Fractal Physics – Scaling Fractals and the Fifth Dimension

Abstract:
An overview of Fractal Physics Theory and Scale Relativity is in press at *Chaos, Solitons, and Fractals* [1]. This article, the first in a series of articles, intends to provide an overview of Fractal Physics theory and Scale Relativity, which is founded on three postulates. The first postulate assumes the structure of physical reality adheres to fractal geometry; physical reality is infinite in matter-energy content, infinite in spatial extent, infinite in duration, and has self-similarities at various scales. The next postulate assumes absolute uniform scale cannot be detected. The meter, kilogram, and second relate to a person's size, mass, and awareness of time passage, the human scale. Atoms are tiny and stars are enormous, both relative to the human scale. In addition to obvious size and mass-energy differences, there also exists a time scale difference between the quantum and cosmic scales as viewed from the human scale. Quantum scale objects appear to exist in accelerated time frames, while cosmic scale objects appear to exist in decelerated time frames, both relative to the human scale. The final postulate assumes the speed (c) of electromagnetic radiation photons in vacuum is independent of scale. This series of articles is intended to begin to call attention to the remarkable self-similarity that exists between the quantum and cosmic realms.

Key words: Fractals, Scaling, Infinity, Dimension

1. **Introduction** [1]

The applicability of Fractal Geometry to further understanding of diverse phenomena has proliferated since Benoit Mandelbrot's seminal work in the 1970s [2]. Fractal Geometry forms the basis of the first Fractal Physics postulate. Einstein's two Special Relativity postulates generalized to "scale" are the basis of the second and third postulates of Fractal Physics. Both the relativity of scale and applying Fractal Geometry to fundamental physics has been explored for decades by Laurent Nottale [3]. Mandelbrot's and Nottale's inspiration to this present work can not be overstated.

The Scaling Fractals of Fractal Physics are all in Golden ratios i.e., a cosmic scale object is to a self-similar human scale object as this human scale object is to a self-similar quantum scale object. M.S. El Naschie's *E* infinity theory [4-8] is based on Fractal Geometry with the Golden Mean $0.5(\sqrt{5} - 1)$ as one of its main pillars. It may be expected that Fractal Physics theory and *E* infinity theory will be complimentary descriptions of physical reality. Additionally, the "ensembles of classical point particles" used successfully by Garnet Ord [9] may well be the quantum scale atoms of Fractal Physics.

2. **Fractal Physics postulates and definitions** [1]

1. Fractal geometry is the structure of physical reality
2. Scale Relativity – absolute uniform scale cannot be detected, the relativity of scale
3. The speed (c) of electromagnetic radiation photons in vacuum is independent of scale

The term "Scalativity" is hereby introduced and defined as the contraction of the two words "Scale Relativity".

2.1. Fundamental physical fractals

If the geometry of physical reality is fractal, it is necessary to identify the fundamental fractals of physical reality. These physical fractals are basic matter and energy entities that comprise the immediate surroundings of the human scale, the confines of the Solar System. The vast majority of observations within the Solar System are described by the properties and interactions of protons, neutrons, electrons, nuclei, photons, neutrinos and their respective antiparticles. Self-similar objects must exist in an infinite set of scales. To identify the fundamental fractals that are adjacent to but smaller than and adjacent to but larger than the human scale is an objective of this article.

2.2. Definitions

Object – any system of mass and/or energy that exists in the universe, symbolized by O. Examples of objects: electron, proton, neutron, atom, molecule, photon, person, car, house, planet, star, and galaxy.

Observable – the measurement of a property of an object, symbolized by f(O). Examples of observables: an electron's charge, a person's height, a planet's mass, and a star's luminosity.

Scale – a level of infinite matter content, infinite spatial extent, and infinite duration in our universe. For instance, the human scale includes as a subset the universe contained within the dimensions of Big Bang theory.

Fractal Universe – the infinite set of scales, the scale contents, and the relationships between the scales, which comprise physical reality.

Scale Relativity – the relativity of scale. The laws of physics are scale invariant. That is, the laws of physics are the same in every scale as viewed from that scale. The laws of physics in scale m as observed in scale n = m are equivalent to the laws of physics in scale m ± x as observed in scale n = m ± x.

Where m, n, and x are defined by the set $\{-\infty, \ldots, -2, -1, 0, 1, 2, \ldots, +\infty\}$

Every object exists within all the infinite scales simultaneously. Therefore, the measurement of any observable of an object requires the specification of two scales, the object's scale and the observer's scale.
Every observer in any scale m, measures observables relative to their scale n = m, therefore every observer, in any scale may set m = n = 0.

Human Scale – the universe as observed from the scale of humans. The human observer is an object in a scale. The observer is part of their scale. Humans use the mks system. The units meter, kilogram, and second are relative to a human's scale of size, mass, and awareness of time passage. Define the human scale as m or n = 0.

Cosmic Scale – the scale adjacent to but larger than the human scale, where m or n = 1.

Quantum Scale – the scale adjacent to but smaller than the human scale, where m or n = -1.

Fractal object – if an object exists in scale m, then a self-similar object could exist in any scale m ± x.
For example, if protons, neutrons, electrons, photons, and neutrinos exist in the human scale, then cosmic scale protons, neutrons, electrons, photons, and neutrinos exist in the cosmic scale, and quantum scale protons, neutrons, electrons, photons, and neutrinos exist in the quantum scale, etc, to an infinite set of scales.

Let an object and its observable be represented by: $$[O, f(O)]_{m,\,n} \qquad (1)$$

m is the object scale location
n is the observable scale location
n and m represent any scale as defined by the set $\{-\infty, \ldots, -2, -1, 0, 1, 2, \ldots, +\infty\}$.

For example, an electron's mass is represented by $[e\text{-}, \text{mass}]_{0,0} = 9.11 \times 10^{-31}$ kg

All the observables of an object in scale m, as measured in scale n = m, are equivalent to all the observables of a self-similar object in scale m ± x, as measured in scale n = m ± x.

$$[O, f(O)]_{m,\, n = m} = [O, f(O)]_{m \pm x,\, n = m \pm x} \qquad (2)$$

Scaling Fractal – represented by the symbol ¥, is a unit less number that relates properties of self-similar objects located in adjacent scales through simple division. There are two ways to calculate a scaling fractal.

1. Two self-similar objects located in adjacent scales have self-similar observables measured in the same scale. The scaling fractal is obtained by dividing these two measurements. For instance, a cosmic scale electron has its mass measured in the human scale. An electron located in the human scale has its mass measured in the human scale. The mass scaling fractal, ¥Mass = (mass of cosmic scale electron)/(mass of human scale electron).

$$¥f(O) = \frac{[O, f(O)]_{m+1,\, n}}{[O, f(O)]_{m,\, n}} \qquad (3)$$

2. An object located in a scale has an observable measured relative to two different but adjacent scales. The scaling fractal is obtained by dividing these two measurements. For instance, a person located in the human scale has their mass measured in the quantum scale. A device located in the human scale also measures this same person's mass. The mass scaling fractal, ¥Mass = (mass measured in quantum scale)/(mass measured in the human scale).

$$¥f(O) = \frac{[O, f(O)]_{m,\, n-1}}{[O, f(O)]_{m,\, n}} \qquad (4)$$

The value of the mass scaling fractal, ¥Mass, from 1 and 2 above must be equivalent:

$$¥f(O) = \frac{[O, f(O)]_{m+1,\, n}}{[O, f(O)]_{m,\, n}} = \frac{[O, f(O)]_{m,\, n-1}}{[O, f(O)]_{m,\, n}}$$

In general: $[O, f(O)]_{m+1, n} = [O, f(O)]_{m, n-1}$ (5)

2.3. Postulate 3

Every observer in any scale obtains the same value for c.
The speed of electromagnetic radiation photons in vacuum in a fixed scale m as measured in scale n = m, is the same as measured from any scale n = m ± x.

$$[\text{photon, c}]_{m,\, n = m} = [\text{photon, c}]_{m,\, n = m \pm x} \quad (6)$$

Furthermore, an electromagnetic radiation photon located in any scale m has the same measured speed in vacuum from a fixed scale n.

$$[\text{photon, c}]_{m,\, n} = [\text{photon, c}]_{m \pm x,\, n} \quad (7)$$

The scaling fractal of a photon's speed c = ¥c = (299 792 458 m/s)/(299 792 458 m/s) = 1 (8)
Additionally, any object's velocity is also scale invariant, ¥velocity = 1.

2.4. Principle of Scalativity

The Principle of Scalativity allows a direct comparison of physical equations in different scales. This leads to scaling fractal equations replacing the physical equations.

For example, $E = mc^2$ is written as ¥Energy = (¥Mass)(¥c)^2 = ¥Mass(1)^2 = ¥Mass (9)
The energy scaling fractal equals the mass scaling fractal; energy and mass scale at the same rate.

Also, from x = ct, write ¥length = (¥c)(¥time) = (1)(¥time) = ¥time (10)
The length scaling fractal equals the time scaling fractal; length and time scale at the same rate.

Lengths that are greatly dilated relative to the human scale correspond to greatly dilated times relative to the human scale. Cosmic scale time is dilated or decelerated relative to the human scale. Lengths that are greatly contracted relative to the human scale correspond to greatly contracted times relative to the human scale. Quantum scale time is contracted or accelerated relative to the human scale.

