universe has Meta-energy, Meta-time and Meta-space. However it has no Meta-mass (no Meta-Matter). This is one of the most striking differences between our "parent Universe" and the Universe created during the Big Bang.

Since a symmetrical distribution of Meta-energy (Meta-universe) has greater entropy (Meta-time is required for entropy to exist) than a less symmetrical distribution of mass and energy (our Universe) we infer that

Definition of the Big Bang and the
Fate of the Universe

The Big Bang is a Meta-transformation from a high entropy Meta-state to low entropy state. Therefore the Universe must expand to increase its entropy. In due time all matter in the Universe will transform into energy, and then energy will transform into Meta-energy (if they were different). When this happens, time will cease to exist, and it will transform into Meta-time, and finally our Universe will merge with the Meta-universe from which it came from.

The fate of the Universe proposed in this paper is in excellent agreement with the latest cosmological observations which suggest the Universe is open. This means that the Universe will expand forever. But this is, in fact, approximately correct. This "eternal expansion" will end when all matter ceases to exist. This will happen because, sadly, all matter is unstable, including protons, electrons and possibly neutrinos. With no matter left, our Universe will no longer expand and finally will cease to exist. The Meta-universe, on the other hand, will continue its eternal existence. Thus, we arrive to the conclusion that the fate of the Universe is already determined. This means that, considering the big picture, Einstein was right "God does not play dice".

You may have noticed that I did not differentiate between Meta-entropy and entropy. Whether they are the same or different does not matter from the qualitative point of view. Likewise, if behaviour means motion, it means, for example, that particle positions change with time (such as translation, rotation, etc.), then behaviour must have come from Meta-time. But because there was no Meta-matter before the Big Bang, we infer that Meta-energy must have its own Meta-behaviour (Meta-laws). In other words the laws of physics must have come from Meta-laws. Thus all the matter created in the Big Bang is just a material replica of the even more primordial Meta-energy. This means that Meta-energy (and therefore energy) and mass are conceptually very different. Then we can say that

Difference between Energy and Mass

Energy is eternal; matter (and therefore mass) is ephemeral (one day all matter will disappear)

The following table summarizes the main differences between the Meta-universe and our Universe.

Meta-universe	Universe
Meta-time	time
Meta-space	space
Meta-energy (There is no Meta-mass)	energy mass
Meta-behaviour among Meta-energy entities (Meta-laws)	Behaviour of matter (laws of physics)
Meta-Entropy (Relatively high entropy)	Entropy (Relatively low entropy)

Table 1*: This table shows the main differences between the Meta-universe and our Universe.*

4. Was Our Universe Created from Nothingness?

Some people state that nothingness is unstable. Then they say that as a consequence of this instability, the Universe popped up into existence. I shall show that this is incorrect.

First of all nothingness means non-existence. Non-existence cannot have properties because only existing things have properties. But instability is a property. Therefore instability cannot be a property of nothingness. In other words to say that nothingness is unstable does not make any sense. Thus we must rule out instability as the cause of creation.

The problem about creation can be solved by accepting that the Meta-universe was not created but it always existed. Accepting that Meta-time, unlike time, did not have a beginning is a simple and beautiful concept. Even if there is only one type of time (normal time) it could have not had an origin. Time did not have a beginning; it always existed. It couldn't have been any other way. This is because in order to create something Nature needs the existence of time, therefore time cannot be created (unless there is a more primordial type of time: Meta-time. But then, for the same reason, Meta-time could have not been created). Time (or Meta-time) along with energy (or Meta-energy) are the most primordial and basic entities there are. Nothing, in the Universe (or Meta-universe), is more fundamental that them. This is the reason why the temporal Heisenberg uncertainty principle relates energy and time in the form of uncertainties [22]:

$$\Delta E \, \Delta t \geq \frac{\hbar}{2}$$

However, let us postulate that there is a cause for everything there is. Thus, the Meta-universe (that we shall call Meta-universe 0) had a beginning. The cause that created the Meta-universe 0 was Meta-universe 1. But because everything has got a cause, Meta-universe 1 must have been created by Meta-universe 2. For the same reason, Meta-universe 2 must have been created by Meta-universe 3, and so on.

This reasoning leads to an infinite number of Meta-universes which were the cause of the existence of a Meta-descendant. Now we can ask: What is the difference between the following two models: Model 1: this model has an infinite number of Meta-universes, and Model 2: this model has only one Meta-universe with no beginning in neither space nor time?

Both models have something in common: both involve the concept of infinity. The former has an infinite number of Meta-universes with a starting point in Meta-time for each of them, while the latter has a finite number of Meta-universes (only one) with no starting point in Meta-time (an infinite Meta-time). So whichever model we choose we can not get rid of the concept of infinity.

Why would everything had to have a beginning? Is this so because we have never seen anything without a beginning? After all plants are born, animals are born, babies are born, planets are born, stars are born, galaxies are born, and the Universe itself was born.

Creation is a concept that reflects our daily experience. But we don't have any experience that can be extended before the Big Bang. Extrapolating the concept of creation beyond the Big-Bang cannot be scientifically justified because we cannot get rid of infinities. Isn't it simpler to accept that Nature had a different way of doing things before the Big Bang?

Some people have asked: why is there something rather than nothing? This is an ill-founded question as I shall explain. When we have an option we chose one or more existing thing among a number of existing things. However we can say: I don't want to choose anything. This means that we did not choose any of the existing things. But this does not mean that we chose “something” called “nothing”. The reason as to why “nothing” cannot be chosen is because you cannot chose something that is non-existent.

Nature did not come with nothingness and it does not come with nothingness. Nature is something and it has always been something (Nature has always been that way!). The confusion arises because we treat nothingness as an existing thing, as an option, as something Nature could have chosen from a pool of possibilities. But this reasoning is ill-founded, in other words it does not make sense. Nothingness is not a possibility or option Nature can "choose from". This is because Nature can only "chose" from existing things. All Meta-properties of the Meta-universe exit (and always existed) even if we are unable to see them or to experiment with them directly. Perhaps the confusion comes from thinking of empty space as nothingness. This is incorrect. According to Einstein spacetime is curved and matter is the source of this curvature. Bodies move in a gravitational field by following the curvature in the fibres of spacetime in the neighbourhood of massive objects. Therefore space must be something, otherwise a massive object would not be able to curve it. On the other hand, the Big Bang tells the same story: spacetime (I assume there is Meta-time which is more primordial than normal time) was created during the Meta-transformation known as the Big Bang, therefore, if spacetime was created it must be something. A web article from NASA Science supports my point of view on the difference between empty space and nothingness

"Albert Einstein was the first person to realize that empty space is not nothing. Space has amazing properties, many of which are just beginning to be understood. The first property that Einstein discovered is that it is possible for more space to come into existence. Then one version of Einstein's gravity theory, the version that contains a cosmological constant, makes a second prediction: "empty space" can possess its own energy." [21]

I shall finish this section by saying that Nature (the Meta-universe) was always something, Nature always existed, Nature did not have a beginning as Meta-time did not have a beginning.

