Calibrating the universe, and why we need to do it

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Abstract: Planck's constant, h, as an action constant is one of the most widely studied concepts in theoretical physics. It appears in many equations from Planck's energy equation to the famous Schrodinger equation. Historically, the energy equation, $E = h\,v$, and units for h, $[J \times s]$, were chosen by convention. However, this essay describes a method of analysis that sees h as an energy constant and not an action constant. Using the logic of the calibration and the equations for calculating Planck natural units, an attempt is made to find the smallest measuring sticks or "pixels" for the domains of time, space, mass, charge and temperature. Using this method, it is found that Planck units for the domains of mass, charge and temperature do not correspond to the smallest measure-units. To correct this, Planck's energy equation is modelled as the equation of an experiment, $E = h\,t\,v$, and the extra unit of $[s]$, which is normally assigned to h, is assigned to a previously hidden measure-time variable, t. Here, h has the units of $[J]$ and interprets as quantum of energy, Q_{energy}. Quantum of mass, Q_{mass}, is calculated using h/c^2 which herein has units of mass. Using this logic, a complete set of quantum measure-units, calibrated to the time scale of the cycle is derived and tested. A self-similar set of measure-units, calibrated to the time scale of the second, is also derived. This approach leads to a modified unit analysis (MUA) that differs somewhat from that found in the NIST standard. MUA offers a slightly more complex but much more exact unit analysis where everything is accounted for and nothing is hidden. Using MUA as a foundation, an alternate cosmology is proposed that puts the first cycle of time or Planck epoch at a temperature of $10^{-12} K$, in stark contrast to the big bang model which puts the Planck epoch at a temperature of $10^{+32} K$. The implications of this result, if correct, are of great significance.

R´esum´e: La constante de Planck h, r´epresentant l'action, est l'un des concepts les plus´etudi´es en physique th´eorique. Elle appara^ıt dans plusieurs ´equations incluant celle de l'´energie de Planck jusqu'aux celles de Schr¨odinger. Historiquement, l'´equation d'´energie, $E = h\,v$, et les unit´es pour h $[J \times s]$ ont ´et´e conventionellement choisis. Cependant, cet essai d´ecrit une m´ethode d'analyse des constantes de la nature ou` $h$ est celle d'´energie et non pas celle d'action. En employant la logique de calibrage, des petites r`egles ou des pixels de mesure sont conc¸us pour le temps, l'espace, la masse, la charge et la temp´erature. En utilisant cette m´ethode, il est constat´e que les unit´es de Planck pour les domaines de la masse, la charge et la temp´erature ne correspondent pas `a la plus petite unit´es-mesure. Pour corriger cela, l'´equation de l'´energie de Planck est mod´elis´ee comme celle d'une exp´erimentation, $E = htv$, et l'unit´e suppl´ementaire de $[s]$, normalement associ´e `a h, devient assign´e `a une variable cach´ee mesure-temps, t. Ici, $h$ a les unit´es de $[J]$ et il est interpr`et´e comme l'´energie quantique, Q_{energy}. La mass quantique, Q_{mass} est calcul´ee en utilisant h/c^2 qui a ici les unit´es de masse. Dans cette logique, un ensemble complet d'unit´es -mesure quantique, calibr´e `a l'´echelle de temps du cycle est d´eriv´e et test´e. Un ensemble d'unit´e-mesure autosimilaire, calibr´e `a l’´echelle de temps de la seconde, est ´egalement d´eriv´e. Cette approche conduit `a une analyse de l’unit´e modifi´ee (AUM) qui diff`ere quelque peu de celle trouv´ee dans la norme NIST. Ainsi, AUM propose une analyse un peu plus complexe, mais beaucoup plus exacte ou` tout est pris en compte et rien est cach´e. En utilisation l’AUM comme fondation, une autre cosmologie est propos´ee qui met le premier cycle de temps ou l’`ere de Planck `a une temp´erature de $10^{-12}\,K$, qui est en contraste frappant avec le mod`ele du Big Bang qui le met `a $10^{+32}\,K$. Les implications de ce r´esultat, si il est correct, sont d’une grande importance.

Key words: unit analysis, calibration, pixel, action, energy, quantum, frequency, cycle, domain, fractal

1 Introduction

When asked the question: "How do you find new laws of nature?", Dirac replied, "I play with equations".[1] Writing the same equation in different ways can and does lead to novel ideas and new interpretations. Although the main equations of theoretical physics have been greatly manipulated over the years (and many new laws have been discovered), the "equations" of unit analysis remain largely untouched. Using the logic of the calibration and the equations for calculating Planck natural units, an attempt is made to find the smallest measuring sticks or pixels for the domains of time, space, mass, charge and temperature. Although the Planck units for the domains of time and space do correspond to reasonable pixel values, the calculated Planck units for the domains of mass, charge and temperature do not.

To correct this, Planck's energy equation is modelled as the equation of an experiment, $E = htv$, and the extra unit of $[s]$, which is normally assigned to h, is assigned to a previously hidden measure-time variable, t. Using this approach, h has the units of $[J]$ and interprets as quantum of energy, Q_{energy}. Quantum of mass, Q_{mass}, can now be calculated using h/c^2 which, in this analysis, has units of mass. Using this logic, a complete set of quantum measure-units, calibrated to the time scale of the cycle is derived (Table IV) and tested. A self similar unit set, calibrated to the time scale of the second is also derived (Table V) and tested. The self similarity of these measure-unit sets is an important feature of this analysis as it accommodates the idea of a fractal universe where self similarity is a requirement.

The modified unit analysis (MUA) presented in this essay represents a clear break with convention. The addition of the domain of oscillation distinct from the domains of time, space, mass, charge and temperature, adds a new dimension to unit analysis leading to an alternate cosmology that differs profoundly from that of the standard cosmology and can be considered a paradigm shift. For example, this approach puts the first cycle of time or Planck epoch at a temperature in the order of $10^{-12}\,K$ (see Table IV) in stark contrast to that predicted by the big bang model.