Figure 1 illustrates "scale" added to Cartesian Coordinates. Let the x, y, z coordinates be infinitely flexible. Imagine that the origin is being pulled inwards toward infinity. Measurement limits still exist for each scale when an observer located in the scale uses photons located in the scale. Scale specific position uncertainties, Δx, Δy, Δz, are depicted in Figure 1 as coordinate line width, similar to Nottale [3].

3. Cosmic scale fundamental physical fractals

To precede it is necessary to accurately identify the cosmic scale fundamental physical fractals. They will appear self-similar to protons, neutrons, nuclei, electrons, photons, neutrinos and their respective antiparticles; larger in size and mass but in a greatly decelerated time frame, relative to the human scale.

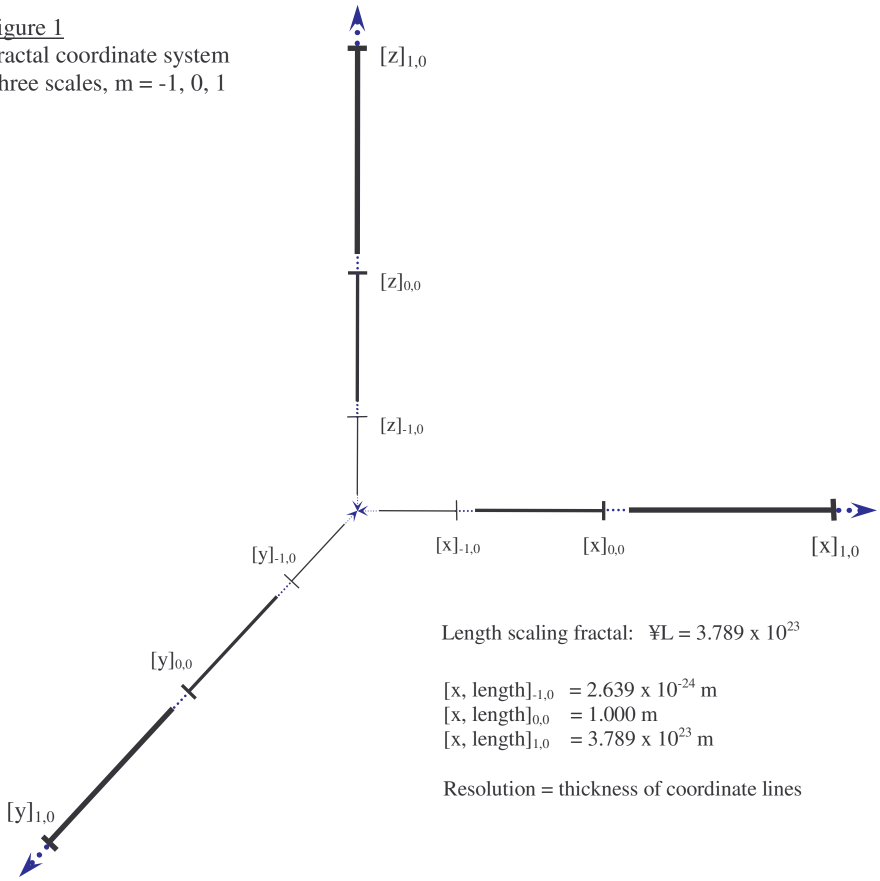
Modern Cosmology has amassed a staggering wealth of observational data and theoretical construct framed within the Big Bang Model. Fractal Physics points out this cosmic scale explosion occurs within a greatly decelerated time frame, relative to the human scale. Readily visible astrophysical bodies include the stars, planets, galaxies, supernovae, etc. Consider stars:

- have mass and radiate energy;
- undergo fusion which alters their chemical composition;
- have masses ranging over two orders of magnitude;
- exist individually, in binary and more complex systems;
- can explode with tremendous energy as nova and supernova;
- aggregate in galaxies.

Would an observer in the cosmic scale be able to detect human scale stars? Typically stars radiate photons, and to lesser extent neutrinos, spherically for billions of human scale years. The cosmic scale would find it very difficult to construct an experiment that could detect these diffuse spherically radiated pulses of energy. Billions of human scale years are decelerated to a very short cosmic scale time.

What fundamental human scale physical fractals, when observed for a very short time in the human scale, could resemble a tiny star?

Figure 1
Fractal coordinate system
Three scales, m = -1, 0, 1



Protons are stable masses that do not appear to radiate energy. Protons are not fractally self-similar to stars. Photons and neutrinos are essentially pure energy. Photons and neutrinos are not fractally self-similar to stars. Electrons all have the same rest mass but exist at variable energy levels in atoms. The variation in atomic electron mass-energy content is relatively small. Electrons are not fractally self-similar to stars. Neutron rest mass is constant, but when free neutrons undergo beta-decay there is an interesting change that occurs in the neutron in a very short time relative to the human scale.

$$n \rightarrow p^+ + e- + \text{anti}\nu$$

An electron is created or forged within the neutron while the neutron radiates antineutrino energy. The antineutrino has been notoriously difficult for observers to detect in the human scale.
Nuclei that are in the process of the beta decay moment:

- have mass and radiate energy;
- undergo a change which alters their composition;
- have masses ranging over two orders of magnitude;
- exist individually, in binaries when capturing neutrons;
- can violently release beta particles with very high kinetic energy;
- aggregate in radioactive materials.

The vast majority of stars are fractally self-similar to nuclei in the process of beta decay. Stars are cosmic scale nuclei in the process of cs-beta decay as observed in the human scale. The luminous output of a star over its life, its sum of electromagnetic radiation and neutrino output, is one cosmic scale antineutrino as observed in the human scale. Stable cosmic scale nuclei and cosmic scale atomic electrons have surface temperatures of 2.7 K. These are cold dark matter whose gravitational effects are observed in the human scale.

Only a nuclear explosion, less than one second into the fireball, if viewed from the quantum scale, would have properties fractally self-similar to the human scale observations of a Big Bang with all galaxies hurdling away from each other. It is proposed that our Big Bang universe is the interior contents of one cosmic scale (cs) nuclear explosion occurring on a cs-planet into a cs-Oxygen atmosphere. Cosmic scale vaporized fission fragments and cs-unfissioned Uranium have already begun to condense, react with the cs-Oxygen and form crystals of cs-Uranium dioxide, the cores of spiral galaxies. Elliptical galaxies contain stars moving in random directions, the motion of which is fractally self-similar to particles suspended in a fluid. Cosmic scale vaporized fission fragments and cs-unfissioned Uranium have already begun to condense into cs-molten liquid drops and along with cs-water vapor droplets, capture cs-neutrons and cs-fission fragments to form elliptical galaxies.

Fission fragment products are typically centered around two mass peaks, A ~95 and A ~138. These fission fragments undergo a series of beta decays before reaching a stable nuclear endpoint. Consequently most stars are cosmic scale fission fragments in the process of cs-beta decay. This cosmic scale explosion will have many cs-free neutrons in flux colliding with cs-nuclei (suggested origin of gamma ray bursts), many cs-neutrons in the process of absorption by other nuclei (suggested origin of binary star systems), and a percentage of cs-neutrons undergoing cs-beta decay (suggested fractal identity of the solar system). This topic of cosmology as a cosmic scale nuclear explosion is further explored in a separate article.

The Heisenberg uncertainty principle is scale dependent. Use of antineutrino energy, which is mostly quantum scale electromagnetic radiation, can determine very accurately and simultaneously the position and momentum of an electron to the human scale. This prediction can be tested.

4. Quantum camera

It is proposed that a quantum camera placed at various positions within a nuclear fission reactor can capture images, that when scaled-up, will resemble images of galaxies. All human scale astronomical pictures imaged with electromagnetic radiation have been imaged using bits of cosmic scale antineutrino energy. Consequently, observers in the quantum scale could utilize qs-electromagnetic radiation to image their visible qs-universe. Can a quantum camera be constructed to image qs-electromagnetic radiation (antineutrino energy)?

Table 1.a, Exposure times to image antineutrino energy

Exposure time in human scale As measured in human scale	Exposure time in human scale As measured in quantum scale
0.83×10^{-6} s	10,000,000,000 y
1×10^{-9} s	12,000,000 y
83×10^{-12} s	1,000,000 y
1×10^{-12} s	12,000 y
1×10^{-15} s	12 y
1×10^{-18} s	4.4 d

Table 1.b, Aperture sizes to image antineutrino energy

Aperture size in human scale As measured in human scale	Aperture size in human scale As measured in quantum scale
1×10^{-10} m	253.25 AU
1×10^{-12} m	2.53 AU
1×10^{-15} m	379,000 km = 0.5 Solar radii
1×10^{-18} m	379 km

The closer the exposure time gets to the attosecond and the aperture size gets to the attometer the more the image resolution will resemble Earth scale astronomical images. Antineutrino energy gathered with femtosecond exposures through femtometer apertures should capture images of qs-galaxies, provided a suitable recording material is found.

The quantum camera must collect and channel the qs-photons for amplification. The qs-photon amplification process must continue until it is capable of affecting a human scale photon. When many qs-photons have been amplified to human scale photons, then these photons can be amplified until an image is possible to view in the human scale.