5. What is a Meta-law?

Before the beginning of normal time there was Meta-energy, Meta-time, Meta-space and Meta-behaviour. Since matter is not primordial, as we have pointed out above, there is no such thing as Meta-matter. Perhaps the non-existence of Meta-matter produced the imbalance between matter and anti-matter we observe today. However this is still unclear.

The concept of Meta-time is very different to the concept of time we are familiar with. One of the main differences between these two concepts is that Meta-time had no beginning and it will have no end. On the other hand, time had a beginning (approximately 13,822 million years ago) [12] and it will have an end.

In general a Meta-law is a Law that deals with other physical laws and fundamental constants. But this is a very superficial definition (the cosmetic definition of Meta-law). We need a deeper definition and therefore a deeper understanding of Meta-laws.

Everything seems to indicate that Meta-laws are organized in a hierarchical mode. The highest Meta-laws are the ones that I shall call *model Meta-laws;* and below them there exist the so called *excluding Meta-laws*. Let us have a look at these two types of Meta-laws more closely:

a) ***Model Meta-laws***. A Model Meta-law indicates the general form or shape of the laws of physics including all Excluding Meta-laws. For example, the Scale-law is a Model Meta-law. A Model Meta-law looks after that the dimensions to be correct. It is worthy to remark that dimensions were created by the Meta-universe when the Big Bang took place; not by humans. The Universe set up the rules by creating different dimensions. As a result 1 Kg of something is different to 1 meter of something. Thus mass and space are different because they were created with different properties or attributes (although energy, space and time are the "ingredients" Nature "used" to create matter).

When we write an equation we follow the Universe's rules that demand a consistency of dimensions. We did not invent the dimensions, a Meta-transformation (the Big Bang) "did". We only invented systems of units to label quantities of a given dimensions. So the equations we invented must be dimensionally correct because the Universe demands this to be so. It is compulsory and therefore it is a law: the Scale Law. Furthermore, the Universe sets up scale factors for each and every normal law of physics so that we write, for example, one equation of the Lorentz transformation as

$$\frac{x'}{x - vt} = \gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} \qquad (S = \gamma)$$ (One equation of the Lorentz transformations)

or we write Einstein's total relativistic energy as

$$\frac{E + m_0 c^2}{pc} = \frac{pc}{E - m_0 c^2} \qquad (S = 1)$$ (Einstein's total relativistic energy)

b) ***Excluding Meta-laws (or Selecting Meta-Laws)***. These Laws rule out other possible behaviours of normal matter by selecting one and only one behaviour. This "allowed" behaviour becomes a normal law of physics. All Excluding Meta-laws (assuming there are more than one) work in synchronism to comply with the Meta-model. For example, the Lorentz covariance principle is an Excluding Meta-law. Einstein referred to Excluding Meta-laws implicitly when he quoted:

"The principle of relativity is a principle that narrows the possibilities; it is not a model, just as the second law of thermodynamics is not a model."

From these words we infer that Einstein knew about the existence of Meta-laws and in particular on the existence of Excluding Meta-laws. The above paragraph clearly shows that Einstein refers to a particular Excluding Meta-law as: *"a principle that narrows the possibilities"*.

Einstein not only knew about the existence of Excluding Meta-laws but also about the existence of Model-Meta laws. He made the difference very clear when referring to an

Excluding Meta-law: *"... it is not a model"*; meaning that Excluding Meta-laws and Model Meta-laws are two different things.

What Einstein perhaps did not realize was one of the implications of having Meta-laws: they determine not only the normal laws of physics but also the most mysterious fundamental constant of Nature: the *fine-structure constant*.

6. Rationale

Meta-laws are not subject to derivation. Because the Scale Principle or Scale Law is a Meta-law, it is not subject to derivation either. There is a fundamental difference between Nature and humans in regards to the laws of physics:

> Nature did not derive the laws of physics from a handful of postulates (sometimes based on experiments) like humans do; Meta-transformations created both all the stuff there is and the corresponding behaviour (the ones we call laws of physics) at the same time during the first instants of the Big Bang.

Nature give us indirect evidence of the existence of more fundamental Natural Laws than the normal laws of physics we are familiar with. The evidence is

a) Layers of creation.
b) Spatial and temporal resemblance among the normal laws of physics.
c) Dimensionless resemblance with a Higher Law: the resemblance of the canonical form of the laws of physics (dimensionless equations) with the Scale Law (dimensionless Meta-law).

We shall investigate all this evidence in the following subsections.

6.1. Evidence 1: Layers of Creation

Let us consider the way Nature builds the stuff around us including us – *Nature builds stuff in layers.*

The first layer, as far as we know, is made of fundamental particles (such as electrons, quarks, etc.), the second layer is made of compound particles such as baryons (e.g. proton and neutron) which, in turn, are made of quarks and gluons, the third layer is made of atoms which are made of both fundamental particles and compound particles, the fourth layer is made of molecules which are made of atoms, and so on until we get to the upper layers of Nature comprising life forms and all the other stuff. Then why wouldn't Nature use a similar mechanism to spawn the normal laws of physics?

Thus I propose that there are, at least, two layers of physical laws: the first layer is made of the Meta-laws such as the Scale Law and the second layer is made of all the normal physical laws we are familiar with.

6.2. Evidence 2: Spatial and Temporal Resemblance among the *normal laws of physics*.

One of the central questions in science is: Why? Now we are in the position of answering one of the most fundamental questions in quantum mechanics:

> Fundamental Question
>
> Why the *spatial version of the Heisenberg uncertainty principle*, the *Planck's spatial equation* and the *Bohr postulate* are so similar? (Despite the fact that the HUP is an inequation and both the *Planck's equation* and *the Bohr postulate* are equations).