Since unit analysis is the primary driver of interpretation in physics and cosmology, any modifications to standard unit analysis must be applied strategically and with care. MUA offers a slightly more complex but much more exact unit analysis where everything in the body of the equation is accounted for in the unit section (and vice versa) and nothing is hidden. The purpose of this essay is twofold 1) it is a lesson in unit analysis and 2) it is the beginning of a new standard. The reason Dirac “played with equations” was because it usually leads to new insights and sometimes, new laws. Whether the MUA approach will lead to new laws remains to be seen. Further investigation is suggested.

“There’s always another way to say the same thing, that doesn’t sound at all like the way it was said before.” Richard Feynman.

2 Methods

Using the logic and language of the calibration, a quasi-calibration procedure is performed (on the Universe) using the measured constants of nature and the equations used for calculating the Planck natural units. The procedure is outlined as follows:

Section 2.1: Definition of terms.

Section 2.2: The main components of the system are identified and recorded. Reference units are assigned and fixed.

Section 2.3: All known and previously measured constants of the system and associated reference-units are identified and recorded.

Section 2.4: Measure-units for all components of the system are calibrated and recorded.

Section 2.5: The measure-units found in 2.4 are studied to see if they make sense in terms of the calibration. All issues associated with this analysis are identified and reported.

Section 2.6: All issues found in the previous steps are addressed and corrected. New measure-units are calculated and reported and the rules for a modified unit analysis (MUA) are defined.

Section 3: The calibration is tested by applying the calibrated measure-units to the unit analysis of the known constants of nature.

2.1 Definition of Terms

2.1.1 Calibration

This term refers to the process of acquiring quantitative information about an instrument or experiment to ensure that accurate measurements can be made within the context of the system.

2.1.2 Pixel calibration

This term refers to the process of measuring the smallest measuring sticks for each component of a system.

2.1.3 Unit analysis

This term refers to the analysis of the relationships between the various components of a system. Unit analysis is one of the most important tools of theoretical physics as all interpretations within the context of a system, are founded in unit analysis.

2.1.4 Reference-unit

A reference-unit is a physical quantity that is used as a reference with which all other measurements are made. In the SI system, this includes the second, meter, kilogram, Coulomb and Kelvin. The rules associated with reference-units are as follows:

- All physical measurements are made relative to reference-units.
- Reference-units are found in the unit section of an equation and are primarily used to analyze the relationships between the components of the system.
- Reference-units are divisible, for example, one can reference a fraction of a second.
- Reference-units must be fixed before performing any physical experiment. For example, one should not arbitrarily switch from SI units to CGS in the middle of an experiment.

2.1.5 Measure-unit

Measure-units are the smallest measuring sticks or pixels of the system. The concept of measure-unit, distinct from reference-unit, is new to this analysis. The rules associated with measure-units are as follows:

- Measure-units are measured relative to the reference-units.
- Any measurement in the system can be expressed as a simple multiple of measure-units.
- Measure-units are scalable. To increase the resolution of a measurement, you must decrease in the size of the measuring stick or pixel.
- Measure-units (pixel dimensions) can only be calculated once reference-units are fixed.

2.1.6 Base-units

This term refers to the set of reference-units with which all other reference-units are derived. Base-units are fundamental as they cannot be derived from other units. The base units of the SI standard are the second $[s]$, the meter $[m]$, the kilogram $[kg]$ the Coulomb $[C]$ and the Kelvin $[K]$.

2.1.7 Derived-units

Derived units are reference-units that are expressed in terms of base-units.

2.1.8 Derived-unit of Energy

The unit of energy $[J]$ is derived from the base-unit $[kg\ m^{2}\ s^{-2}]$.

2.1.9 Derived-unit of Force

The unit of force $[N]$ is derived from the base units $[kg\ m\ s^{-2}]$

2.1.10 Derived-unit of Momentum

The unit of momentum $[P]$ is derived from the base units $[kg\ m\ s^{-1}]$.

2.1.11 Planck units

Planck units, also known as natural units, correspond to a set of physical units derived using the five universal constants of nature alone, the gravitational constant, G, Planck's constant, h, the speed of light, c, the Coulomb constant, k_e, and the Boltzmann constant, k_B.

2.1.12 Modified Unit Analysis, MUA

Modified Unit Analysis (MUA) is distinguished from standard unit analysis by the addition of the domain of oscillation (distinct from the domain of time) to the list of domains of the system. This necessitates the addition of the unit terms cycle $[cy]$ and measure-time $[T_{cy}]$ to the language of unit analysis.

2.1.13 MUA: Cycle $[cy]$

The $[cy]$ term corresponds to the indivisible cycle or unit in the domain of oscillation. It is loosely analogous to one clock cycle of a computer processor.

2.1.14 MUA: Measure-time $[T_{cy}]$

The measure-time term $[T_{cy}]$ is found in the unit sections of equations that have the measure-time variable, t, in the body of the equation. In MUA, measure-time $[T_{cy}]$ belongs to the domain of oscillation and reference-time $[s]$ belongs to the domain of time. Note: since the units from different domains cannot arbitrarily cancel with each other, in MUA, $[T_{cy}]$ cannot arbitrarily cancel with $[s]$.

2.2 Components of the System

The main components or domains of the system (the Universe) are identified as time, space, mass, charge and temperature. The domain of oscillation is also identified as a component of the system, distinct from the other 5 domains.

Component	Reference-unit	Symbol
Time	Second	s
Space	Meter	m
Mass	Kilogram	kg
Charge	Coulomb	C
Temperature	Kelvin	K
Oscillation	***Measure-time***	$\boldsymbol{cy}$**,** $\boldsymbol{T_{cy}}$

Table I: Components of the system and associated reference-units. These are considered the base units of the system. The domain of oscillation and corresponding reference-units [cy] and [T_{cy}] are new the MUA standard.