5. Mass scaling fractal, ¥Mass

Identifying the pre-solar system mass with the mass of a cosmic scale neutron is all that is required to establish values for the mass scaling fractal and the length scaling fractal, ¥Mass, ¥Length. These two scaling fractals and the Principle of Scalativity is all that is required to derive the scaling fractals for a multitude of scientific variables and constants. The mass scaling fractal will be determined by dividing the mass of a cosmic scale neutron by the mass of a human scale neutron, both measured in the human scale. The human scale (hs) neutron mass is well established as $1.674\,927\,28 \times 10^{-27}$ kg.

The solar system is proposed to be a cosmic scale neutron about halfway through the process of cosmic scale beta decay. It is assumed that all the mass of all the objects in the solar system were once contained in one massive, frozen body of mostly hydrogen, a cosmic scale neutron. All the electromagnetic radiation radiated by the Sun during the past 5×10^9 y needs to have its mass equivalent included in the mass of a cosmic scale neutron.

Table 2.a, Solar System Planetary Masses [10]

Object	Mass (kg)	AU
Sun	1.9891×10^{30}	
Mercury	3.3022×10^{23}	0.38710
Venus	4.8690×10^{24}	0.72333
Earth	5.9742×10^{24}	1.00000
Mars	6.4191×10^{23}	1.52369
Jupiter	1.8988×10^{27}	5.20283
Saturn	5.685×10^{26}	9.53876
Uranus	8.6625×10^{25}	19.19139
Neptune	1.0278×10^{26}	30.06107
Pluto	1.5×10^{22}	39.52940
$\Sigma_{planets}$	$2.668\,535 \times 10^{27}$	

Table 2.b, Solar System Satellite Masses [10]

Planet	Planet Mass (kg)	Satellite	Satellite relative mass	Satellite Mass (kg)
Earth	5.9742×10^{24}	Moon	0.01230002	7.3483×10^{22}
Mars	6.4191×10^{23}	Phobos	1.5×10^{-08}	9.6287×10^{15}
		Deimos	3×10^{-09}	1.9257×10^{15}
Jupiter	1.8988×10^{27}	Io	4.68×10^{-05}	8.8864×10^{22}
		Europa	2.52×10^{-05}	4.7850×10^{22}
		Ganymede	7.80×10^{-05}	1.4811×10^{23}
		Callisto	5.66×10^{-05}	1.0747×10^{23}
		Amalthea	3.8×10^{-09}	7.2154×10^{18}
		Himalia	5.0×10^{-09}	9.4940×10^{18}
		Elara	4×10^{-10}	7.5952×10^{17}
		Pasiphae	1×10^{-10}	1.8988×10^{17}
		Sinope	4×10^{-11}	7.5952×10^{16}
		Lysithea	4×10^{-11}	7.5952×10^{16}
		Carme	5×10^{-11}	9.4940×10^{16}
		Ananke	2×10^{-11}	3.7976×10^{16}
		Leda	3×10^{-12}	5.6964×10^{15}
		Thebe	4×10^{-10}	7.5952×10^{17}
		Adrastea	1×10^{-11}	1.8988×10^{16}
		Metis	5×10^{-11}	9.4940×10^{16}
Saturn	5.685×10^{26}	Mimas	8.0×10^{-08}	4.5480×10^{19}
		Enceladus	1.3×10^{-07}	7.3905×10^{19}
		Tethys	1.3×10^{-06}	7.3905×10^{20}
		Dione	1.85×10^{-06}	1.0517×10^{21}
		Rhea	4.4×10^{-06}	2.5014×10^{21}
		Titan	2.38×10^{-04}	1.3530×10^{23}
		Hyperion	3×10^{-08}	1.7055×10^{19}
		lapetus	3.3×10^{-06}	1.8761×10^{21}
		Phoebe	7×10^{-10}	3.9795×10^{17}
Uranus	8.6625×10^{25}	Ariel	1.56×10^{-05}	1.3514×10^{21}
		Umbriel	1.35×10^{-05}	1.1694×10^{21}
		Titania	4.06×10^{-05}	3.5170×10^{21}
		Oberon	3.47×10^{-05}	3.0059×10^{21}
		Miranda	8×10^{-07}	6.9300×10^{19}
Neptune	1.0278×10^{26}	Triton	2.09×10^{-04}	2.1481×10^{22}

		Nereid	2×10^{-07}	2.0556×10^{19}
Pluto	1.5×10^{22}	Charon	0.22	3.3×10^{21}

Total mass of solar system planetary satellites: $6.413\ 163 \times 10^{23}$ kg

A solar luminosity of 3.8418×10^{26} W radiating for 4.54×10^{9} y releases $5.504\ 204\ 641 \times 10^{43}$ J, which has a mass equivalent of $6.124\ 253\ 602 \times 10^{26}$ kg.

Current mass of sun:	1.9891×10^{30} kg
Total mass of planets:	$2.668\ 535 \times 10^{27}$ kg
Total mass of planetary satellites:	$6.413\ 163 \times 10^{23}$ kg
Mass loss from Sun shining 4.54×10^{9} y:	$6.124\ 253\ 602 \times 10^{26}$ kg
Total solar system mass 4.54×10^{9} y ago:	$1.992\ 381\ 602 \times 10^{30}$ kg

Therefore the cosmic scale neutron mass is estimated here to be $1.992\ 381\ 602 \times 10^{30}$ kg

Mass Scaling Fractal, ¥Mass = (cosmic scale neutron mass)/(human scale neutron mass)
¥Mass = $(1.992\ 381\ 602 \times 10^{30}$ kg$)/(1.674\ 927\ 28 \times 10^{-27}$ kg$) = 1.189\ 533 \times 10^{57}$ (11)

6. Cosmic scale proton radius estimate and the length scaling fractal

6.1. Cosmic scale proton radius estimate

Cosmic scale proton mass = (proton's mass)$(1.189\ 533 \times 10^{57})$ $=1.989\ 639 \times 10^{30}$ kg
If one starts with the mass of a cs-neutron composed of 100% H_2 molecules and allows these H_2 molecules to fuse a mass of iron equal to the mass of a cs-electron then to obtain the calculated cs-proton mass the follow composition is necessary: 88.635 652 % H_2 & 11.364 348 % He. Nucleon composition is more extensively explored in the third article of this series. The size of the cs-proton is estimated from the atomic densities of Hydrogen and Helium.

Table 3, Hydrogen Atomic Radii [10]

	Internuclear distance	Atomic radius	Abundance (%)
$^1H_2$	0.741 44 Å	0.370 72 Å	99.988 5
$^2H_2$	0.741 52 Å	0.370 76 Å	0.011 5
$^3H_2$	0.741 42 Å	0.370 71 Å	

The hydrogen atomic volume in the cs-proton has been determined using 1/2 the inter-nuclear distance of the hydrogen molecule. A Hydrogen radius of 3.7072×10^{-11} m results in a Hydrogen atomic volume of $2.134\ 158\ 442 \times 10^{-31}$ m^3.

Hydrogen atom mass = (1.007 940 754 amu)$(1.660\ 538\ 86 \times 10^{-27}$ kg/amu$) = 1.673\ 724\ 791 \times 10^{-27}$ kg
Hydrogen atom density = $(1.673\ 724\ 791 \times 10^{-27}$ kg$)/(2.134\ 158\ 442 \times 10^{-31}$ $m^3) = 7842.551\ 697$ kg/m^3
Helium atom radius = 0.2734 Å, results in a Helium atom volume = $8.559\ 562\ 042 \times 10^{-32}$ m^3
Helium atom mass = (4.002 601 932 amu)$(1.660\ 538\ 86 \times 10^{-27}$ kg/amu$) = 6.646\ 476\ 049 \times 10^{-27}$ kg
Helium atom density = $(6.646\ 476\ 049 \times 10^{-27}$ kg$)/(8.559\ 562\ 042 \times 10^{-32}$ $m^3) = 77\ 649.721\ 053$ kg/m^3

M_T = cs-proton mass:	$1.989\ 639\ 050 \times 10^{30}$ kg
d_1 = Hydrogen atomic density:	7842.551 697 kg/m^3
d_2 = Helium atomic density:	77 649.721 053 kg/m^3
m_1 = Hydrogen mass =	$(0.886\ 356\ 52)(1.989\ 639\ 050 \times 10^{30}$ kg$) = 1.763\ 529\ 544 \times 10^{30}$ kg
m_2 = Helium mass =	$(0.113\ 643\ 48)(1.989\ 639\ 050 \times 10^{30}$ kg$) = 2.261\ 095\ 056 \times 10^{29}$ kg
v_1 = Hydrogen volume =	$(1.763\ 529\ 544 \times 10^{30}$ kg$)/(7842.551\ 697$ kg/$m^3) = 2.248\ 668\ 051 \times 10^{26}$ kg
v_2 = Helium volume =	$(2.261\ 095\ 056 \times 10^{29}$ kg$)/(77\ 649.721\ 053$ kg/$m^3) = 2.911\ 916\ 521 \times 10^{24}$ m^3
V_T =	$2.248\ 668\ 051 \times 10^{26}$ m^3 + $2.911\ 916\ 521 \times 10^{24}$ m^3 = $2.277\ 787\ 216 \times 10^{26}$ m^3
D_T =	$(1.989\ 639\ 050 \times 10^{30}$ kg$)/(2.277\ 787\ 216 \times 10^{26}$ $m^3) = 8734.964\ 513$ kg/m^3
Cosmic scale proton radius, R_T =	$3.788\ 565\ 912 \times 10^{8}$ m = 378 856 591.2 m

6.2. Length scaling fractal, ¥Length

The length scaling fractal = (cosmic scale proton radius)/(human scale proton radius)
Experiments reveal the densities of nuclei are fairly constant, although there appears to be a density decrease towards nuclear surfaces. The cs-proton is used to calculate the length scaling fractal. The nuclear radius formula is:

$R = R_0A^{1/3}$, where R_0 = 1.0 to 1.5 fm, (12)
A = nuclear mass number = 1 for the proton or neutron
Minimum proton radius = 1.0 fm.