To find the answer let us consider the following table of scale factors

	Spatial version of Heisenberg uncertainty principle	**Planck's spatial equation**	**Bohr postulate**	**Temporal version of Heisenberg uncertainty principle**	**Planck's temporal equation**
Relationship	$\Delta p_x \, \Delta x \geq \frac{\hbar}{2}$	$M_P \, c \, L_P = \hbar$	$m v r = n\hbar$ $n = 1, 2, 3, ...$	$\Delta E \, \Delta t \geq \frac{\hbar}{2}$	$E_P \, T_P = \hbar$
Type of relation	Inequation	Equation	Equation	Inequation	Equation
Momentum or Energy	Δp_x	$M_P \, c$	$m v$	ΔE	E_P
Length or Time	Δx	L_P	r	Δt	T_P
Scale factor	½	1	1, 2, 3, …	½	1

Table 2: *Table of scale factors (or scaling factors). The similarity among these relationships suggests that a common more fundamental law governs them.*

If we look at Table 2 we shall discover a similarity among the relationships shown on the *Relationships* row. This resemblance suggests that a common and more fundamental law operates above them.

Answer to the Above Fundamental Question

The answer to the above fundamental question emerges from the above table. These relations are similar because all of them were spawned by the same Meta-laws (the Scale Law and the Excluding Meta-laws) with different scale factors (or scaling factors), different relationship types (inequation vs. equation), and different magnitudes (length, time, mass, etc). As Table 2 shows the scale factor for both *Heisenberg uncertainty principles* is ½, while the scale factor for both *Planck's equations* is one. For the Bohr postulate the scale factor is a quantum number 1, 2, 3, … instead.

6.3. Evidence 3: Dimensionless Resemblance with a Higher Law

There are also similarities in the equations among apparently very different laws of physics as shown on Table 3. Then it is natural to ask: Who dictates the resemblance among the laws of physics shown on this table? Again, the answer is the Scale Law which is, in certain way similar to what Newton called "the great principle of similitude". The following paragraph from Wikipedia casts more light into the similitude of the laws of physics

"The most basic rule of dimensional analysis is that of dimensional homogeneity, first formulated by Newton, who called it the "great principle of similitude" Only commensurable quantities (quantities with the same dimensions) may be compared, equated, added, or subtracted."

I did not know about the "the great principle of similitude" when I formulated the Scale Law but I believe that the Scale Law and "the great principle of similitude" are essentially the same principle, however there are, at least, four main differences:

a) The Scale Law focuses not only on the dimensional homogeneity of equations and inequations but also on scale factors (or scaling factors) and scale tables (something Newton, as far as I know, did not consider).

b) The Scale Law focuses on the quantum mechanical descriptions of the laws when such descriptions are known or applicable (Of course, Newton could not possibly have considered this point).

c) The Scale Law is a Model Meta-law. The similarities Newton might have referred to are explained, in this formulation, in terms of the primordial form of the Scale Law: $M_1 \Re \ sM_2$, and the corresponding Meta-transformations.

d) The Scale Law explains the Big Bang as a Meta-transformation and not as a creation (something Newton, as far as I know, did not consider). Thus the Scale Law is connected to the origin of the Universe.

The following table contains one fundamental constant and a number of natural laws spawned by Meta-laws

Model Meta-law: the Scale Law

$$M_1 \Re s M_2$$

Name of the Law or constant	Dimensionless Meta Quantities and their Meta-transformations	Canonical form of the law (This form resembles the Meta-law)	How humans formulated this law or constant	Ref.
(1) **The fine structure constant**	$M_1 \to \dfrac{\sqrt{\varepsilon_0 hc}}{e}$ $M_2 \to \dfrac{e}{\sqrt{\varepsilon_0 hc}}$ $s \to \dfrac{1}{2\alpha}$	$\dfrac{\sqrt{\varepsilon_0 hc}}{e} = \dfrac{1}{2\alpha}\dfrac{e}{\sqrt{\varepsilon_0 hc}}$ (Canonical)	$\alpha = \dfrac{e^2}{2\varepsilon_0 hc} = \left(\dfrac{e}{Q_P}\right)^2$ $Q_P = \sqrt{2\varepsilon_0 hc}$	[7]
(2) **Heisenberg uncertainty principle**	$M_1 \to \dfrac{\Delta p}{M_P c}$ $M_2 \to \dfrac{\Delta p}{M_P c}$ $s \to \dfrac{1}{2}$	$\dfrac{\Delta p}{M_P c} \geq \dfrac{1}{2}\dfrac{L_P}{\Delta x}$ (Canonical)	$\Delta p \, \Delta x \geq \dfrac{\hbar}{2}$	[8]
(3) **Black Hole Entropy Formula**	$M_1 \to \dfrac{\dfrac{A_H}{hG}}{c^3}$ $M_2 \to \dfrac{S_{BH}}{k_B}$ $s \to \dfrac{2}{\pi}$	$\dfrac{\dfrac{A_H}{hG}}{c^3} = \dfrac{2}{\pi}\dfrac{S_{BH}}{k_B}$ (Canonical)	$S_{BH} = \dfrac{k_B c^3}{4\hbar G} A_H$	[9]
(4) **Einstein's relativistic energy formula**	$M_1 \to \dfrac{E + m_0 c^2}{pc}$ $M_2 \to \dfrac{pc}{E - m_0 c^2}$ $s \to 1$	$\dfrac{E + m_0 c^2}{pc} = \dfrac{pc}{E - m_0 c^2}$ (Canonical)	$E^2 = p^2 c^2 + m_0^2 c^4$	[10]

Name of the Law or constant	Dimensionless Meta Quantities and their Meta-transformations	Fundamental form of the law as dimensionless ratios (Canonical form)	How humans formulated this law or constant	Ref.
(5) **Newton's law of universal gravitation**	$M_1 \to \frac{F_G r}{m_1 c^2}$ $M_2 \to \frac{m_2 c^2}{F_P r}$ $s \to 1$	$\frac{F_G r}{m_1 c^2} = \frac{m_2 c^2}{F_P r}$ (Canonical)	$F_G = G\frac{m_1 m_2}{r^2}$	[11]
(6) **Friedmann equation**	$M_1 \to \frac{\dot{R}}{\left(\frac{R}{R_0} + K\right)c}$ $M_2 \to \frac{\left(\frac{R}{R_0} - K\right)c}{\dot{R}}$ $s \to 1$	$\frac{\dot{R}}{\left(\frac{R}{R_0} + K\right)c} = \frac{\left(\frac{R}{R_0} - K\right)c}{\dot{R}}$ (Canonical)	$\left(\frac{\dot{R}}{R}\right)^2 = \frac{8}{3}\pi G\rho - \frac{kc^2}{R^2} + \frac{\Lambda}{3}$	[12]
(7) **Formula for the Schwarzschild radius**	$M_1 \to \frac{R_S}{M}$ $M_2 \to \frac{L_P}{M_P}$ $s \to 2$	$\frac{R_S}{M} = 2\frac{L_P}{M_P}$ (Canonical)	$R_S = \frac{2GM}{c^2}$	[13]