Table I lists the components of the system required by the calibration along with associated reference-units. The second, meter, kilogram, coulomb and kelvin are arbitrary reference measurements that were chosen by convention. (Note: These reference measurements were selected because they are easily calibrated at the human scale and have no special meaning in of themselves.) The domain of oscillation, with unit terms $[cy]$ and $[T_{cy}]$, is new to MUA and represents a distinct departure from convention.

2.3 Measured constants of the system.

Table II lists the main constants of the system required by the calibration. The values in this table are displayed to the digits of precision found in the NIST standard,[2] except for k_e which has more digits of precision as shown in Appendix A. Corresponding reference units are also shown. Although the unit relationships for these constants were historically chosen by convention, some of these relationships are called into question in this research, in particular, the unit relationship of Planck's constant. The units for the gravitational constant and the coulomb constant are also indirectly affected by MUA as discussed in Section 3.

Constant	**Symbol**	**Value**	**Reference-units**
Speed of Light	c	2.99792458 e+8	$[m\ \ s^{-1}]$
Planck's Constant	h	6.626070040 e-34	$[J\ \ s]$
Gravitational Constant	G	6.67408 e-11	$[N\ m^2\ \ kg^{-2}]$
Coulomb Constant	k_e	8.98755178736... e+9	$[N\ m^2\ \ C^{-2}]$
Boltzmann Constant	k_B	1.38064852 e-23	$[J\ \ K^{-1}]$

Table II: List of the measured constants of nature from the NIST standard and corresponding standard-units. Here, *m* is meter, *s* is second, *kg* is kilogram, *C* is Coulomb, *K* is Kelvin, *J* is Joule and *N* is Newton.

In the next section, we begin the calibration procedure by attempting to quantify the smallest measuring sticks or pixels for each component of the system.

2.4 Pixel Calibration

In this section, we attempt to identify and measure the smallest measure-units (pixels) for each component of the system, Historically, the measured constants from Table II along with unit analysis are used to calculate Planck units as follows:

$$t_{pl} = \sqrt{\frac{G\,h}{c^5}} \quad l_{pl} = \sqrt{\frac{G\,h}{c^3}} \quad m_{pl} = \sqrt{\frac{h\,c}{G}} \quad q_{pl} = \sqrt{\frac{h\,c}{k_e}} \quad T_{pl} = \sqrt{\frac{h\,c^5}{G\,k_B{}^2}} \quad f_{pl} = \sqrt{\frac{c^5}{h\,G}} \qquad (1)$$

Planck Unit	**Value**	**Reference-unit**
Planck Time t_{pl}	$1.3513627945321461 \times 10^{-43}$	s
Planck Length l_{pl}	$4.0512837382254104 \times 10^{-35}$	m
Planck Mass m_{pl}	$5.4556017312683428 \times 10^{-8}$	kg
Planck Charge q_{pl}	$4.7012966910233661 \times 10^{-18}$	C
Planck Temp T_{pl}	$3.5514109768523649 \times 10^{32}$	K
Planck Frequency f_{pl}	$\mathbf{7.3999373376725895 \times 10^{42}}$	$\boldsymbol{cy, T_{cy}}$

Table III: Planck units calculated using the measured constants of nature. The numerical value of *h* is used in all calculations and all values are calculated and shown to 16 digits of precision corresponding to the digits of precision of the computer used to calculate these values.

The calculated values for each Planck unit is shown in Table III. By convention (throughout this essay), the numerical value of h, found in Table II, is used in all calculations. All calculated values are shown to 16 digits of precision corresponding to the digits of precision of the computer used to do the calculations. The reason for keeping so many digits of precision is explained in Appendix A.

2.5 Review and Analysis

The goal of this calibration step was to find the smallest measure-units or pixels for each component of the system. Looking closely at the values in Table III, we see that Planck time is much smaller than any physically measurable time and therefore, is a good candidate for the pixel of time. Planck length being such a small value is also a good candidate for the pixel of space. Planck mass however, is significantly larger than the mass of the electron, the proton and all particles with measurable mass. Planck mass therefore, is not a good candidate for the pixel of mass. Planck charge is also bigger than elementary charge and thus, cannot be the pixel of charge. Planck temperature and Planck frequency are also too big to be considered as pixels of the system. A good calibration requires measure-units that are much smaller than what we are trying to measure.

2.6 Further Investigation

In the previous sections, an attempt was made to quantify the smallest measuring sticks or pixels for the domains of time, space, mass, charge and temperature. It was discovered that Planck mass, Planck charge and Planck temperature do not correspond to the smallest measuring sticks requiring further investigation. An experienced calibrator would begin the analysis by studying the system from first principles.

2.6.1 First Principles.

The investigation begins with the study of the two most important energy equations (2) and (3). The mass-energy equivalence equation, often referred to as Einstein's equation, is written as follows:

$$E = mc^2 \quad [kg\,\frac{m^2}{s^2}] \tag{2}$$

In this equation, c^2 is constant and energy varies with mass. The unit section in square brackets shows the relationship between mass $[kg]$, space $[m]$ and time $[s]$ that defines the Joule $[J]$. Although this equation can be verified by experiment, notice that this is not the equation of an experiment since it does not contain a time variable, t. It is merely expressing a relationship.

Next, we look more closely at Planck's energy equation which by convention is written as follows:

$$E = h\nu \quad [J \times s \times \frac{1}{s}] \tag{3}$$

In this equation, h is constant and energy varies with frequency. The unit section on the right, however, requires a bit of explaining. Historically and by convention, the unit of frequency was defined as $[1/s]$ and the unit of oscillation, $[cy]$, was replaced by the unit [1] (since cycles are indivisible countable units). As you can see, in order to balance the unit equation on the right, an extra unit of $[s]$ that is not explicitly accounted for in the body of the equation is required. Historically and by convention, this extra unit of $[s]$ was assigned to Planck's constant, *h*, giving us the ubiquitous action constant with units $[J \times s]$.