Length Scaling Fractal = (cosmic scale proton radius)/(human scale proton radius)
Length Scaling Fractal, ¥Length = (3.788 565 912 x 10^8 m)/(1.0 fm) = 3.788 566 x 10^{23} (13)

7. Cosmic scale proton central pressure and temperature estimate

7.1. The pressure & temperature at the Sun's center [11]

P_c = 19G(Sun's Mass)^2/(Sun's radius)^4 (14)

G	= 6.6742 x 10^{-11} Nm^2/kg^2
M_S	= 1.99 x 10^{30} kg
R_S	= 6.96 x 10^8 m
P_c	= 2.14 x 10^{16} Pa

$P_c = n_ckT_c$ (15)

m_c	= mean particle mass at the Sun's center is averaged over ions & electrons
n_c	= central density/(m_c) = 150 g/cm^3/1.5 x 10^{-24} g = 1.0 x 10^{32} m^{-3}
k	= 1.380 6505 x 10^{-23} J/K
T_c	= central temperature = 15 x 10^6 K

7.2. The pressure & temperature at a cosmic scale proton's center

Let the cosmic scale beta decay of a cs-neutron end with mostly Helium formed in the core of the cs-proton.

Central pressure, P_c = 19G(1.989 639 05 x 10^{30} kg)^2/(3.788 566 x 10^8 m)^4 = 2.436 6995 x 10^{17} Pa

Let the central Helium atoms have their two electrons per atom exist in their quantum scale (qs) plasma phase. The translational kinetic energies of the two electrons have been divided amongst the electron's composite qs-Iron atoms in random directions. Thus, an ideal qs-iron plasma gas is formed, contracted in size until the pressure of the delocalized electrons equal the ambient central pressure.

PV = nRT = 24.587 387 eV + 54.417 760 eV = 1.265 801 923 x 10^{-17} J (16)

Volume = 5.194 739 535 x 10^{-35} m^3, radius = 2.314 684 x 10^{-12} m

Compare this Helium radius to the Helium shell radius of ~ 1 x 10^{-12} m in the Radon atom.
Helium atomic mass = (4.002 601 932 amu)(1.660 538 86 x 10^{-27} kg/amu) = 6.646 476 049 x 10^{-27} kg
The Helium atomic density at the core of the cs-proton ρ = 1.279 462 811 x 10^8 kg/m^3

$P_c = n_ckT_c$

m_c	= 6.646 476 049 x 10^{-27} kg/3 = 2.215 492 016 x 10^{-27} kg
n_c	= (1.279 462 811 x 10^8 kg/m^3)/m_c = 5.775 072 993 x 10^{34} m^{-3}
k	= 1.380 6505 x 10^{-23} J/K
T_c	= 305,600 K

The cosmic scale proton's central temperature is 305,600 K. The temperature decreases until 2.725 K at the cs-proton's surface. Cs-proton's must be in thermodynamic equilibrium with the microwave background radiation.

8. Scaling fractals & the fractal dimension

A function that extends to the infinitely large and approaches but never reaches the infinitely small is sought. Logarithmic functions such as y = ln(x), or equivalently x = e^y, are good candidates as is the fractal function p = q^D, where D is the fractal self-similarity dimension, p is the number of self-similar pieces, and q is the scaling reduction factor applied to obtain the pieces. Scaling fractals considered thus far have been obtained from the Principle of Scalativity and are reducible to the product of the length scaling fractal and the mass scaling fractal each raised to their respective quantized numbers j, k.

¥f(O) = ¥L$^{j/2}$¥M$^{k/2}$ (17)
j, k = {–∞,…, –2, –1, 0, 1, 2,…, +∞} are scaling fractal quantum numbers

Values of ¥f(O) are listed in Table 4 to the sixth decimal place only to aid in finding scaling relationships. The scaling fractal value certainties derive from the certainty of the mass and length scaling fractals. The mass scaling fractal may be accurate to 3 significant figures, while the length scaling fractal is even less certain. From the fractal dimension function $p = q^D$, a similar scaling fractal function is written:

$$¥f(O) = ¥L^F \quad (18)$$

¥L = length scaling fractal = $3.788\ 565\ 912 \times 10^{23}$
F = Fractal Dimension of an observable, F = ln¥f(O)/ln¥L

Equating equations (17) & (18): $¥L^{j/2}¥M^{k/2} = ¥L^F$

$$F = j/2 + 0.5k[\ln¥M/\ln¥L] = 0.5j + 1.210328k \quad (19)$$

Physical fractal dimensions can be positive or negative and are not necessarily integers. Consider the fifth dimension to be the set of all an objects fractal dimensions. The fifth dimension incorporates objects and observers into the coordinate system. The SI unit scaling fractals are listed in Table 5.

Table 4, Scaling fractals & fractal dimensions

¥f(O)	Observable	$¥L^{j/2}¥M^{k/2}$	j	k	Scaling Fractal	F
¥L	length	¥L	2	0	$3.788\ 566 \times 10^{23}$	1.0000
¥t	time	¥L	2	0	$3.788\ 566 \times 10^{23}$	1.0000
¥λ	wavelength	¥L	2	0	$3.788\ 566 \times 10^{23}$	1.0000
¥M	mass	¥M	0	2	$1.189\ 533 \times 10^{57}$	2.4207
¥E	energy	¥M	0	2	$1.189\ 533 \times 10^{57}$	2.4207
¥f	frequency	$¥L^{-1}$	-2	0	$2.639\ 521 \times 10^{-24}$	-1.0000
¥**a**	linear acceleration	$¥L^{-1}$	-2	0	$2.639\ 521 \times 10^{-24}$	-1.0000
¥**p**	linear momentum	¥M	0	2	$1.189\ 533 \times 10^{57}$	2.4207
¥Vol	volume	$¥L^3$	6	0	$5.437\ 816 \times 10^{70}$	3.0000
¥A	Area	$¥L^2$	4	0	$1.435\ 323 \times 10^{47}$	2.0000
¥D	density	$¥L^{-3}¥M$	-6	2	$2.187\ 520 \times 10^{-14}$	-0.5793
¥Q	charge	$¥L^{1/2}¥M^{1/2}$	1	1	$2.122\ 881 \times 10^{40}$	1.7103
¥Q/M	charge per mass	$¥L^{1/2}¥M^{-1/2}$	1	-1	$1.784\ 634 \times 10^{-17}$	-0.7103
¥M/Q	Mass per charge	$¥L^{-1/2}¥M^{1/2}$	-1	1	$5.603\ 390 \times 10^{16}$	0.7103
¥SA/Vol	Surface area to volume ratio	$¥L^{-1}$	-2	0	$2.639\ 521 \times 10^{-24}$	-1.0000
¥Q/SA	Electric flux density	$¥L^{-3/2}¥M^{1/2}$	-3	1	$1.479\ 027 \times 10^{-7}$	-0.2897
¥h	Planck's constant	¥L¥M	2	2	$4.506\ 625 \times 10^{80}$	3.4207
¥**S**	Spin	¥L¥M	2	2	$4.506\ 625 \times 10^{80}$	3.4207
¥**L**	Angular momentum	¥L¥M	2	2	$4.506\ 625 \times 10^{80}$	3.4207
¥**μ**	Magnetic dipole moment	$¥L^{3/2}¥M^{1/2}$	3	1	$8.042\ 676 \times 10^{63}$	2.7103
¥EDM	Electric dipole moment	$¥L^{3/2}¥M^{1/2}$	3	1	$8.042\ 676 \times 10^{63}$	2.7103
¥c	speed of light	$¥L^0¥M^0$	0	0	1	0.0000
¥v	velocity	$¥L^0¥M^0$	0	0	1	0.0000
$¥k_C$	coulomb's constant	$¥L^0¥M^0$	0	0	1	0.0000
$¥\varepsilon_0$	permittivity	$¥L^0¥M^0$	0	0	1	0.0000
$¥\mu_0$	permeability	$¥L^0¥M^0$	0	0	1	0.0000
¥x	cross product	$¥L^0¥M^0$	0	0	1	0.0000
¥Ω	Ohm, resistance	$¥L^0¥M^0$	0	0	1	0.0000
¥G	gravitational constant	$¥L¥M^{-1}$	2	-2	$3.184\ 918 \times 10^{-34}$	-1.4207
¥**g**	gravitational field	$¥L^{-1}$	-2	0	$2.639\ 521 \times 10^{-24}$	-1.0000