Name of the Law or constant	Dimensionless Meta Quantities and their Meta-transformations	Fundamental form of the law as dimensionless ratios (Canonical form)	How humans formulated this law or constant	Ref.
(8) **The Bohr postulate**	$M_1 \rightarrow \frac{mvr}{M_P c L_P}$ $M_2 \rightarrow 1$ $s \rightarrow 1, 2, 3, ...$	$\frac{mvr}{M_P c L_P} = S$ $S = 1, 2, 3, ...$ (Canonical)	$mvr = n\frac{h}{2\pi}$ $n = 1, 2, 3, ...$	[14]
(9) **De Broglie wavelength-momentum formula**	$M_1 \rightarrow \frac{r}{\lambda}$ $M_2 \rightarrow 1$ $s \rightarrow \frac{1}{2\pi}, \frac{2}{2\pi}, \frac{3}{2\pi}, ...$	$\frac{r}{\lambda} = S$ $S = \frac{1}{2\pi}(1, 2, 3, ...)$ (Canonical)	$2\pi r = n\lambda$ $n = 1, 2, 3, ...$	[14]
(10) **Schrödinger equation**	$M_1 \rightarrow \frac{\lambda}{\sqrt{\frac{\Psi}{\nabla^2 \Psi}}}$ $M_2 \rightarrow \frac{\sqrt{\frac{\Psi}{\nabla^2 \Psi}}}{\lambda}$ $s \rightarrow -4\pi^2$	$\frac{\lambda}{\sqrt{\frac{\Psi}{\nabla^2 \Psi}}} = -4\pi^2 \frac{\sqrt{\frac{\Psi}{\nabla^2 \Psi}}}{\lambda}$ (Canonical)	$\nabla^2 \Psi + \frac{8\pi^2 m(E-U)}{h^2} \Psi = 0$	[15]

Name of the Law or constant	Dimensionless Meta Quantities and their Meta-transformations	Fundamental form of the law as dimensionless ratios (Canonical form)	How humans formulated this law or constant	Ref.
(11) **Lorentz transformation's x' coordinate** $x'=f(x, t)$	$M_1 \to \frac{x'}{x - vt}$ $M_2 \to 1$ $s \to \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$	**Meta-law** $\frac{x'}{x - vt} = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$ **(Canonical)**	$x' = \gamma (x + vt)$ $\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$	[16]
(12) **Lorentz transformation's t' coordinate** $t'=f(x, t)$	$M_1 \to \frac{t'}{t - \frac{vx}{c^2}}$ $M_2 \to 1$ $s \to \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$	**Meta-law** $\frac{t'}{t - \frac{vx}{c^2}} = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$ **(Canonical)**	$t' = \gamma \left(t - \frac{vx}{c^2} \right)$ $\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$	[16]
(13) **Lorentz reverse transformation's x coordinate** $x=f(x', t')$	$M_1 \to \frac{x}{x'+ vt'}$ $M_2 \to 1$ $s \to \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$	**Meta-law** $\frac{x}{x'+ vt'} = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$ **(Canonical)**	$x = \gamma (x'+ vt')$ $\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$	[16]
(14) **Lorentz reverse transformation's t coordinate** $t=f(x', t')$	$M_1 \to \frac{t}{t'+ \frac{vx'}{c^2}}$ $M_2 \to 1$ $s \to \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$	**Meta-law** $\frac{t}{t'+ \frac{vx'}{c^2}} = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$ **(Canonical)**	$t = \gamma \left(t'+ \frac{vx'}{c^2} \right)$ $\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$	[16]

Name of the Law or constant	Dimensionless Meta Quantities and their Meta-transformations	Fundamental form of the law as dimensionless ratios (Canonical form)	How humans formulated this law or constant	Ref.
(15) **Relativistic momentum**	$M_1 \rightarrow \frac{\vec{p}}{m_0 \vec{v}}$ $M_2 \rightarrow 1$ $s \rightarrow \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$	$\frac{\vec{p}}{m_0 \vec{v}} = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$ (Canonical)	$\vec{p} = \gamma\, m_0 \vec{v}$ $\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$	--
(16) **Planck radiation equation (Blackbody radiation)**	$M_1 \rightarrow \frac{\rho_{EV\lambda}}{\frac{8\pi\, ch}{\lambda^5}}$ $M_2 \rightarrow 1$ $s \rightarrow \frac{1}{e^{ch/\lambda k\theta} - 1}$	$\frac{\rho_{EV\lambda}}{\frac{8\pi\, ch}{\lambda^5}} = \frac{1}{e^{ch/\lambda k\theta} - 1}$ (Canonical)	$\rho_{EV\lambda} = \frac{8\pi\, ch}{\lambda^5} \frac{1}{e^{ch/\lambda k\theta} - 1}$	--
(17) **Quantum harmonic oscillator**	$M_1 \rightarrow \frac{E_n T}{h}$ $M_2 \rightarrow 1$ $s \rightarrow n + \frac{1}{2}$	$\frac{E_n T}{h} = n + \frac{1}{2}$ $n = 0, 1, 2, 3, \ldots$ (Canonical)	$E_n = \left(n + \frac{1}{2}\right) hf$ $n = 0, 1, 2, 3, \ldots$	--
(18) **Compton effect**	$M_1 \rightarrow \frac{\Delta\lambda}{\frac{h}{m_0 c}}$ $M_2 \rightarrow 1$ $s \rightarrow 1 - \cos\theta$	$\frac{\Delta\lambda}{\frac{h}{m_0 c}} = 1 - \cos\theta$ (Canonical)	$\Delta\lambda = \frac{h}{m_0 c}(1 - \cos\theta)$	--