There is, however, another way to deal with the extra $[s]$ in the unit section. In equation (4), Planck's energy equation is modelled as the equation of an experiment and a (previously hidden) measure-time variable, t, is inserted into the body of the equation as follows:

$$E(t) = h\ t\ v = h \times t \times \frac{n}{t}\ \ [J \times T_{cy} \times \frac{1}{T_{cy}} = J] \qquad (4)$$

Here, measure-time, t, corresponds to the time interval of the experiment, n is the number of cycles counted and $E(t)$ is the total energy measured over the time interval of the experiment. For example, if we want to know the amount of energy collected in a ten second experiment, we set $t = 10$ and write: $E(10) = h \times 10 \times n/10$. If we want to know the amount of energy collected in a one second experiment, we set $t = 1$ and write: $E(1) = h \times 1 \times n/1$which in turn, simplifies to equation (3). Using this logic, it becomes clear that equation (3) has measure-time hard coded to exactly one second.

In this essay, a break with convention is presented that introduces a measure-time variable, t, into the body of the equation as shown in equation (4). The extra reference-unit $[s]$ that is normally assigned to h is replaced by a measure-unit $[T_{cy}]$ and is subsequently assigned to the measure-time variable t in the body of the equation. This approach offers an alternate interpretation of h as an energy constant instead of an action constant.

Note that these manipulations only affect unit analysis and do not affect nor do they change in any way tested and verifiable experimental results. For the sake of the calibration, it is preferable to have all the cards on the table. For a complete picture, the following is written:

$$E(t) = \frac{h}{1} \times t \times \frac{n}{t} \ [\frac{J}{cy} \times T_{cy} \times \frac{cy}{T_{cy}} = J] \tag{5}$$

Notice how ALL the terms in the unit section are now accounted for in the body of the equation. Here, the $[cy]$ terms belong to the cycle counting terms (1 and n) in the body of the equation. The term now reads "quantum of energy" or Q_{energy} and has units $[J]$. The frequency term n/t reads "cycles per measure-time" and has units $[cy/T_{cy}]$.

This approach leads to a slightly more complicated but much more exact unit analysis where nothing is hidden and everything is accounted for.

Equation (5) can now be simplified as follows:

$$E = h\ n\ \ [J\ \ \frac{T_{cy}\ cy}{cy\ T_{cy}}\ ] \tag{6}$$

Here, measure-time in the body is set equal to 1 (i.e. 1 second) and subsequently assigned to the frequency term n leaving us with the harmonic quintessence[3] equation

(6). The oscillation terms in the unit section are grouped. Technically these terms cancel, but for the sake of discussion, they are shown. Here, the unit term to the right of J belongs to the frequency term n in the body of the equation. In MUA, all frequency terms are, for all intents and purposes, unitless and thus, dimensionless. The concept of a dimensionless domain is a new and important feature of the modified unit analysis presented in this essay. In MUA, the unit term $[(T_{cy} / cy) \times (cy / T_{cy})]$can be thought of as virtual units.

2.6.2 Modified Unit Analysis (MUA)

In this section a new convention is proposed, based on the logic presented in the previous section. It is referred to as Modified Unit Analysis or MUA and is specified as follows:

- The domain of oscillation, distinct from the domains of time, space, mass, charge and temperature, shall be added as a domain of the system.
- The unit term cycle $[cy]$ shall be added to the domain of oscillation as the unit of the cycle counting terms (1 and n) in the body of an equation.
- The unit term measure-time $[T_{cy}]$ shall be added to the domain of oscillation as the unit of the measure-time variables, t, in the body of an equation.
- Reference-unit $[s]$ and measure-unit $[T_{cy}]$ shall not arbitrarily cancel (with each other) in the unit section of an equation.

- The domain of oscillation is dimensionless and thus unitless. All unitless values in physics belong to the domain of oscillation.

- All frequency terms in the body of the equation shall be given the label, n, and associated with the unitless (virtual) frequency term $[(T_{cy}/cy)\times(cy/T_{cy})]$ in the unit section.

2.7 Recalibration

In this section, quantum of energy, Q_{energy} is used to recalibrate the pixel of mass. A recalibration of charge and temperature is also presented.

2.7.1 Recalibration of Mass

Using Q_{energy} and the mass-energy relationship in equation (2), the quantum of mass is calculated as follows:

$$Q_{mass} = \frac{Q_{energy}}{c^2} = 7.3724972014\ 212022 \times 10^{-51}\ [kg] \tag{7}$$

Clearly, this mass is much smaller than the mass of the electron, the proton and all other known particles with mass and thus, can be considered a pixel of mass. This value appears in the NIST standard as the "hertz-kilogram relationship"[2] with units $[kg]$. In the above analysis, Q_{mass} interprets as the "quantum of mass". Using the form of equation (6), and the rules of MUA, the variable mass of a particle is written as follows:

$$M = Q_{mass} \times n \quad [kg \frac{T_{cy}}{cy} \frac{cy}{T_{cy}}] \tag{8}$$

Here the variable time parameter is set equal to exactly 1 second and buried in the frequency term, *n*, which in equation (8) corresponds to the Compton frequency (f_c) of the particle. Although NIST does not report the Compton frequency directly, it does report the Compton wavelengths of some particles.[2] As the standard model puts the focus on the wavelength of photons and particles, MUA puts the focus on the frequency domain. For instance, Compton scattering, can be completely described in terms of the Compton frequency and de Broglie frequency.[4] Thus, in the MUA standard, Compton frequency is reported and Compton wavelength is inferred using the equation $\lambda = c / f_c$ when required.