¥E	electric field	¥L$^{-3/2}$¥M$^{1/2}$	-3	1	1.479 027 x 10^{-7}	-0.2897
¥B	magnetic field	¥L$^{-3/2}$¥M$^{1/2}$	-3	1	1.479 027 x 10^{-7}	-0.2897
¥F$_g$	gravitational force	¥L^{-1}¥M	-2	2	3.139 798 x 10^{33}	1.4207
¥F$_E$	electric force	¥L^{-1}¥M	-2	2	3.139 798 x 10^{33}	1.4207
¥F$_M$	magnetic force	¥L^{-1}¥M	-2	2	3.139 798 x 10^{33}	1.4207
¥i	current	¥L$^{-1/2}$¥M$^{1/2}$	-1	1	5.603 390 x 10^{16}	0.7103
¥Volt	voltage	¥L$^{-1/2}$¥M$^{1/2}$	-1	1	5.603 390 x 10^{16}	0.7103
¥N$_A$	Avogadro's #	¥L^0¥M^0	0	0	1	0.0000
¥mol	grams/molecular weight	¥L^0¥M^0	0	0	1	0.0000
¥C$_Q$	specific heat capacity	¥L^3¥M^{-1}	6	-2	4.571 387 x 10^{13}	0.5793
¥TC	Thermal conductivity	¥L	2	0	3.788 566 x 10^{23}	1.0000
¥P	power	¥L^{-1}¥M	-2	2	3.139 798 x 10^{33}	1.4207
¥T	temperature	¥L^{-3}¥M	-6	2	2.187 520 x 10^{-14}	-0.5793
¥Pr	pressure	¥L^{-3}¥M	-6	2	2.187 520 x 10^{-14}	-0.5793
¥k	Boltzmann constant	¥L^3	6	0	5.437 816 x 10^{70}	3.0000
¥R	gas constant	¥L^3	6	0	5.437 816 x 10^{70}	3.0000
¥σ	Stefan-Boltzmann const	¥L^9¥M^{-3}	18	-6	9.553 091 x 10^{40}	1.7380
¥Wie	Wien's const	¥L^{-2}¥M	-4	2	8.287 564 x 10^9	0.4207
¥α	Polarizability	¥L^3	6	0	5.437 816 x 10^{70}	3.0000
¥Cap	Capacitance, F = C/Volt	¥L	2	0	3.788 566 x 10^{23}	1.0000
¥cd	Luminous intensity, cd	¥L^{-1}¥M	-2	2	3.139 798 x 10^{33}	1.4207
¥Lum	Luminance, cd/m^2	¥L^{-3}¥M	-6	2	2.187 520 x 10^{-14}	-0.5793
¥Ent	Entropy	¥L^3	6	0	5.437 816 x 10^{70}	3.0000
¥sr	Steradian, solid angle	¥L^0¥M^0	0	0	1	0.0000
¥rad	Radian, plane angle	¥L^0¥M^0	0	0	1	0.0000
¥ω	Angular velocity	¥L^{-1}	-2	0	2.639 521 x 10^{-24}	-1.0000
¥*d*ω/*d*t	Angular acceleration	¥L^{-2}	-4	0	6.967 072 x 10^{-48}	-2.0000
¥I	Moment of inertia	¥L^2¥M	4	2	1.707 365 x 10^{104}	4.4207
¥Φ$_0$	Magnetic flux quantum	¥L$^{1/2}$¥M$^{1/2}$	1	1	2.122 881 x 10^{40}	1.7103
¥wb	Magnetic flux, weber	¥L$^{1/2}$¥M$^{1/2}$	1	1	2.122 881 x 10^{40}	1.7103
¥H	Inductance, Henry	¥L	2	0	3.788 566 x 10^{23}	1.0000
¥cir	Quantum of circulation	¥L	2	0	3.788 566 x 10^{23}	1.0000
¥ST	Surface tension, N/m	¥L^{-2}¥M	-4	2	8.287 564 x 10^9	0.4207
¥Vis	Viscosity, Pa•s	¥L^{-2}¥M	-4	2	8.287 564 x 10^9	0.4207
¥Flu	Fluidity, m•s/kg	¥L^2¥M^{-1}	4	-2	1.206 627 x 10^{-10}	-0.4207
¥Q/Vol	Charge density	¥L$^{-5/2}$¥M$^{1/2}$	-5	1	3.903 922 x 10^{-31}	-1.2897
¥Ψ	Wave function	¥L$^{-3/2}$	-3	0	4.288 325 x 10^{-36}	-1.5000
¥Ψ^2	Probability density	¥L^{-3}	-6	0	1.838 973 x 10^{-71}	-3.0000
¥V^2/K^2	Lorentz coefficient	¥L^5¥M^{-1}	10	-2	6.561 417 x 10^{60}	2.5793
¥DS	Density of states, 1/J	¥M^{-1}	0	-2	8.406 659 x 10^{-58}	-2.4207
¥K^{-1}	Linear expansion coefficient	¥L^3¥M^{-1}	6	-2	4.571 387 x 10^{13}	0.5793
¥K/Pa	Joule-Thomson coefficient	¥L^0¥M^0	0	0	1	0.0000
¥Col	Collision #, m^{-3}s^{-1}	¥L^{-4}	-8	0	4.854 009 x 10^{-95}	-4.0000

¥BBR	Black body radiation	¥L^{-4}¥M	-8	2	5.774 005 x 10^{-38}	-1.5793
¥E¥B¥g	Natural force fields	¥L^{-4}¥M	-8	2	5.774 005 x 10^{-38}	-1.5793
¥Vol-¥t	Space-time	¥L^{4}	8	0	2.060 153 x 10^{94}	4.0000

Figure 2, The Fifth Dimension (plotted from Table 4 fractal dimensions)

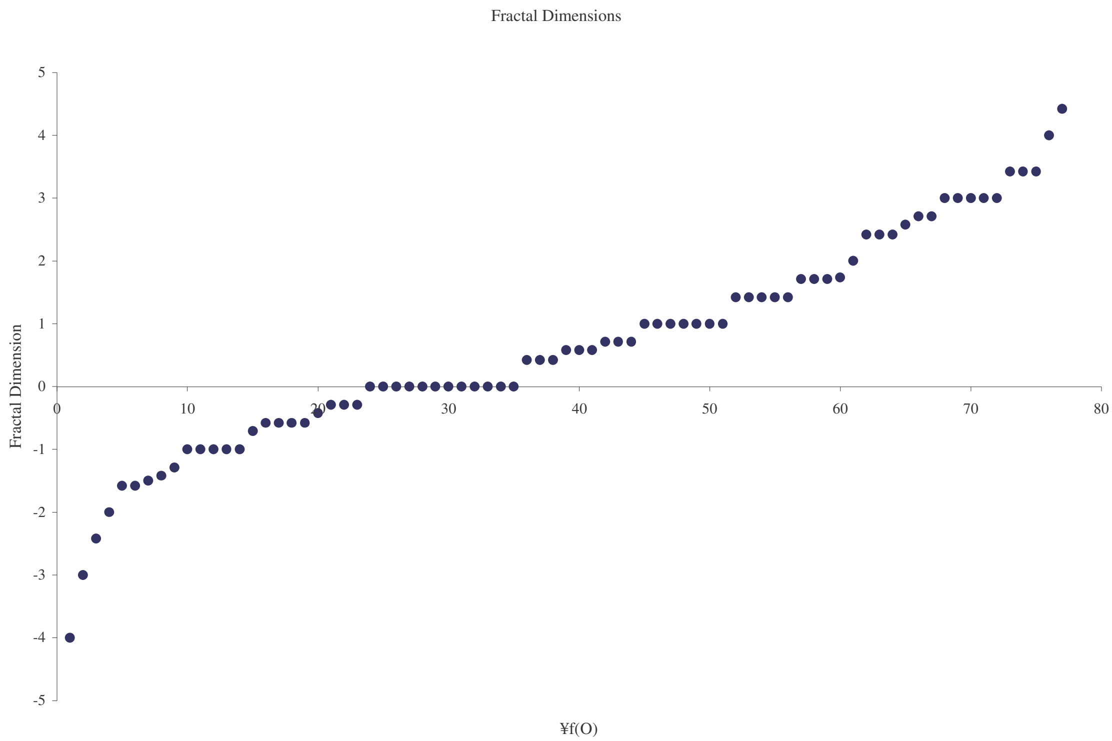


Table 5, International System of Units (SI), Scaling Fractals & Fractal Dimensions

Base quantity	Name	unit	¥f(O)	Scaling Fractal	F
Length	Meter	m	¥L	3.788 566 x 10^{23}	1.0000
Mass	Kilogram	kg	¥M	1.189 534 x 10^{57}	2.4207
Time	Second	s	¥t	3.778 834 x 10^{23}	1.0000
Electric current	Ampere	A	¥i	5.603 390 x 10^{16}	0.7103
Thermodynamic temperature	Kelvin	K	¥T	2.187 520 x 10^{-14}	-0.5793
Amount of substance	Mole	mol	¥mol	1	0.0000
Luminous intensity	Candela	cd	¥cd	3.139 798 x 10^{33}	1.4207