Name of the Law or constant	Dimensionless Meta Quantities and their Meta-transformations	Fundamental form of the law as dimensionless ratios (Canonical form)	How humans formulated this law or constant	Ref.
(19) **Shockley diode equation**	$M_1 \to \frac{I}{I_S}$ $M_2 \to 1$ $s \to e^{\frac{qV}{\eta k_B T}} - 1$	$\frac{I}{I_S} = e^{\frac{qV}{\eta k_B T}} - 1$ (Canonical)	$I = I_S\left(e^{\frac{qV}{\eta k_B T}} - 1\right)$	--
(20) **Rocket equation**	$M_1 \to \frac{m_1}{m_0}$ $M_2 \to 1$ $s \to e^{-\frac{\Delta v}{v_g}}$	$\frac{m_f}{m_i} = e^{-\frac{v_f}{v_g}}$ (Canonical)	$m_f = m_i\left(e^{-\frac{\Delta v}{v_g}}\right)$	--
(21) **Boltzmann entropy**	$M_1 \to \frac{S}{k_B}$ $M_2 \to 1$ $s \to \ln W$	$\frac{S}{k_B} = \ln W$ (Canonical)	$S = k_B \ln W$	--
(22) **Perfect gas equation**	$M_1 \to \frac{\frac{pV}{T}}{k_B}$ $M_2 \to 1$ $s \to N$	$\frac{\frac{pV}{T}}{k_B} = N$ (Canonical)	$pV = Nk_B T$	--
(23) **Classical Doppler effect (Sound)**	$M_1 \to \frac{f_{obs}}{f_s}$ $M_2 \to 1$ $s \to \frac{1 \pm \frac{v_{obs}}{v}}{1 \mp \frac{v_s}{v}}$	$\frac{f_{obs}}{f_s} = \frac{1 \pm \frac{v_{obs}}{v}}{1 \mp \frac{v_s}{v}}$ (Canonical)	$\frac{f_{obs}}{f_s} = \frac{v \pm v_{obs}}{v \mp v_s}$	--

Name of the Law or constant	Dimensionless Meta Quantities and their Meta-transformations	Fundamental form of the law as dimensionless ratios (Canonical form)	How humans formulated this law or constant	Ref.
(24) **Relativistic Doppler redshift** **(Special Relativity)**	$M_1 \to \frac{\lambda_{obs}}{\lambda_{emitted}}$ $M_2 \to 1$ $s \to \frac{1+\frac{v_r}{c}}{\sqrt{1-\frac{v^2}{c^2}}}$	$\frac{\lambda_{obs}}{\lambda_{emitted}} = \frac{1+\frac{v_r}{c}}{\sqrt{1-\frac{v^2}{c^2}}}$ (Canonical)	$z = \frac{1+\frac{v_r}{c}}{\sqrt{1-\frac{v^2}{c^2}}} - 1$ $z = \frac{\lambda_{obs} - \lambda_{emitted}}{\lambda_{emitted}}$	--
(25) **Gravitational redshift (General Relativity)**	$M_1 \to \frac{\lambda_{obs}}{\lambda_{emitted}}$ $M_2 \to 1$ $s \to \frac{1}{\sqrt{1-\frac{2GM}{rc^2}}}$	$\frac{\lambda_{obs}}{\lambda_{emitted}} \to \frac{1}{\sqrt{1-\frac{2GM}{rc^2}}}$ (Canonical)	$z = \frac{1}{\sqrt{1-\frac{2GM}{rc^2}}} - 1$ $z = \frac{\lambda_{obs} - \lambda_{emitted}}{\lambda_{emitted}}$	--
(26) **Cosmological redshift (Due to the expansion of space)**	$M_1 \to \frac{\lambda_{obs}}{\lambda_{emitted}}$ $M_2 \to 1$ $s \to \frac{a(t_{obs})}{a(t_{emitted})}$	$\frac{\lambda_{obs}}{\lambda_{emitted}} = \frac{a(t_{obs})}{a(t_{emitted})}$ (Canonical)	$z = \frac{a(t_{obs})}{a(t_{emitted})} - 1$ $z = \frac{\lambda_{obs} - \lambda_{emitted}}{\lambda_{emitted}}$	--

Name of the Law or constant	Dimensionless Meta Quantities and their Meta-transformations	Fundamental form of the law as dimensionless ratios (Canonical form)	How humans formulated this law or constant	Ref.
(27) **Hubble Law**	$M_1 \to \dfrac{H(t)}{\dfrac{dS(t)}{dt}}$ $M_2 \to 1$ $s \to S(t)$	$\dfrac{H(t)}{\dfrac{dS(t)}{dt}} = S(t)$ (Canonical)	$H(t) = \dfrac{dR(t)}{dt} R(t)$	--
(28) **Radioactive decay**	$M_1 \to \dfrac{\dfrac{dN(t)}{dt}}{\lambda N(t)}$ $M_2 \to 1$ $s \to -1$	$\dfrac{\dfrac{dN(t)}{dt}}{\lambda N(t)} = -1$ (Canonical)	$\dfrac{dN(t)}{dt} = -\lambda N(t)$	--
(29) **Absorption of photons by a medium**	$M_1 \to \dfrac{I(x)}{I_i}$ $M_2 \to 1$ $s \to e^{-\mu x}$	$\dfrac{I(x)}{I_i} = e^{-\mu x}$ (Canonical)	$I(x) = I_i e^{-\mu x}$	--
(30) **Lens formula for Thin Lenses**	$M_1 \to \dfrac{o+i}{o}$ $M_2 \to \dfrac{i}{f}$ $s \to 1$	$\dfrac{o+i}{o} = \dfrac{i}{f}$ (Canonical)	$\dfrac{1}{o} + \dfrac{1}{i} = \dfrac{1}{f}$	--
(31) **Lens manufacture's formula**	$M_1 \to \dfrac{\dfrac{1}{f}}{\dfrac{1}{r_1} - \dfrac{1}{r_2}}$ $M_2 \to 1$ $s \to n-1$	$\dfrac{\dfrac{1}{f}}{\dfrac{1}{r_1} - \dfrac{1}{r_2}} = n-1$ (Canonical)	$\dfrac{1}{f} = (n-1)\left(\dfrac{1}{r_1} - \dfrac{1}{r_2}\right)$	--