2.7.2 Recalibration of Charge

Here, we notice that Q_{mass} could have been calculated by dividing Planck mass (m_{pl}) by Planck frequency (f_{pl}) from Table III. Using a similar logic, the quantum of charge, Q_{charge}, is calculated using the values of Planck charge (q_{pl}) and Planck frequency (f_{pl}) as follows:

$$Q_{charge} = \frac{q_{pl}}{f_{pl}} = 6.3531574343060681 \times 10^{-61} \; [kg] \tag{9}$$

This value is significantly smaller than elementary charge and thus can be considered a pixel of charge. Q_{charge}, however, is not found in the NIST standard and does not appear to be related to any known physical quantity. Planck charge (q_{pl}) is also not found in the NIST standard. This should raise some red flags to the calibrator. To further investigate this issue, the following excerpt from equation (1) is studied:

$$m_{pl} = \sqrt{\frac{h\,c}{G}} \qquad q_{pl} = \sqrt{\frac{h\,c}{k_e}} \tag{10}$$

Here, we notice that q_{pl} is calculated using the exact same formula aa m_{pl} only G is replaced by k_e. To investigate further, equation (10) is rearranged as follows:

$$q_{pl}{}^2 \times k_e = m_{pl}{}^2 \times G = hc = 1.9864458241\ \ 717582\ \times 10^{-25} = Q_{flow}\,[\frac{kg\,m^3}{s^3} = \frac{kg}{s^2}\frac{m^3}{s}] \tag{11}$$

This value appears in the NIST standard as the "inverse meter-joule relationship"[2] with units $[J]$. These units, however, do not make sense since the units for hc using the standard rules should be $[kg\ m^3\ s^{-2}] = [J\ m]$. In the MUA standard, hc, has units $[kg\ m^3\ s^{-3}]$ and when rearranged, interpret as volumetric flow $[m^3\ s^{-1}]$ and surface tension $[kg\ s^{-2}]$. Interestingly, the latest scientific research points to a cosmology that is better modelled using the language of fluid dynamics.[5,6] In the MUA standard, Q_{flow} is a constant of nature that interprets as the "quantum of flow". The Rydberg relationship, Ry / R_∞ also evaluates to Q_{flow}. Looking closely at equation (11), we see that Planck mass and Planck charge are closely related. This relationship is further evaluated in Appendix A.

Elementary charge is related to Planck charge as follows:

$$q_e = q_{pl}\ \sqrt{\alpha} = Q_{charge}\ \sqrt{\alpha}\ \ f_{pl} \tag{12}$$

Here, q_e is elementary charge, q_{pl} is Planck charge, f_{pl} is Planck frequency and α is the fine structure constant. When grouped with the frequency term, the α term can be seen as belonging to the domain of oscillation. This may explain why α is unitless.

2.7.3 Recalibration of Temperature

Using the logic of the previous section, the quantum of temperature, Q_{temp}, is calculated by dividing Planck temperature (T_{pl}) by Planck frequency (f_{pl}) as follows:

$$Q_{temp} = \frac{T_{pl}}{f_{pl}} = 4.79924466221135\,08 \times 10^{-11}\ [K] \tag{13}$$

Q_{temp} is smaller than any currently measurable temperature and thus can be considered a pixel of temperature. Currently, a group at MIT[7] holds the record for physically measuring the smallest temperature at around $0.5 \times 10^{-9} K$. According to the above analysis, a physical temperature of less than Q_{temp} can never be measured.

Q_{temp} is related to the Q_{energy} in the following manner:

$$k_B \times Q_{temp} = 6.626070040000008 \times 10^{-34} = h\,[\frac{J}{K} \times K = J] \tag{14}$$

Here, Q_{temp} interprets as the same physical quantity as h, only calibrated to a different reference-unit with Boltzmann's constant, (k_B), serving as the conversion factor between the domain of temperature and the domain of energy. A temperature of less than Q_{temp} would correspond to an energy of less than h and, if energy is in fact quantized by h, measuring a temperature of less than Q_{temp} should not be possible.

More importantly, the value of Q_{temp} puts the first cycle of time (ie. the Planck epoch) at a temperature in the order of 10^{-12} K. This is in stark contrast to the big bang model that puts the first cycle of time in the order of 10^{+32} K. The implications of this result are discussed in more detail in Section 4.1.

2.8 Report of Calibrated Measure-Units

Now that we have reasonable pixel sizes for the domains of time, space, mass, charge and temperature, a complete set of quantum measure-units calibrated to the time scale of one cycle can now be reported:

Label	Domain	Value	Reference-unit
Q_{time}	Time	$1.3513627945321461 \times 10^{-43}$	*s*
Q_{space}	Space	$4.0512837382254104 \times 10^{-35}$	*m*
Q_{mass}	Mass	$7.3724972014212022 \times 10^{-51}$	*kg*
Q_{charge}	Charge	$6.3531574343060681 \times 10^{-61}$	*C*
Q_{temp}	Temperature	$4.7992446622113508 \times 10^{-11}$	*K*
Q_{cycle}	Oscillation	1	T_{cy}

Table IV: This table shows the measure-units for each component of the system calibrated to the time scale of Planck time. The unit of oscillation [T_{cy}] is new to MUA and is equal to 1 (ie. 1 cycle) in this table. The values from this table can be used during unit analysis to quantify the relationships between the various components of the system.

A self-similar set of measure-units, calibrated to the time scale of one second is calculated by multiplying each component from Table IV by Planck frequency:

Label	Domain	Value	Reference-unit
ST_{time}	Time	1	*s*

ST_{space}	Space	$2.9979245800000000 \times 10^{8}$	m
ST_{mass}	Mass	$5.4556017312683428 \times 10^{-8}$	kg
ST_{charge}	Charge	$4.7012966910233661 \times 10^{-18}$	C
ST_{temp}	Temperature	$3.5514109768523649 \times 10^{32}$	K
ST_{cycle}	Oscillation	$7.3999373376725895 \times 10^{42}$	T_{cy}

Table V: This table shows the set of measure-units calibrated to the time scale of one second. These values can also be used in unit analysis to quantify the relationships between the components of the system. The unit of oscillation [T_{cy}] is new to MUA. In this table, [T_{cy}] is not equal to one but instead is equal to one second worth of oscillations or Planck frequency.