9. Constants in adjacent scales as measured in the human scale

9.1. Constants of the human scale as measured in the human scale (see Table 6)

Table 6, Constants of the Human Scale (m = 0), as measured in the Human Scale (n = 0) [10]

c	299 792 458	m/s	Speed of emr in vacuum
ε_0	8.854 187 817 x 10^{-12}	$C^2/(Nm^2)$	Exact – permittivity or electric constant
μ_0	4π x 10^{-7}	$N/(Amp)^2$	Exact – permeability or magnetic constant
k_C	898 755 1788	Nm^2/C^2	Coulomb constant, $1/(4\pi\varepsilon_0)$
$[e, charge]_{0,0}$	1.602 176 53 x 10^{-19}	C	Electron charge
$[e, mass]_{0,0}$	9.109 3826 x 10^{-31}	kg	Electron mass
$[p, mass]_{0,0}$	1.672 621 71 x 10^{-27}	kg	Proton mass
$[n, mass]_{0,0}$	1.674 927 28 x 10^{-27}	kg	Neutron mass
k	1.380 6505 x 10^{-23}	J/K	Boltzmann constant, R/N_A

h	$6.626\ 0693 \times 10^{-34}$	Js	Planck constant
G	6.6742×10^{-11}	$m^3/(s^2kg)$	Gravitational constant
N_A	$6.022\ 1415 \times 10^{23}$	1/mol	Avogadro constant
R	8.314 472	J/(molK)	Molar gas constant
F	96 485.3383	C/mol	Faraday constant, N_Ae
σ	$5.670\ 400 \times 10^{-8}$	$W/(m^2K^4)$	Stefan-Boltzmann constant
eV	$1.602\ 176\ 53 \times 10^{-19}$	J	Electron volt
u	$1.660\ 538\ 86 \times 10^{-27}$	kg	Atomic mass unit, 931.494 047 MeV
μ_B	$9.274\ 009\ 49 \times 10^{-24}$	J/T	Bohr magneton, $0.5e\hbar/m_{e-}$
μ_N	$5.050\ 783\ 43 \times 10^{-27}$	J/T	Nuclear magneton, $0.5e\hbar/m_p$
a_0	$5.291\ 772\ 108 \times 10^{-11}$	m	Bohr radius, $4\pi\varepsilon_0\hbar^2/(m_{e-}e^2)$
v	$2.187\ 691\ 263 \times 10^6$	m/s	H-atom n = 1, electron orbital velocity

9.2. Constants of the quantum scale as measured in the human scale

Table 7 tabulates various constants in the quantum scale as measured in the human scale, based on the scaling fractal values in Table 4, and the constant values in Table 6.

Table 7, Constants of the Quantum Scale (m = -1), as measured in the Human Scale (n = 0)

$[c]_{-1,0}$	299 792 458	m/s	Speed of emr in vacuum
$[\varepsilon_0]_{-1,0}$	$8.854\ 187\ 817 \times 10^{-12}$	$C^2/(Nm^2)$	Electric constant
$[\mu_0]_{-1,0}$	$4\pi \times 10^{-7}$	H/m	Exact – permeability constant
$[k_C]_{-1,0}$	898 755 1788	Nm^2/C^2	Coulomb constant, $1/(4\pi\varepsilon_0)$
$[e, charge]_{-1,0}$	$7.547\ 179\ 141 \times 10^{-60}$	C	Electron charge
$[e, mass]_{-1,0}$	$7.657\ 947\ 355 \times 10^{-88}$	kg	Electron mass
$[p, mass]_{-1,0}$	$1.406\ 116\ 041 \times 10^{-84}$	kg	Proton mass
$[n, mass]_{-1,0}$	$1.408\ 054\ 255 \times 10^{-84}$	kg	Neutron mass
$[k]_{-1,0}$	$2.538\ 979\ 606 \times 10^{-94}$	J/K	Boltzmann constant
$[h]_{-1,0}$	$1.470\ 295\ 269 \times 10^{-114}$	Js	Planck constant
$[G]_{-1,0}$	$2.095\ 564\ 033 \times 10^{23}$	$m^3/(s^2kg)$	Gravitational constant
$[N_A]_{-1,0}$	$6.022\ 141\ 50 \times 10^{23}$	1/mol	Avogadro constant
$[R]_{-1,0}$	$1.529\ 009\ 322 \times 10^{-70}$	J/(molK)	Molar gas constant
$[F]_{-1,0}$	$4.545\ 018\ 099 \times 10^{-36}$	C/mol	Faraday constant
$[\sigma]_{-1,0}$	$5.935\ 670\ 299 \times 10^{-49}$	$W/(m^2K^4)$	Stefan-Boltzmann constant
$[1\ eV]_{-1,0}$	$1.346\ 895\ 180 \times 10^{-76}$	J	Electron volt
$[u]_{-1,0}$	$1.395\ 958\ 401 \times 10^{-84}$	kg	amu
$[\mu_B]_{-1,0}$	$1.153\ 100\ 025 \times 10^{-87}$	J/T	Bohr magneton
$[\mu_N]_{-1,0}$	$6.279\ 979\ 017 \times 10^{-91}$	J/T	Nuclear magneton
$[a_0]_{-1,0}$	$1.396\ 774\ 461 \times 10^{-34}$	m	Bohr radius
$[v]_{-1,0}$	$2.187\ 691\ 263 \times 10^6$	m/s	H-atom n = 1, electron orbital velocity

9.3. Constants of the cosmic scale as measured in the human scale

Table 8 tabulates various constants in the cosmic scale as measured in the human scale, based on the scaling fractal values in Table 4, and the constant values in Table 6.

Table 8, Constants of the Cosmic Scale (m = 1), as measured in the Human Scale (n = 0)

$[c]_{1,0}$	299 792 458	m/s	Speed of emr in vacuum
$[\varepsilon_0]_{1,0}$	$8.854\ 187\ 817 \times 10^{-12}$	F/m	Exact – permittivity constant
$[\mu_0]_{1,0}$	$1.256\ 637\ 061\ 43 \times 10^{-6}$	H/m	Exact – permeability constant
$[k_C]_{1,0}$	898 755 1788	Nm^2/C^2	Coulomb constant, $1/(4\pi\varepsilon_0)$
$[e, charge]_{1,0}$	$3.401\ 230\ 560 \times 10^{21}$	C	Electron charge
$[e, mass]_{1,0}$	$1.083\ 591\ 301 \times 10^{27}$	kg	Electron mass

$[p, mass]_{1,0}$	$1.989\ 639\ 050 \times 10^{30}$	kg	Proton mass
$[n, mass]_{1,0}$	$1.992\ 381\ 602 \times 10^{30}$	kg	Neutron mass
$[k]_{1,0}$	$7.507\ 723\ 963 \times 10^{47}$	J/K	Boltzmann constant
$[h]_{1,0}$	$2.986\ 120\ 904 \times 10^{47}$	Js	Planck constant
$[G]_{1,0}$	$2.125\ 678\ 096 \times 10^{-44}$	$m^3/(s^2kg)$	Gravitational constant
$[N_A]_{1,0}$	$6.022\ 141\ 500 \times 10^{23}$	1/mol	Avogadro constant
$[R]_{1,0}$	$4.521\ 257\ 239 \times 10^{71}$	J/(molK)	Molar gas constant
$[F]_{1,0}$	$2.048\ 269\ 183 \times 10^{45}$	C/mol	Faraday constant
$[\sigma]_{1,0}$	$5.416\ 984\ 862 \times 10^{33}$	$W/(m^2K^4)$	Stefan-Boltzmann constant
$[1\ eV]_{1,0}$	$1.905\ 842\ 170 \times 10^{38}$	J	Electron volt
$[u]_{1,0}$	$1.975\ 266\ 099 \times 10^{30}$	kg	amu
$[\mu_B]_{1,0}$	$7.458\ 785\ 027 \times 10^{40}$	J/T	Bohr magneton
$[\mu_N]_{1,0}$	$4.062\ 181\ 289 \times 10^{37}$	J/T	Nuclear magneton
$[a_0]_{1,0}$	$2.004\ 822\ 742 \times 10^{13}$	m	Bohr radius = 134 AU
$[v]_{1,0}$	$2.187\ 691\ 263 \times 10^{6}$	m/s	H-atom n = 1, electron orbital velocity

10. Fundamental physical fractal observables

Observables for electrons, protons, and neutrons located in two scales as measured in the Human Scale.