Name of the Law or constant	Dimensionless Meta Quantities and their Meta-transformations	Fundamental form of the law as dimensionless ratios (Canonical form)	How humans formulated this law or constant	Ref.
(32) **Balmer equation**	$M_1 \to \frac{1}{\lambda R}$ $M_2 \to 1$ $s \to \frac{1}{n_f^2} - \frac{1}{n_i^2}$	$\frac{1}{\lambda R} = \frac{1}{n_f^2} - \frac{1}{n_i^2}$ (Canonical)	$\frac{1}{\lambda} = R\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$	--
(33) **Fermi-Dirac distribution function**	$M_1 \to p_{FD}(E)$ $M_2 \to 1$ $s \to \frac{1}{Fe^{(E/k_BT)} + 1}$	$p_{FD}(E) = \frac{1}{Fe^{(E/k_BT)}+1}$ (Canonical)	$p_{FD}(E) = \frac{1}{Fe^{(E/k_BT)}+1}$	--
(34) **Bose-Einstein distribution function**	$M_1 \to p_{BE}(E)$ $M_2 \to 1$ $s \to \frac{1}{Be^{(E/k_BT)} - 1}$	$p_{BE}(E) = \frac{1}{Be^{(E/k_BT)}-1}$ (Canonical)	$p_{BE}(E) = \frac{1}{Be^{(E/k_BT)}-1}$	--
(35) **Photoelectric effect**	$M_1 \to \frac{\frac{1}{2} m v_{\max}^2}{hf - W}$ $M_2 \to 1$ $s \to 1$	$\frac{\frac{1}{2} m v_{max}^2}{hf - W} = 1$ (Canonical)	$\frac{1}{2} m v_{max}^2 = hf - W$	--
(36) **Magnetic moment**	$M_2 \to \frac{\tau}{i A B}$ $M_2 \to 1$ $s \to \sin\theta$	$\frac{\tau}{i A B} = \sin\theta$ (Canonical)	$\tau = i A B \sin\theta$	--

Name of the Law or constant	Dimensionless Meta Quantities and their Meta-transformations	Fundamental form of the law as dimensionless ratios (Canonical form)	How humans formulated this law or constant	Ref.
(37) **Lorentz force**	$M_1 \rightarrow \frac{\vec{F} - q\vec{E}}{q\,v\,B\,\vec{n}}$ $M_2 \rightarrow 1$ $s \rightarrow 1$	$\frac{\vec{F} - q\vec{E}}{q\,v\,B\,\vec{n}} = \sin\theta$ (Canonical)	$\vec{F} = q\vec{E} + q\vec{v} \times \vec{B}$ or $\vec{F} = q\vec{E} + q\,v\,B\sin\theta\ \vec{n}$ $\vec{n}$ is an unitary vector normal to the plane defined by the vectors $\vec{v}$ and $\vec{B}$	
(38) **Electron orbit magnetic moment**	$M_1 \rightarrow \frac{m_e}{e}\frac{\vec{\mu}_{orbital}}{\vec{L}}$ $M_2 \rightarrow 1$ $s \rightarrow -\frac{1}{2}$	$\frac{m_e}{e}\frac{\vec{\mu}_{orbital}}{\vec{L}} = -\frac{1}{2}$ (Canonical)	$\vec{\mu}_{orbital} = -\frac{e}{2m_e}\vec{L}$	--
(39) **Electron spin magnetic moment**	$M_1 \rightarrow \frac{m_e}{e}\frac{\vec{\mu}_{spin}}{\vec{S}}$ $M_2 \rightarrow 1$ $s \rightarrow -\frac{g_e}{2}$	$\frac{m_e}{e}\frac{\vec{\mu}_{spin}}{\vec{S}} = -\frac{g_e}{2}$ (Canonical)	$\vec{\mu}_{spin} = g_e\frac{q_e}{2m_e}\vec{S}$ $g_e = 2\left(\sqrt[4096]{\frac{1}{\alpha} - \frac{2}{\alpha^{0.5}} + \frac{1}{\alpha^{0.1}} + \frac{0.00002}{\alpha^{0.09}}}\right)$ $g_e \approx 2.002\ 319\ 304\ 361\ 17$ $q_e = -e$	[18]

Table 3: *This table shows how Nature spawned the fine-structure constant and several laws of physics from one Model Meta-law and several Excluding Meta-laws. All equations/inequations shown in column 3 are expressed in its canonical form (n=1; m=1). The complete Lorentz transformations also include: y'=y, z'=z, y=y' and z=z' which are not shown here.*

The Lorentz transformations are one of the equations whose scale factors are not numbers (real or quantum) but real functions:

$$S = S(v) = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

Excluding Meta-laws obey the Scale Law

The Lorentz transformations are an example of Excluding Meta-laws and they also obey the Scale Law. Therefore the Scale Law is, hierarchically, above the Excluding Meta-laws.

The Lorentz transformation is probably the most powerful evidence in favour of the Scale Law. I invite the reader to read my article "*The Lorentz Transformations and the Scale Principle"* [16].

7. The Structure of the Scale Law

So far we know Meta-laws deal with dimensionless quantities and not with specific quantities. For example (and this is the only example we have) the representation of the Scale Law in its primordial form is given by

(1)

Scale Principle or *Scale Law*
$M_1 \Re\ s\ M_2$

M_1 = dimensionless Meta-quantity 1
M_2 = dimensionless Meta-quantity 2
s = dimensionless Meta-scale-factor
$\Re$ = Meta-relationship-type

Thus we arrive to the first property of this Meta-law:

Property

The Scale Law is a relationship between dimensionless Meta-quantities.

It is worthy to remark that the Scale-law in its Primordial form is not a relationship among any of the dimensions of our Universe. Thus both M_1 and M_2 have no ordinary dimensions. The dimensions we all are familiar with (length, time, mass) were created during the Big Bang, and then is when the Meta-quantities M_1 and M_2 became ratios (Q_1/Q_2 and Q_3/Q_4 respectively) as shown by the following Meta-transformation:

$$M_1 \rightarrow (Q_1/Q_2)^n$$
$$\Re \rightarrow [<' \leq ' = ' \geq ' >]$$

$$M_2 \rightarrow (Q_3/Q_4)^m$$
$$s \rightarrow S$$

And consequently Meta-equation (1) transformed into equation (2)

(2)

Scale Principle or *Scale Law*
$\left(\frac{Q_1}{Q_2}\right)^n \left[< \mid \leq \mid = \mid \geq \mid > \right] S \left(\frac{Q_3}{Q_4}\right)^m$

Where the ratios, Q_1/Q_2 , and Q_3/Q_4 , represent particular ratios and the scale factor S represents a specific scale factor.

