Fine-Tuning for Intelligent Life in a Logical World

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The numerical values of many significant physical quantities in the explicitly human SI units are expressed intelligibly in a specific format conceived by an observer for the purpose, disclosing the influence of human cognition on what is perceived. The values of five of the six dimensionless physical constants that Martin Rees identified in *Just Six Numbers* as being especially significant for life are also expressed intelligibly in the same format. It seems the value of the sixth constant, the dimensionality of space, also originated in cognition. In the logical world of our experience, the values of the six especially significant physical constants are necessarily, not accidentally, compatible with human life.

1 Introduction

In his book *Just Six Numbers* [1], Martin Rees identified six dimensionless physical constants whose values seem fine-tuned for life. It is reasoned here that the values of the six numbers originated in human cognition. Logically, the values of the constants have never changed and so have always been compatible with human life in a world in which, as argued by Immanuel Kant in the *Critique of Pure Reason* [2], time is an *a priori* intuition that structures our perceptions.

To cognise an object, that is, to properly know something one observes, it must be understandable by the cogniser. A method has been developed to render understandable in terms of the cogniser's mathematical concept the irrational numerical values of physical constants. If the numerical value, N, of a physical constant (in any units) is mapped to another number, n, by a function, f, of the observer's choice, then n, *if intelligible*, will explain N. The inverse function, f^{-1}, will map the intelligible number n to N, which will consequently be understandable. The number N will have been cognised in the synthesis of an intuition, which is mediated through the senses and relates immediately to the object, and a concept (the mapping function and its inverse) generated in the 'understanding' of the cogniser. As an *object of experience*, the cognised value of N is knowable to all rational beings [2].

To make n intelligible, the numerical values, N, of physical quantities have been mapped to numbers, n, which have then been plotted within an infinitely-divisible discrete graphical framework. This expedient clearly produces rational values of n with any mapping function chosen by the cogniser [3]; the function $f: N \rightarrow \ln(N)/\ln(\pi/2)$ is used here. Significant[1] quantities give rise to integer and low-denomination fractional values of n. Physical quantities of great significance often give rise to values of n that are multiples of 25 [4]. An example of the cognitive process follows.

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[1] Worthy of attention.

Ignoring the measurement uncertainty, the mass of the top quark is equal to 172.56 GeV [5]. In SI units it is equal to 3.076×10^{-25} kg. The number N, of value 3.076×10^{-25}, maps to the number n by application of the function $f\colon N \to \ln(N)/\ln(\pi/2)\ (=n)$. *On the basis of experience*, n is expected to be a rational number of low denomination, probably an integer, and quite possibly a multiple of 25 because of the great significance of the top quark in the mind of the cogniser. On calculation, n is found to be of value -125.0; this value of n maps to N by application of the inverse function, $f^{-1}\colon n \to (\pi/2)^n\ (=N)$. The number N, of value equal to $(\pi/2)^{-125.0}$, will have become an object of experience.

Below, the numerical value of a significant physical quantity in SI units is expressed as a small integer power of either the meaningful number α (the fine structure constant) or $(\pi/2)^{25}$, or the product of small integer powers of each number; that is, the numerical value, v, can be expressed as

$$v = \alpha^p (\pi/2)^{25q} \tag{1}$$

where p and q are small integers, as in [3] and [4]. For example, the up quark mass (2.16 MeV [5]) is equal to $(\pi/2)^{-150.0}$ kg and the radius of the observable universe (46.5 Glyr) is equal to $\alpha^{-1}(\pi/2)^{125.0}$ m.

The particle masses and decay widths used in the calculations are the current evaluations of the Particle Data Group [5]. CODATA 2022 values of the fundamental physical constants have been used [6]. The (*Planck*) cosmological data used are those tabulated in *Astrophysical Constants and Parameters,* in [5].

Any small disparity between the cognised value and the measured value arises from uncertainty in the measurement, changes in the measurement value since first cognition and the necessity that all cognised values are interconnected logically.

2   Selected expressions in SI units

Planck mass ($2.176434(24) \times 10^{-8}$ kg : $\alpha^{-1}(\pi/2)^{-50.0}$ kg (2)

GUT scale (2×10^{16} GeV): $\alpha^{-2}(\pi/2)^{-75.1}$ kg (3)

top quark mass (172.56 ± 0.31 GeV): $(\pi/2)^{-125.0}$ kg (4)

charm quark mass (1.2730 ± 0.0046 GeV): $\alpha(\pi/2)^{-125.0}$ kg (5)

up quark mass (2.16 ± 0.07 MeV): $(\pi/2)^{-150.0}$ kg (6)

electron mass ($9.1093837139(28) \times 10^{-31}$ kg): $\alpha^{-2}(\pi/2)^{-175.0}$ kg (7)