10.1. Electron

$[e\text{-}, radius]_{0,0}$	$7.231\ 425\ 325 \times 10^{-17}$	m	
$[e\text{-}, mass]_{0,0}$	$9.109\ 3826 \times 10^{-31}$	kg	
$[e\text{-}, charge]_{0,0}$	$- 1.602\ 176\ 53 \times 10^{-19}$	C	
$[e\text{-}, spin\ (\mathbf{S})]_{0,0}$	$9.132\ 858\ 671 \times 10^{-35}$	Js	$= 0.5\hbar\sqrt{3}$
$[e\text{-}, spin\ (\mathbf{S_Z})]_{0,0}$	$5.272\ 858\ 412 \times 10^{-35}$	Js	$= 0.5\hbar$
$[e\text{-}, surface\ area]_{0,0}$	$6.571\ 396\ 554 \times 10^{-32}$	m^2	
$[e\text{-}, volume]_{0,0}$	$1.584\ 018\ 782 \times 10^{-48}$	m^3	
$[e\text{-}, density]_{0,0}$	$5.750\ 804\ 664 \times 10^{17}$	kg/m^3	
$[e\text{-}, q/M]_{0,0}$	$- 1.758\ 820\ 109 \times 10^{11}$	C/kg	
$[e\text{-}, \mu_S]_{0,0}$	$- 9.284\ 764\ 116 \times 10^{-24}$	J/T	$= -1.001\ 159\ 652\ 2\ \mu_B$
$[e\text{-}, q/surface\ area]_{0,0}$	$- 2.438\ 106\ 599 \times 10^{12}$	C/m^2	
$[e\text{-}, q/volume]_{0,0}$	$- 1.011\ 463\ 089 \times 10^{29}$	C/m^3	
$[e\text{-}, SA/Volume]_{0,0}$	$4.148\ 559\ 745 \times 10^{16}$	m^{-1}	
$[e\text{-}, composition]_{0,0}$	charged $[2.122\ 881 \times 10^{40}\ e\text{-}s]_{-1,0}$ qs-magnetic sphere of $1.168\ 506 \times 10^{52}$ qs-Iron		

10.2. Proton

$[p^+, radius]_{0,0}$	1.000 000 000	fm	
$[p^+, mass]_{0,0}$	$1.672\ 621\ 71 \times 10^{-27}$	kg	
$[p^+, charge]_{0,0}$	$1.602\ 176\ 53 \times 10^{-19}$	C	
$[p^+, spin\ (\mathbf{S})]_{0,0}$	$9.132\ 858\ 671 \times 10^{-35}$	Js	$= 0.5\hbar\sqrt{3}$
$[p^+, spin\ (\mathbf{S_Z})]_{0,0}$	$5.272\ 858\ 412 \times 10^{-35}$	Js	$= 0.5\hbar$
$[p^+, surface\ area]_{0,0}$	$1.256\ 637\ 061 \times 10^{-29}$	m^2	
$[p^+, volume]_{0,0}$	$4.188\ 790\ 205 \times 10^{-45}$	m^3	
$[p^+, density]_{0,0}$	$3.993\ 090\ 196 \times 10^{17}$	kg/m^3	
$[p^+, q/M]_{0,0}$	$9.578\ 833\ 758 \times 10^{7}$	C/kg	
$[p^+, \mu_p]_{0,0}$	$1.410\ 606\ 712 \times 10^{-26}$	J/T	$= 2.792\ 847\ 351\ \mu_N$
$[p^+, q/surface\ area]_{0,0}$	$1.274\ 971\ 573 \times 10^{10}$	C/m^2	
$[p^+, q/volume]_{0,0}$	$3.824\ 914\ 717 \times 10^{25}$	C/m^3	
$[p^+, composition]_{0,0}$	88.635 652 % $[H_2]_{-1,0}$ & 11.364 348% $[He]_{-1,0}$ & $2.122\ 881 \times 10^{40}\ [H_2^+]_{-1,0}$		

10.3. Neutron

$[n, radius]_{0,0}$	1.037 057 778	fm	
$[n, mass]_{0,0}$	$1.674\ 927\ 28 \times 10^{-27}$	kg	

[n, charge]$_{0,0}$	0		
[n, spin (**S**)]$_{0,0}$	9.132 858 671 x 10^{-35}	Js	$= 0.5\hbar\sqrt{3}$
[n, spin ($\mathbf{S_Z}$)]$_{0,0}$	5.272 858 412 x 10^{-35}	Js	$= 0.5\hbar$
[n, surface area]$_{0,0}$	1.351 499 129 x 10^{-29}	m^2	
[n, volume]$_{0,0}$	4.671 942 228 x 10^{-45}	m^3	
[n, density]$_{0,0}$	3.585 077 037 x 10^{17}	kg/m^3	
[n, q/M]$_{0,0}$	0		
[n, μ_S]$_{0,0}$	- 0.966 236 45 x 10^{-26}	J/T	= - 1.913 042 73 μ_N
[n, q/surface area]$_{0,0}$	0		
[n, q/volume]$_{0,0}$	0		
[n, composition]$_{0,0}$	100.000% [H_2: 1.190 388 x 10^{57} atoms, 1.976 685 x 10^{33} mol]$_{-1,0}$		

10.4. Cosmic scale electron

[e-, radius]$_{1,0}$	2.739 673 148 x 10^{7}	m
[e-, mass]$_{1,0}$	1.083 591 301 x 10^{27}	kg
[e-, charge]$_{1,0}$	- 3.401 230 560 x 10^{21}	C
[e-, spin (**S**)]$_{1,0}$	4.115 836 850 x 10^{46}	Js
[e-, spin ($\mathbf{S_Z}$)]$_{1,0}$	2.376 279 513 x 10^{46}	Js
[e-, surface area]$_{1,0}$	9.432 077 713 x 10^{15}	m^2
[e-, volume]$_{1,0}$	8.613 603 347 x 10^{22}	m^3
[e-, mass density]$_{1,0}$	12,580	kg/m^3
[e-, q/M]$_{1,0}$	3.138 850 004 x 10^{-6}	C/kg
[e-, μ_S]$_{1,0}$	- 7.467 434 623 x 10^{40}	J/T
[e-, σ]$_{1,0}$	360,602.474	C/m^2
[e-, q/volume]$_{1,0}$	0.039 486 733 C/m^3	C/m^3
[e-, composition]$_{1,0}$	charged [2.122 881 x 10^{40} e-s]$_{0,0}$ magnetic sphere of 1.168 506 x 10^{52} Fe atoms	

10.5. Cosmic scale proton

[p^+, radius]$_{1,0}$	3.788 565 912 x 10^{8}	m
[p^+, mass]$_{1,0}$	1.989 639 050 x 10^{30}	kg
[p^+, charge]$_{1,0}$	3.401 230 560 x 10^{21}	C
[p^+, spin (**S**)]$_{1,0}$	4.115 836 850 x 10^{46}	Js
[p^+, spin ($\mathbf{S_Z}$)]$_{1,0}$	2.376 279 513 x 10^{46}	Js
[p^+, surface area]$_{1,0}$	1.803 680 287 x 10^{18}	m^2
[p^+, volume]$_{1,0}$	2.277 787 217 x 10^{26}	m^3
[p^+, mass density]$_{1,0}$	8,734.964 509	kg/m^3
[p^+, q/M]$_{1,0}$	1.709 471 153 x 10^{-9}	C/kg
[p^+, μ_p]$_{1,0}$	1.134 505 225 x 10^{38}	J/T
[p^+, σ]$_{1,0}$	1885.716 989	C/m^2
[p^+, q/volume]$_{1,0}$	1.493 216 985 x 10^{-5}	C/m^3
[p^+, composition]$_{1,0}$	88.635 652% [H_2]$_{0,0}$ & 11.364 348% [He]$_{0,0}$ & 2.122 881 x 10^{40} [H_2^+]$_{0,0}$	

10.6. Cosmic scale neutron

[n, mass]$_{1,0}$	1.992 381 602 x 10^{30}	kg
[n, radius]$_{1,0}$	3.928 941 005 x 10^{8}	m
[n, charge]$_{1,0}$	0	
[n, spin (**S**)]$_{1,0}$	4.115 836 850 x 10^{46}	Js
[n, spin ($\mathbf{S_Z}$)]$_{1,0}$	2.376 279 513 x 10^{46}	Js
[n, surface area]$_{1,0}$	1.939 817 529 x 10^{18}	m^2
[n, volume]$_{1,0}$	2.540 476 211 x 10^{26}	m^3
[n, density]$_{1,0}$	7,842.551 697	kg/m^3
[n, q/M]$_{1,0}$	0	
[n, μ_S]$_{1,0}$	- 7.771 126 365 x 10^{37}	J/T
[n, q/surface area]$_{1,0}$	0	
[n, q/volume]$_{1,0}$	0	
[n, composition]$_{1,0}$	100.000 % Hydrogen: 1.190 388 x 10^{57} atoms, 1.976 685 x 10^{33} mol	

11. Observables of electrons, protons, and neutrons in several scales

11.1. Human scale mass, radius, and charge of an electron located in seven adjacent scales (see Table 9.a)

Table 9.a, Electron located in seven adjacent scales

Electron In Scale m	Human scale n = 0 measures mass (kg)	Human scale n = 0 measures radius (m)	Human scale n = 0 measures charge (C)
3	1.533 2700 x 10^{141}	3.932 316 x 10^{54}	1.532 807 04 x 10^{102}
2	1.288 9678 x 10^{84}	1.037 943 x 10^{31}	7.220 408 68 x 10^{61}
1	1.083 5913 x 10^{27}	2.739 673 x 10^{7}	3.401 230 56 x 10^{21}
0	9.109 3826 x 10^{-31}	7.231 425 x 10^{-17}	1.602 176 53 x 10^{-19}
-1	7.657 9474 x 10^{-88}	1.908 750 x 10^{-40}	7.547 179 14 x 10^{-60}
-2	6.437 7752 x 10^{-145}	5.038 186 x 10^{-64}	3.555 158 37 x 10^{-100}
-3	5.412 0181 x 10^{-202}	1.329 840 x 10^{-87}	1.674 685 44 x 10^{-140}