Whether Nature produced the final ratios directly form the Scale Law (1) or through intermediate transformations, it is not known. However we shall normally write the Scale Law according to relationship (2) instead of using relationship (1) because this way the Law's shape is closer to the shape of the laws we are familiar with.

Let us investigate relationship (3) more closely. The symbols shown there 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 vice versa. (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. There must be one and only one scale factor per equation.

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 $m = 1$; (canonical form)
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 (1). This means that the exponents will not change when we express the relationship in a mathematically equivalent form such as

$$\left(\frac{Q_4}{Q_3}\right)^m \left[< \left| \leq \right| = \left| \geq \right| > \right] S \left(\frac{Q_2}{Q_1}\right)^n \qquad (3)$$

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.
iv) When the exponents, *n* and *m*, are both equal to *one,* then we say that the equation is in its *canonical form*. Whenever we express a particular law of physics in the form of the Scale Law, we should use its canonical form, if possible, provided we don't mix up the variables (defined in a).

The scale law (1) can also be written as

$$Q_1^n Q_4^m \left[< \left| \leq \right| = \left| \geq \right| > \right] S\, Q_2^n\, Q_3^m \qquad (4)$$

However we shall not use this form because is not as clear as equation (2).

8. The Origin of the Fine-Structure Constant

The fine-structure constant, denoted by α, is a fundamental physical constant. It was discovered in 1916 by the German physicist Arnold Sommerfeld through his relativistic theory of the hydrogen atom. For the first time in history this constant appeared explicitly in an equation. The constant is also a measure of the strength of the electromagnetic interaction between photons and electrons.

The fine-structure constant is dimensionless, which means that its value is independent of the system of units we use to measure it. Since its discovery this fascinating and mystic constant has captured the attention of people including the American physicist Richard Feynman, who quoted:

"It has been a mystery ever since it was discovered more than fifty years ago, and all good theoretical physicists put this number up on their wall and worry about it." [20]

"One of the greatest damn mysteries of physics: a magic number that comes to us with no understanding by man."

The Standard Model cannot predict the value of this constant and therefore the constant is one of the "external parameters" of the model. It is interesting to note that the fine-structure constant is dimensionless and this is exactly one of the properties of the Meta-law we are considering in this paper. Let us consider the two canonical forms of this constant:

(a) Canonical form 1 (n=m=1)

$$\frac{Q_P}{e} = \frac{1}{\alpha}\frac{e}{Q_P} \qquad (5a)$$

(b) Canonical form 2 (n=m=1)

$$\frac{e}{Q_P} = \alpha\ \frac{Q_P}{e} \qquad (5b)$$

Where

$$Q_P \equiv \sqrt{2\varepsilon_0 hc} \qquad (6)$$

Because both forms are in fact the same equation, it does not matter which one we adopt. Thus we shall adopt the first canonical form.

Expression (5a) is a reflection of the Scale Law with the following values

$n=1$
$Q_1 = e$ = elementary charge (electron charge/proton charge)
$Q_2 = Q_P$
$m=1$

$Q_3 = Q_P$
$Q_4 = e$
$S = \alpha$ = fine-structure constant

Substituting Q_P in equation (5a) with the second side of equation (6) yields

$$\frac{\sqrt{2\varepsilon_0 hc}}{e} = \frac{1}{\alpha}\frac{e}{\sqrt{2\varepsilon_0 hc}} \tag{7}$$

We notice that there is a numerical constant, $\sqrt{2}$, on both sides of the equation. However, we want an expression with only one real number, the scale factor, (a complex number or a function in other cases) so we divide both sides of the equation by $\sqrt{2}$. This produces

$$\frac{\sqrt{\varepsilon_0 hc}}{e} = \frac{1}{2\alpha}\frac{e}{\sqrt{\varepsilon_0 hc}} \tag{8}$$

To compare with the Scale Law we write the above expression as follows

$$\left(\frac{\sqrt{\varepsilon_0 hc}}{e}\right)^1 = \frac{1}{2\alpha}\left(\frac{e}{\sqrt{\varepsilon_0 hc}}\right)^1 \tag{9a}$$

or

$$\left(\frac{e}{\sqrt{\varepsilon_0 hc}}\right)^1 = 2\alpha\left(\frac{\sqrt{\varepsilon_0 hc}}{e}\right)^1 \tag{9b}$$

Expression (9a) is a reflection of the Scale Law with the following values

n=1
$Q_1 = \sqrt{\varepsilon_0 hc}$
$Q_2 = e$ = elementary charge
m=1
$Q_3 = e$
$Q_4 = \sqrt{\varepsilon_0 hc}$
$S = \frac{1}{2\alpha}$ (10)

Therefore, the value of the scale factor depends on the way we write the equation. This seems to be awkward since we would like to have one and only one scale factor. However we have to remember that we encountered this situation when we studied the normal laws of physics. The values of the physical constants in a given system of units depend on the way they are defined.

Anyway, this duality of scale factors can be resolved observing that equation (8) is more fundamental than equation (5a) because the quantities in equation (7) : Q_1, Q_2, Q_3 and Q_4 do not contain the number $\sqrt{2}$. This argument leads to a scale factor of $1/2\alpha$.

Thus we have solved the problem of the origin of the fine-structure constant.

The Origin of the Fine-Structure Constant

The fine-structure constant is the direct consequence of a Meta-law (the Scale Law) and an unknown number of Excluding Meta-laws.