Rydberg constant, R_∞ ($10973731.568157(12)$ m^{-1}): $\alpha^{-1}(\pi/2)^{25.00}$ m^{-1} (8)

distance from earth of Andromeda (765 kpc [7]): $\alpha(\pi/2)^{125.0}$ m (9)

End of Greatness[2] (100 Mpc): $\qquad$ $(\pi/2)^{124.9}$ m $\qquad$ (10)

radius of observable universe (46.5 Glyr): $\qquad$ $\alpha^{-1}(\pi/2)^{125.0}$ m $\qquad$ (11)

W boson mean lifetime (3.08×10^{-25} s from decay width of 2.14 GeV):

$$(\pi/2)^{-125.0} \text{ s} \qquad (12)$$

Higgs boson mean lifetime (1.78×10^{-22} s from decay width of 3.7 MeV):

$$\alpha(\pi/2)^{-100.00} \text{ s} \qquad (13)$$

3   Expressions of the dimensionless numbers in *Just Six Numbers*

N   Rees calculated this number as the magnitude of the electric force divided by the gravitational force between two protons. Here, *N* has been calculated as the magnitude of the electric force divided by the gravitational force between two electrons (4.17×10^{42}), which can be expressed as

$$N = \alpha^3(\pi/2)^{250.00} \qquad (14)$$

ε   The efficiency of fusion from hydrogen to helium, $\varepsilon \approx 0.007$, can be expressed in terms of the cognitive scheme as

$$\varepsilon = \alpha \qquad (15)$$

which is of value 0.0073.

Ω   Rees used the symbol Ω, of value ~0.3, for the ratio of the density of matter in the universe to the critical density above which the expansion of the universe will eventually cease. The critical density ($1.87834(4) \times 10^{-29} \ h^2 . \text{g} . \text{cm}^{-3}$) is equal to 8.53×10^{-27} kg. m^{-3} with the scaling factor for the Hubble expansion rate, *h*, equal to 0.674(5) from CMB anisotropies (*Planck*); that is,

$$\rho_{\text{crit,CMB}} = \alpha^3(\pi/2)^{-100.24} \text{ kg. m}^{-3} \qquad (16)$$

With $h = 0.730(10)$ from the extragalactic distance ladder [8], the value of the critical density is equal to 1.00×10^{-26} kg. m^{-3}, which can be expressed as

$$\rho_{\text{crit,DL}} = \alpha^3(\pi/2)^{-99.89} \text{ kg. m}^{-3} \qquad (17)$$

The values of the two significant quantities, $\rho_{\text{crit,CMB}}$ and $\rho_{\text{crit,DL}}$ lie either side of $\alpha^3(\pi/2)^{-100}$ kg. m^{-3}. Such an arrangement is typical of closely associated significant values, e.g., see [3].

With *h* equal to 0.674 (from CMB anisotropies) the total mass plus energy of a critically dense observable universe of radius 46.5 Glyr is equal to 3.04×10^{54} kg. With the matter density parameter, Ω_{m} (Rees's Ω), equal to 0.315(7), the matter content of the observable

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[2] The End of Greatness refers to the observational scale beyond which the universe appears isotropic.

universe, M_{OU}, is 0.96×10^{54} kg, and with the dark energy density parameter, Ω_Λ, equal to $0.685(7)$, the dark energy content of the observable universe, E_{OU}, is 2.08×10^{54} kg. The values of M_{OU} and E_{OU} can be expressed as

$$M_{OU} = (\pi/2)^{275.25} \text{ kg} \tag{18}$$

$$E_{OU} = e^{125.07} \text{ kg} \tag{19}$$

Powers of e are always calculated in tandem with powers of π and $\pi/2$, and have featured elsewhere in this project, e.g., in [9].

From (18) and (19), and since $\Omega_m + \Omega_\Lambda = 1$,

$$\Omega_m \approx \frac{(\pi/2)^{275}}{(\pi/2)^{275} + e^{125}} \tag{20}$$

which is of value 0.307.

The dark matter content of the observable universe, $M_{OU,dark}$, is equal to 26.5% of the total mass plus energy content, that is, it is of value 0.81×10^{54} kg. The light matter content, $M_{OU,light}$, is equal to 4.93% of the total mass plus energy content, that is, it is of value 0.15×10^{54} kg. The values of the two significant quantities, $M_{OU,dark}$ and $M_{OU,light}$, lie either side of α^{-25} kg in the arrangement of closely associated significant values, that is,

$$M_{OU,dark} = \alpha^{-25.23} \text{ kg} \tag{21}$$

$$M_{OU,light} = \alpha^{-24.89} \text{ kg} \tag{22}$$

The cosmic microwave background radiation density of the universe, $\Omega_\gamma = \rho_\gamma/\rho_{crit}$, of value $5.38(15) \times 10^{-5}$, can be expressed in terms of the cognitive scheme as

$$\Omega_\gamma = \alpha^{2.00} \tag{23}$$

λ Rees used the symbol λ for the dark energy density parameter (Ω_Λ), now measured at $0.685(7)$. Since $\Omega_m + \Omega_\Lambda = 1$,

$$\Omega_\Lambda \approx \frac{e^{125}}{(\pi/2)^{275} + e^{125}} \tag{24}$$

which is equal to 0.693.