11.2. Human scale mass, radius, and magnetic moment of a proton located in seven adjacent scales (see Table 9.b)

Table 9.b, Proton located in seven adjacent scales

Proton In Scale m	Human scale n = 0 measures mass (kg)	Human scale n = 0 measures radius (m)	Human scale n = 0 measures Magnetic moment, **μ** (J/T)
3	2.815 317 82 x 10^{144}	5.437 816 42 x 10^{55}	7.338 505 246 x 10^{165}
2	2.366 741 70 x 10^{87}	1.435 323 17 x 10^{32}	9.124 457 543 x 10^{101}
1	1.989 639 05 x 10^{30}	3.788 565 91 x 10^{8}	1.134 505 225 x 10^{38}
0	1.672 621 71 x 10^{-27}	1.000 000 00 x 10^{-15}	1.410 606 712 x 10^{-26}
-1	1.406 116 04 x 10^{-84}	2.639 521 19 x 10^{-39}	1.753 902 276 x 10^{-90}
-2	1.182 073 81 x 10^{-141}	6.967 072 11 x 10^{-63}	2.180 744 759 x 10^{-154}
-3	9.937 291 49 x 10^{-199}	1.838 973 45 x 10^{-86}	2.711 466 749 x 10^{-218}

11.3. Human scale mass and spin of a neutron located in seven adjacent scales (see Table 9.c)

Table 9.c, Neutron located in seven adjacent scales

Neutron In Scale m	Human scale n = 0 measures mass (kg)	Human scale n = 0 measures spin, $\mathbf{S_Z}$ (Js)
3	2.819 198 50 x 10^{144}	4.826 144 840 x 10^{207}
2	2.370 004 06 x 10^{87}	1.070 900 047 x 10^{127}
1	1.992 381 60 x 10^{30}	2.376 279 512 x 10^{46}
0	1.674 927 28 x 10^{-27}	5.272 858 412 x 10^{-35}
-1	1.408 054 26 x 10^{-84}	1.170 023 799 x 10^{-115}
-2	1.183 703 20 x 10^{-141}	2.596 230 704 x 10^{-196}
-3	9.950 989 23 x 10^{-199}	5.760 920 311 x 10^{-277}

12. Scaling fractal discussion

12.1. Unified fields of scale

The unified field equation of Fractal Physics: $¥\mathbf{B}¥\mathbf{E}¥\mathbf{g} = ¥M/¥L^{4}$ (20)
The product of the three basic fields scale as the density of space–time scales.

The gravitational field scaling fractal equals the linear acceleration scaling fractal: $¥\mathbf{g} = ¥\mathbf{a} = ¥L^{-1}$. This equality is similar to the principle of equivalence. The gravitational field scaling fractal also equals the surface area to volume ratio scaling fractal: $¥\mathbf{g} = ¥SA/Vol = ¥L^{-1}$. This is remarkable in that the gravitational field scales without any, a priori, requirement of particle masses. The product of the electric & magnetic fields scale as density or temperature or pressure scales:

$$¥\mathbf{B}¥\mathbf{E} = ¥D = ¥T = ¥Pr \quad (21)$$

This is also remarkable in that density, temperature, and pressure are all understood with an a priori requirement of particle masses.

12.2. Fractal certainty principle

Planck's constant is not scale invariant. Consider the Heisenberg uncertainty principle:

$\Delta x \Delta p \geq 0.5\hbar$ $\Delta t \Delta E \geq 0.5\hbar$

Measuring an electron's position with quantum scale electromagnetic radiation (a small percent of a single neutrino) will not significantly alter the electron's momentum. The position and momentum of an electron can be determined, for practical purposes, simultaneously.

The Fractal certainty principle:

$$[\Delta x]_{m,n}[\Delta p]_{m,n} \geq [0.5\hbar]_{m,n} \qquad [\Delta t]_{m,n}[\Delta E]_{m,n} \geq [0.5\hbar]_{m,n} \tag{22}$$

The Fractal certainty principle embodies a paradigm shift for scientific inquiry. Fractal Physics assumes that it is always possible for humans to draw a picture of any physical phenomena and that the picture can truly reflect the reality of the phenomena. Furthermore, Fractal Physics assumes that based on the accurate visual representation of the phenomena, physical equations can be determined and written to detail the specific cause and effect of the physical phenomena, accurately, realistically, and completely.

12.3. Planck values

Modern Physics Planck values do not compare to common Earth science limits (Table 10.a). The mass is very far above atomic masses, the temperature is very far above fusion temperatures, the length is very far below nuclear dimensions and the time is very far below elementary particle half-lives.

Table 10.a, Planck Values in Modern Physics ($G = 6.6742 \times 10^{-11}$ Nm^2/kg^2) [10]

Planck		Formula	Value	Units
Mass	m_p	$(\hbar c/G)^{1/2}$	$2.176\,451 \times 10^{-8}$	kg
Temperature	T_p	$(\hbar c^5/G)^{1/2}/k$	$1.416\,792 \times 10^{32}$	k
Length	l_p	$(\hbar G/c^3)^{1/2}$	$1.616\,243 \times 10^{-35}$	m
Time	t_p	$(\hbar G/c^5)^{1/2}$	$5.391\,206 \times 10^{-44}$	s

Fractal Physics Planck values compare well to known Earth science limits (Table 10.b). The mass is 234 amu, about the limit of nuclear masses, the temperature is somewhat beyond high fusion temperatures, the length is 1 % of the electron's diameter, and the time is ppm fraction of short lived elementary particle half-lives like Σ^0.

Table 10.b, Planck Values in Fractal Physics ($G_{-1,0} = 2.095\,564 \times 10^{23}$ Nm^2/kg^2)

Planck		Formula	Value	Units
Mass	m_p	$(\hbar c/G)^{1/2}$	$3.884\,167 \times 10^{-25}$	kg
Temperature	T_p	$(\hbar c^5/G)^{1/2}/k$	$2.528\,456 \times 10^{15}$	k
Length	l_p	$(\hbar G/c^3)^{1/2}$	$9.056\,439 \times 10^{-19}$	m
Time	t_p	$(\hbar G/c^5)^{1/2}$	$3.020\,903 \times 10^{-27}$	s

12.4. String Theory and quantum scale atoms

In string theory particles are perceived as highly localized vibration of Planck length strings.

$$l_p = (\hbar_{0,0}G_{0,0}c^{-3})^{1/2} = [(1.054\,5717 \times 10^{-34}\text{ Js})(6.6742 \times 10^{-11}\text{ Nm}^2/\text{kg}^2)(299\,792\,458\text{ m/s})^{-3}]^{1/2} = 1.62 \times 10^{-35}\text{ m}$$

From the Bohr model of the Hydrogen atom and in particular quantized angular momentum: $mv_nr_n = n\hbar$
Combined with the de Broglie relation: $\lambda = h/p$

The relation has long been known: $2\pi r_n = nh/p_n = n\lambda$

The smallest atomic orbital circumferences are the ground state Helium shells ($1s^2$ orbital) of the heaviest atoms. The diameter of the helium shell for Radon (z = 86) ~ 0.02 Å [12]. This shell has an average circumference = $(2\pi)(1 \times 10^{-12}$ m$) = 6.28 \times 10^{-12}$ m, which is also the smallest ground state wavelength of an atomic orbital in the Human scale.

Fractal Physics length scaling fractal: $¥L = 3.789 \times 10^{23}$

A self-similar Radon atom existing in the quantum scale will have a self-similar quantum scale $1s^2$ orbital circumference measured relative to the Human Scale:

$$[\text{Radon, 1s}^2 \text{ circumference}]_{-1,0} = 6.28 \times 10^{-12} \text{ m}/3.789 \times 10^{23} = 1.66 \times 10^{-35} \text{ m}$$

Vibrating string particles correspond to quantum scale atoms. Strings are quantum scale atomic oscillators.

12.5. Mole of solid atoms

A mole of solid atoms, like iron, demonstrates the connection of three adjacent scales.

Let iron's atomic radius = 1.2×10^{-10} m
A 55.8 g iron ball located in scale m = 0 as measured in scale n = 0 fits in the palm of a human hand. It is a good representative sample size in a human scale laboratory.

$[\text{iron sphere, mass}]_{0,0}$	55.8 g = 1 mol
$[\text{iron sphere, density}]_{0,0}$	7800 kg/m^3
$[\text{iron sphere, radius}]_{0,0}$	1.2 cm

One atom of this iron sphere located in scale m = 0, is still a tiny part of the human scale, but is enormous relative to the quantum scale.

$[\text{iron atom, mass}]_{0,-1}$	1.10×10^{32} kg = 55.4 solar masses
$[\text{iron atom, radius}]_{0,-1}$	4.5×10^{13} m = 300 AU

Take each atom of this iron sphere, $6.022\ 1415 \times 10^{23}$ atoms, and place them in a straight line, aligned with each atom touching. Located in scale m = 0, is still a part of the human scale, but is tiny relative to the cosmic scale.

$[\text{iron line, length}]_{0,0}$	1.4×10^{14} m
$[\text{iron line, length}]_{0,1}$	3.8×10^{-10} m

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