It seems that we have replaced a mystery with another one. However there is a significant advance: the origin of both the fine-structure constant and the laws of physics have a common explanation. It is worthy to observe that when we use the Scale Law to express both the fine-structure constant and the laws of physics, we obtain the same fundamental form for all of them as dimensionless ratios. The following example illustrates this point:

Quantum-Relativistic Atomic Models

(canonical form of the fine-structure constant)
(ratio of electric charges)

$$\left(\frac{e}{\sqrt{\varepsilon_0 hc}} \right)^1 = 2\alpha \left(\frac{\sqrt{\varepsilon_0 hc}}{e} \right)^1$$

Special Relativity

(canonical form of the total relativistic energy)
(ratio of energies)

$$\left(\frac{pc}{E + m_0 c^2} \right)^1 = \left(\frac{E - m_0 c^2}{pc} \right)^1$$

Quantum Mechanics

(canonical form of the Schrödinger equation)
(ratio of lengths)

$$\left(\frac{\lambda}{\sqrt{\frac{\Psi}{\nabla^2 \Psi}}} \right)^1 = -4\pi^2 \left(\frac{\sqrt{\frac{\Psi}{\nabla^2 \Psi}}}{\lambda} \right)^1$$

General Relativity
(canonical form of the Friedmann Equation)
(ratio expansion rates/speeds)

$$\left(\frac{\dot{R}}{\left(\frac{R}{R_0} + K \right) c} \right)^1 = \left(\frac{\left(\frac{R}{R_0} - K \right) c}{\dot{R}} \right)^1$$

Note 2: I have used the power of 1 in the previous canonical equations for clarity.

It is worthy to note the striking similarities in shape among these four equations. The fine-structure constant equation is expressed as a ratio of electric charges with a scale factor equal to 2α, the relativistic energy equation is expressed as a ratio of energies with a the scale factor equal to 1, the Schrödinger equation is expressed as a ratio of lengths with a scale factor equal to $(2\pi i)^2$, and finally the Friedman equation is expressed as a ratio of "speeds" with a scale factor equal to 1.

9. Two Types of Meta-laws

According to the knowledge we have so far, it seems all the laws of physics obey the Scale Law (see Table 3) even if some particular laws do not obey the Lorentz covariance principle. The Scale Law is a Non-Excluding Law and its "purpose" is to serve as a model or a template all laws of physics, including the Excluding Meta-laws, must obey. The canonical form of the laws of physics (see Table 3) show the resemblance these laws have with the Scale Law regardless which Excluding Meta-laws they obey to. Thus we conclude that the Scale Law is a Model Meta-law.

The Scale Law explains why the laws of physics have the form they do. There must be other Meta-laws to dictate what is allowed and what is forbidden. For example in order to get a seat into a commercial airline you need to be human (assuming that pets are not allowed to seat with humans). Being human is necessary but is not sufficient; you also need an airline ticket and a passport. Thus the Scale Law is like the condition of being human while the Excluding Meta-laws are like airline tickets and passports.

All equations that represent laws of physics can be written in the form of the Scale Law, but not all equations written in the form of the Scale Law represent laws of physics. This is so because of the exclusion process carried out by the Excluding Meta-laws. To summarize this point we can say that the laws of physics are the result of two types of Meta-laws – a Model Meta-law and an unknown number of Excluding Meta-laws.

The Universal "Dictators"

A Model Meta-law tells Excluding Meta-laws the general model they must follow; Excluding Meta-laws dictate which laws of the model are "allowed" and which ones are "forbidden".

To illustrate this point let us consider the following example. The Einstein's relativistic total energy equation written in its canonical form is given by

$$\frac{E + m_0 c^2}{pc} = \frac{pc}{E - m_0 c^2} \qquad (11)$$

However, despite having the form of the Scale Law, the following two relationships

$$\frac{E + m_0 c^2}{pc} = \frac{pc}{E + m_0 c^2} \qquad \text{(Forbidden)} \qquad (12)$$

$$\frac{E - m_0 c^2}{pc} = \frac{pc}{E - m_0 c^2} \qquad \text{(Forbidden)} \qquad (13)$$

are forbidden. They do not represent laws of physics because they have been ruled out by Excluding Meta-laws. Equations (12) and (13) lead to the following expressions

$$E^2 = (pc)^2 - 2E m_0 c^2 - (m_0 c^2)^2 \qquad \text{(Forbidden)} \qquad (14)$$

$$E^2 = (pc)^2 + 2E m_0 c^2 - (m_0 c^2)^2 \qquad \text{(Forbidden)} \qquad (15)$$

respectively, which, as we know, do not represent physical laws.

10. Conclusions

My previous papers [6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19] and the rest of the analysis suggest that all the laws of physics are the result of more fundamental laws: Meta-laws. Thus, this paper introduces two new concepts: a Model Meta-law (The Scale Law) and Excluding Meta-laws. I have proposed that Nature "invoked" these Laws to create the laws of physics we are familiar with. However, the laws of physics, by themselves, could have not created our Universe. Matter is the result of the Meta-transformation we call the Big Bang. Behaviour (laws of physics) is one of the consequences of creation; not the cause. Where did matter come from then? From Meta-energy that existed before the Big Bang. Thus if we include the Meta-universe in our analysis then we can assert that there was no creation. Strictly speaking the Big Bang was a transformation not a creation. The Einstein's famous equation of equivalence of mass and energy:

$$m = \frac{E}{c^2}$$

indicates that matter was the result of energy, space and time [22]. Thus matter is the result of a Meta-transformation known as the Big Bang. Our Universe is an embedded material replica of a hidden immaterial Pre-universe which was never created and that we are just beginning to understand. So creation is a misconception that we should dismiss in its most profound meaning.

Before the discovery of the Scale Law, the origin of the laws of physics was a mystery and the resemblance between any two apparently non-related laws (laws describing two different phenomena – having different dimensions -) was not even known. Thus, the Scale Law

i. unveils a "hidden" resemblance all laws of physics share, regardless of the Nature of the phenomenon they describe (regardless of the dimensions) (Table 3),
ii. allows us to make predictions through scale tables as we did to find the limits for the size of the electron [6],
iii. allows us to unveil exact laws of physics, including other Meta-laws, as we did when we derived the Lorentz transformations [16], and
iv. provides a rational explanation about the origin of the laws of physics and the fine-structure constant.

It is worth to emphasize that the first three statements (i, ii, iii) would still hold even if the Scale Law were not considered to be a Meta-law. Therefore the usefulness of this formulation is guaranteed.

After the analysis carried out above we are in a position to answer the question: where do the laws of physics come from? They come from a hierarchical structure of Meta-laws. But this answer spawns another question: where do Meta-laws come from? We can answer this question easily if we observe that this question is equivalent to asking: what is the origin of the Meta-laws of physics? Then the answer is: something that has always existed has no origin, therefore questions such as: where do Meta-laws come from? or: what is the origin of the Meta-laws of physics? do not make any sense.

Finally we can say that the mystery on the origin of the laws of physics has been solved: the normal laws of physics where created during the Big Bang, however the higher order laws: the Meta-laws of physics, had no origin, and therefore "they do not come from anywhere".

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