2.8.1 Discussion

Planck units are often referred to as natural units because they can be calculated using the constants of nature alone as specified in equation (1). Here, we see that Planck time and Planck length appear in Table IV whereas Planck mass, Planck charge and Planck temperature appear in Table V. Also notice that Q_{mass} was calculated using the constants of nature, (h/c^{2}), whereas the calculations of Q_{charge} and Q_{temp} were based on assumption alone. Looking at equation (11), it appears that Q_{charge} is not an independent quantity of the system but instead, is Q_{mass} calibrated to a different reference-unit, ie. the Coulomb. This is further discussed in section 3.3 and Appendix A. Q_{temp} is also not an independent quantity of the system but instead is Planck's constant, h, only calibrated to a different reference-unit, ie. the Kelvin.

3 Unit Analysis

All the constants of nature can now be calculated using the new tools derived in the previous section. In this section, the gravitational constant, G, the Coulomb constant, k_e and Planck's constant h are derived using the measure-units from Tables IV and V. A new constant of nature with units of momentum $[P]$ is also derive. These sections demonstrate how to apply measure-time, t,to unit analysis using the rules of the MUA standard.

3.1 How to use Table IV and Table V.

The values from Tables IV and V can now be used to quantify the unit relationships in the unit section of an equation. For example, whenever you see an $[s]$ in the unit section, you can plug in Q_{time} or ST_{time} depending on the time scale you are analysing. The same applies to the reference-units $[m]$, $[kg]$, $[C]$ and $[K]$ and their respective measure units. New to this analysis is measure-time $[T_{cy}]$. Here, whenever you see $[T_{cy}]$ in the unit section, you plug in the value Q_{cycle} or ST_{cycle} depending on which time scale you are analysing. A few examples are given herein. A more extensive analysis will be the subject of a follow up article.

3.2 Gravitational Constant, G

Using the newly defined MUA presented in this essay, the units for G are expressed as

follows:

$$G = [N\frac{m^2}{kg^2}] = [\frac{P}{T_{cy}}\ \frac{m^2}{kg^2}] = [\frac{kg\ m}{s\ T_{cy}} \times \frac{m^2}{kg^2}] = [\frac{m^3}{kg\ s\ T_{cy}}] \qquad (15)$$

In the above analysis, the reference-unit of $[N]$ is replaced with the unit expression $[P/T_{cy}]$ which reads "momentum per measure-time". This is how MUA puts the domain of oscillation back into the unit equation. Using the calibrated measure-units from Tables IV and V and the last unit expression from (15), the following is written:

$$G = \frac{{Q_{space}}^3}{Q_{mass}\ Q_{time}\ Q_{cycle}} = \frac{{ST_{space}}^3}{ST_{mass}\ ST_{time}\ ST_{cycle}} \qquad (16)$$

MUA gives us a new set of tools for doing unit analysis. Notice that ST_{cycle} is not equal to one but instead, is equal to Planck frequency. This is why it is important to not set cycle equal to 1 as was historically done. Also notice how the gravitational constant can be calculated using either tables without mixing measure scales. The standard unit analysis used to calculate the gravitational constant, G, is as follows:

$$G = \frac{{l_p}^3}{m_p\ {t_p}^2} = \frac{{Q_{space}}^3}{ST_{mass}\ {Q_{time}}^2} \qquad (17)$$

Notice that (17) calculates G using units from two different MUA measure scales (or tables). This should raise some red flags to the calibrator. Although mixing measure scales may produce the correct and expected numerical value, it may also result in an incorrect interpretation of the physical system.

3.3 Coulomb Constant, k_e

Using the logic from the previous section, the units for k_e are derived as follows:

$$k_e = [N \frac{m^2}{C^2}] = [\frac{P}{T_{cy}} \frac{m^2}{C^2}] = [\frac{kg\ m^3}{C^2\ s\ T_{cy}}] \tag{18}$$

Using the measure-units from Tables IV and V, k_e is calculated accordingly:

$$k_e = \frac{Q_{mass}\ Q_{space}{}^3}{Q_{charge}{}^2\ Q_{time}\ Q_{cycle}} = \frac{ST_{mass}\ ST_{space}{}^3}{ST_{charge}{}^2\ ST_{time}\ ST_{cycle}} \tag{19}$$

Again, either measure scale can be used to calculate this constant. Using equation (11), the conversion equation between the domain of mass and the domain of charge is generalized as:

$$q^2 = m^2 \times \frac{G}{k_e} [C^2] \tag{20}$$

Substituting equation (20) into equation (19) gives the following:

$$k_e = \frac{Q_{mass}\ Q_{space}{}^3}{Q_{mass}{}^2\ \frac{G}{k_e}\ Q_{time}\ Q_{cycle}} = \frac{ST_{mass}\ ST_{space}{}^3}{ST_{mass}{}^2\ \frac{G}{k_e}\ ST_{time}\ ST_{cycle}} \tag{21}$$

This then simplifies to equation (16), thus confirming that Q_{mass} and Q_{charge} (ST_{mass} and ST_{charge}) are physically the same quantity, only calibrated to different reference units. Since Q_{charge} and ST_{charge} are redundant, they need not be included in the standard. (Remember, Q_{charge} and ST_{charge} also do not appear in the NIST standard).