The energy density of dark energy, ρ_Λ, of value $5.83(16) \times 10^{-30}$ g. cm^{-3}, was first cognised in Planck units [10]. The above (*Planck*) value of ρ_Λ corresponds to $1.13(3) \times 10^{-123} E_P l_P^{-3}$ and can be expressed as follows:

$$\rho_\Lambda = \frac{1}{2} \times \left(\frac{\pi}{2}\right)^{-625} E_P l_P^{-3} \tag{25}$$

where the factor ½ reflects the cogniser's thoughts on zero-point energy, and the power of $\pi/2$ reflects the great significance of dark energy.

Q   The amplitude, $Q \sim 10^{-5}$, of cosmic microwave background density fluctuations tells us how the structure of the universe – a universe conducive to life – is organised. The value of Q can be expressed as

$$Q = (\pi/2)^{-25} \tag{26}$$

which is of value 1.25×10^{-5}.

D   For Kant, space and time are the *a priori* human intuitions that structure our perceptions. On the basis of the results presented here, one imagines the *dimensionality* (D) of space was *produced* in the synthesis of sensible intuition and concept. If, as Kant said, all knowledge begins with experience, the act of cognition may have occurred when someone who knew from experience that two independent coordinates will specify the location relative to a point of any other point on a plane conceived a way to specify the location relative to a point of any other point in space, and then counted the required number of independent coordinates (3) by referring to objects of experience. Logically, then, in our experience space has always been three dimensional.

4   Discussion

A number (as descriptive of some quantity) cognised in the synthesis of sensible intuition (on observation) and concept becomes an object of experience, knowable to all. The formulation of the concept used here is so specific as to make it plain the numerical values of the quantities considered here have arisen in the cognitive process described.

A self-consistent *system of knowledge* has been produced in cognition. The newly cognised numerical value of some quantity is necessarily consistent with all the previously cognised numerical values of quantities, whatever units are used. To produce a more satisfying system, there has been an attempt of late to concentrate cognition on quantities in SI units.

The *Prolegomena to Any Future Metaphysics That Will Be Able to Come Forward as Science* [11], was written by Kant to provide an accessible introduction to and summary of the key ideas in the *Critique of Pure Reason*.

5   Conclusion

The values of the six especially significant dimensionless physical constants identified by Martin Rees in *Just Six Numbers* as seemingly fine-tuned for life have been shown to be expressible in terms of the concept used in the cognitive process described here, indicating that they have arisen in this cognition.

Logically, the values of the constants have never changed and so have always been compatible with our existence in a world in which time is an *a priori* human intuition that structures our perceptions.

References

1. M. J. Rees, *Just Six Numbers*, Basic Books (2000)
2. I. Kant, *Critique of Pure Reason* (1781 & 1787), translated and edited by P. Guyer and A. W. Wood, Cambridge University Press (1998)
3. B. F. Riley, *How the Observer Creates Reality*, viXra:2205.0139 (2022)
4. B. F. Riley, *A Kantian System of Knowledge in SI Units*, viXra:2506.0091 (2025)
5. S. Navas et al. (Particle Data Group), The Review of Particle Physics (2024), Phys. Rev. D 110, 030001 (2024) and 2025 update
6. CODATA Internationally recommended 2022 values of the Fundamental Physical Constants; physics/nist.gov/constants
7. A. G. Riess, J. Fliri and D. Valls-Gabaud, *Cepheid Period-Luminosity Relations in the Near-Infrared and the Distance to M31 from the Hubble Space Telescope Wide Field Camera 3*, The Astrophysical Journal **745** (2): 156 (2012)
8. A. G. Riess et al, The Astrophysical Journal **730**, 119 (2011)
9. B. F. Riley, *The Act of Measurement I: Astronomical Distances*, viXra:2006.0247 (2020)
10. B. F. Riley, *The Cosmological Constant From $AdS_5 \times S^5$*, viXra:1307.0107 (2013)
11. I. Kant, *Prolegomena To Any Future Metaphysics That Will Be Able to Come Forward as Science* (1783), Translated by J. W. Ellington – 2nd ed., Hackett Publishing Company (2001)