3.4 Quantum of Energy, Q_{energy} and Planck's constant, h

Using the measure-units from Table IV and the MUA standard, Q_{energy} is calculated as follows:

$$Q_{energy}\ [\frac{kg\ m^2}{s^2}] = \frac{Q_{mass}\ Q_{space}{}^2}{Q_{time}{}^2} = 6.6260700400000008 \qquad (22)$$

When Planck's constant is modelled an action constant, h is calculated as follows:

$$h\ [\frac{kg\ m^2\ s}{s^2}] = \frac{m_{pl}\ l_{pl}\ t_{pl}}{t_{pl}{}^2} = \frac{ST_{mass}\ Q_{space}{}^2\ Q_{time}}{Q_{time}{}^2} = 6.6260700400000008 \qquad (23)$$

Here, ST_{mass} evaluates to Planck mass and Q_{space} and Q_{time} evaluate to Planck length and Planck time respectively. Although (23) does produce the correct value for h, it does so using values from two different measure scales (ie. from Table IV and Table V). The main difference between standard unit analysis (SUA) and modified unit analysis (MUA) is, MUA is calibrated to two distinct yet self-similar measure scales. For example, $Q_{space}/Q_{time} = ST_{space}/ST_{time} = c$. Here, c defines the self-similar relationship between the domain of space $[m]$ and the domain of time $[s]$ at all scales. In a similar manner, $Q_{mass}/Q_{time} = ST_{mass}/ST_{time} = 5.4556017312683421 \times 10^{-8} = m_{pl}$ or Planck mass, defines the self-similar relationship between the domain of mass $[kg]$ and the domain of time $[s]$. The unit relationship $[kg/s]$ (new to MUA) loosely interprets as "speed of mass" somewhat analogous to the "speed of light" in the space-time relationship. Whether this is a useful definition in terms of new physics remains to be seen. Further investigation is suggested.

3.5 Quantum of Momentum, Q_{mom}

One of the main objections to Planck's constant as an energy constant is that unit analysis of all equations that include h no longer pass standard unit analysis. For example, if the units of h are $[J]$ and not $[J \times s]$, then de Broglie's equation for the variable momentum of a photon, $p = h/\lambda$, no longer has units of momentum $[P]$ but instead has units $[J/m]$. When converted to the frequency domain using $f = c/\lambda$, the

following is written:

$$p = \frac{h}{c} f \qquad (24)$$

The constant relationship, $h/c = 2.2102190576121830 \times 10^{-42}$ can also be calculated using the measure-units from Table IV as follows:

$$Q_{mom} [\frac{kg\ m}{s}] = \frac{Q_{mass}\ Q_{space}}{Q_{time}} = 2.2102190576121836 \times 10^{-42} \qquad (25)$$

NIST refers to this value as the "inverse meter-kilogram relationship" with assigned units $[kg]$. This however, does not make sense in terms of standard unit analysis since the units of h/c in standard units should be $[P \times s]$. Q_{mom} in MUA interprets as "quantum of momentum" and has units of momentum or $[P]$. Using these new tools, the variable momentum equation is written as follows:

$$p = Q_{mom} \times n\,[P\,\frac{T_{cy}}{cy}\frac{cy}{T_{cy}}] \tag{26}$$

Like the variable energy equation (6), this equation can also be applied to particles with mass (ie. electrons and protons) given the Compton frequency. For example, the momentum of an electron (at rest) is calculated as follows:

$$P_e = Q_{mom} \times f_e = m_e\,c = 2.73092429345209340 \times 10^{-22}\ [P\,\frac{T_{cy}}{cy}\frac{cy}{T_{cy}}] \tag{27}$$

This value is found in the NIST standard as the "natural unit of momentum[2]" with units $[P]$. Here, it interprets this as the natural momentum or rest momentum of the electron. In the MUA standard, the oscillation (frequency) domain is seen as the unifying principle between particles with mass and particles without mass. Of course, one can always convert back to wavelength at any time using the equation: $\lambda = c / f$. Whether anything new can be learned from the frequency centric approach to quantum mechanics is out of the scope of the calibration. More work still needs to be done to vindicate this approach.

4 Discussion, Summary and Conclusion

4.1 Discussion: The Planck Epoch

The Planck epoch is the period of time of the universe that goes from the beginning of time (ie. zero time) to approximately 10^{-43} seconds or Planck time. The temperature of the Planck epoch is assumed to be in the order of $10^{+32}\,K$ or Planck temperature which is calculated using standard unit analysis as seen in Section 2. This is often sited as evidence of the validity of the big bang model. Modified unit analysis however puts the Planck epoch at a temperature in the order of $10^{-12} K$ as found in Table IV. If correct, MUA calls into question the big bang model which hinges on a very hot early universe. The analysis presented in this essay suggests that Planck temperature is not the temperature of the first cycle of time but instead is the temperature of one second worth of temperature quanta or $Q_{temp} \times planckFrequency$. Although the supporters of the big bang model (BBM) purport many successes, the author would like to point out that the two elephants in the room, dark matter and dark energy, were not predicted by the big bang model but instead, were complete surprises. Being a tweakable model, the BBM was able to accommodate this new information, however, this is better seen as an exercise in curve fitting rather than "a great success" in terms of a predictive model. History also shows that one of the predictions, that of the microwave background radiation temperature, was adjusted after-the-fact to agree with observed temperatures.[8]

What is the evidence for this much cooler earlier Universe? The answer can be found in the red shift data itself. The standard model interprets the redshift data as evidence of an earlier, much hotter universe. This interpretation, however, is extremely counterintuitive as we know that low frequency light is much less energetic than high frequency light. The author suggests an alternate approach to cosmology, fractal cosmology, may be able to resolve this discrepancy. In a previous paper by the author,[9] a framework for a fractal cosmology is outlined that proposes that the laws of physics are scalable and self-similar. The magnet is a great example of a self-similar object whose "laws" are scalable as when you break a magnet in half, you get two magnets that are exactly identical to each other and self-similar to the original magnet.

In the fractal model proposed by the author, the early universe is seen as self-similar to the current universe, only the measuring sticks (pixels) of the earlier universe were very different (ie. red-shifted) to that measured in our local space and time. Halton Arp et al referred to this as intrinsic redshift.[10–12] The calibrated (self-similar) measure-unit sets presented in this essay support this logic. It is the relationships between these measure-units that make them self-similar.

The concept of "fractal" was not known to the founders of theoretical physics and therefore they could not possibly have considered this possibility. The benefits of modelling the Universe as a fractal are 1) it predicts an earlier redshifted universe and 2) it predicts the observed accelerated expansion of the universe,[13] although the apparent acceleration of the universe is a direct result of the quantum measure-units shrinking as the universe evolves. This kind of expansion can be found in the fractal expansion of trees[14,15] and other plants. Also, it is important to note that a fractal universe does not contradict the laws of entropy when entropy is defined in terms of "degrees of freedom" since the degrees of freedom (quantum information) of a fractal always increases over time (ie. with each iteration).

Although out of the scope of the calibration procedure, the author thought it important to address the some of the implications of the MUA results. Much more work still needs to be done to vindicate this approach.

4.2 Summary

- When Planck energy equation is modelled as the equation of an experiment: $E = h t v$, Planck's constant, h, emerges an energy constant with units $[J]$.

- A set of measure-units calibrated to the time scale of Planck time is derived (Table IV) that differs from Planck units in the domains of mass, charge and temperature.

- A self-similar unit set of measure-units calibrated to the time scale of the second is derived (Table V) that differs from Planck units in the domains of time and space.

- Measure-units from Tables IV and V can be used in unit analysis to calculate all the constants of nature without mixing measure-units from different tables.

- Q_{mass} appears in the NIST standard and can be used to calculate the Compton frequency of a particles with mass but dividing the mass of the particle by Q_{mass}.

- Q_{charge} does not appear in the NIST standard and does not appear to have any physical correlation.

- The constant relationship h/c has units of momentum and evaluates to Q_{mom}.

- The equation for the variable momentum of a photon can now be written in terms of Q_{mom} (25). This equation can be applied to particle with mass as well as particles without mass, ie. photons.

- The constant relationship hc has the units of volumetric flow and surface tension and is given the label Q_{flow}.

- Q_{temp} and Q_{energy} are the same physical quantity only calibrated to different reference-units. The same can be said of Planck temperature and Planck energy.

- Q_{temp} is the temperature associated with one cycle or one Planck time. This puts the temperature of the Planck epoch at a temperature of 10^{-12} K.

4.3 Conclusion

In his book, “Before the Big Bang”,[18] Ernest Sternglass speculates about what might have happened before the big bang. As a 23-year-old Cornell University graduate, Sternglass requested a meeting with Albert Einstein to discuss this novel theory. Einstein agreed to meet with him. At one point during their discussion, Einstein asked him if he was going to continue with his education. Although Sternglass did have plans to continue with graduate school, Einstein actually tried to discourage him from pursuing a career in theoretical physics. “He urged me to remain in my present job doing applied physics and not to go back to school for a doctoral degree, where he suggested that I would have any originality crushed out of me.” Einstein encouraged Sternglass to study on his own, in his spare time, so he “could make his mistakes in private”. “Don’t do what I have done” Einstein said. “Always keep a cobbler’s job...”.

What this story clearly shows is that Einstein himself was not happy with the state of academia of his time, especially in the physics community. The culture that existed back then, and that persists to this day, does discourage original ideas exactly as Einstein warned Sternglass so many years ago. As a result of this culture, alternate cosmologies remain largely uninvestigated. Even if the BBM were one hundred percent successful, it is still possible that an equally successful cosmology exists that is much simpler (ie. makes less assumptions) than the BBM. According to Occam’s razor, the simple solution would be the better solution. Unless we allow the discussion of original ideas and alternate cosmologies, how will be know that the BBM is the best solution? That said, the author suggests that the fractal paradigm under modified unit analysis is worth a closer look.

Appendix A

When rearranged, (11) can be written as follows:

$$\frac{G\ m_{pl}{}^{2}}{k_{e}\ q_{pl}{}^{2}} = 1.0 = unity \tag{A1}$$

In order for this equation to be true, all the units must cancel, and they do. Keep in mind that most of the constants of nature specified in Table II (h, c, G, k_e) are embedded into (A1) as they were originally used to calculate m_{pl} and q_{pl} in equation (1). When the constant values from Table II are used, equation (A1) evaluates to 1.0000000000023028.

This result is of great interest to the calibrator as it shows that there is some inherent error in the calibration of the system. In a perfect calibration, this value would be exactly equal to one. If instead, we use the calculated value for the coulomb constant, $k_e = c^2 \times 10^{-7}$, and keep all 16 digits of precision, the above equation evaluates to 1.0000000000000002 thus improving our calibration by 4 orders of magnitude. This is the main reason the author chose to keep so many digits of precision in the results. There is however, still a bit of error in the calculation as the last digit is non-zero. To test if this is a real error or just a rounding error, a math library was used to do the calculations to 32 digits of precision instead of 16. The result, 1.0000000000000002104315844911516 4 shows that this is not a rounding error. Further investigation is suggested to improve this result (ie. to get more zeros past the decimal point). The author suspects that improvements to the digits of precision of the gravitational constant will improve this result since the digits of precision of G (0.0000000000667408) is in the order of the digits of precision of the corrected unity value. To demonstrate this, Table A1 below shows the constants of nature used to calculate (A1) to their full known digits of precision.

Constant	**Value**
h	00000000000000000.000000000000000000000000000000000662607004
c	00000000299792458.000000000000000000000000000000000000000000
G	00000000000000000.000000000066740800000000000000000000000000
k_e	00000008987551787.368175548670451468395920000000000000000000

Table A1: This table shows the constants of nature to known digits of precision. Note that Boltzmann's constant is not included here because it is not used to calculate equation (A1).

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