Judging the Values of Paired Physical Quantities

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The values of pairs of related physical quantities are shown to arise in the judgement of one person, the first cogniser, in the union of observation and concept. An expression of each value is observed and, using an original method, its numerical value is mapped, by a mathematical function deemed appropriate, to an explanatory rational number that both indicates the significance of the physical quantity and establishes its value. If the physical quantity is considered to be significant the explanatory number will take a rational value of low denomination. If the quantity is considered to be of great significance the explanatory number will take a special integer or half-integer value. Having been explained with sound judgement, the value of the physical quantity is what anyone will experience on observation. By the use of two mapping functions, the numerical values of significant quantities deemed to be paired are mapped to closely coincident special integers or half-integers. Mathematical relationships established between the values of quantities reflect the thinking of the observer. Fundamental particle and atomic quantities are judged in Planck units. Astronomical and cosmological quantities are judged in SI units.

1 Introduction

Observation is necessary for the acquisition of knowledge that is new to human beings, but the observation of an object tells one nothing of substance without some concept of what it is that is being observed. That concept comes from the mind of an observer, the *first cogniser*, and is grounded in experience. In what follows, the value of a physical quantity, a denominate numerical object (a number with a unit), is shown to arise in the judgement of the first cogniser, in the union of an observation of an expression of the value and a concept that says the significance of the quantity is reflected in its numerical value, e.g. see [1] and [2].

The method is outlined by which the numerical value of a quantity is mapped to a rational number that indicates the significance of the quantity in the view of the first cogniser, and establishes its value in the phenomenal world. The numerical values of quantities are judged here in pairs, as powers of α, the fine structure constant (1/137.036) and e, the base of natural logarithms (2.718). Fundamental particle and atomic quantities are judged in the Planck units deemed appropriate by the first cogniser. Astronomical and cosmological quantities are judged in the SI units deemed appropriate.

The method of judgement is described in section 2. The judgements are then presented, along with the thinking behind them, in section 3. A discussion follows in section 4 and some conclusions are drawn in section 5.

The particle data used are the current (as of November 2026) evaluations of the Particle Data Group [3]. Referenced astronomical data are from the NSSDCA Planetary Fact Sheets [4]. The values of cosmological quantities have been calculated from data in the review of Astrophysical Constants and Parameters by the Particle Data Group [5]. Current (2022) CODATA recommended values of the fundamental physical constants have been used [6]. Central values are used in all calculations.

2 Method of Judgement

Two logarithmic functions are used to map the numerical value of each member of a pair of physical quantities to the exponents, n_1 and n_2, of the bases α and e, respectively. The two points (n_1, n_2) – one point for each quantity – are plotted within a notionally infinitely divisible two-dimensional array of rational numbers. The numerical value of each quantity is then established, in the understanding of the first cogniser, by the values, separately, of two rational powers, α^{n_1} and e^{n_2}. Rational powers are deemed to indicate sound judgement. The significance of one of the two physical quantities is judged to be reflected in the denomination of the rational exponent, n_1, of the base α. The significance of the other physical quantity is judged to be reflected in the denomination of the rational exponent, n_2, of the base e. Integers and low-denomination fractions imply particular significance. Explained in terms of a mathematical concept by the value of a rational power, the value of each physical quantity is objectively valid. There is no reason to believe the value so cognised is not also universally valid.

An example judgement (of a single quantity) is that of the Bohr radius (5.292×10^{-11} m) in Planck units. Hypothesising the numerical value of the quantity is equal to a rational power of $\pi/2$, the first cogniser used a logarithmic function to map the numerical value to the (rational) exponent of the base $\pi/2$. The Bohr radius was then found, in judgement, to be $\sim(\pi/2)^{125}$ Planck lengths (actually, $(\pi/2)^{125.00}$ Planck lengths) [7]. The number 125 is a *special integer*[1], which implies the Bohr radius was judged to have great significance. How a physical constant has been given its value many years after it was first known with that value is explained in section 4.

The method of judgement outlined above originated in work first described in [8], which was motivated in part by the Randall and Sundrum RS1 model [9]. It was only when the current distances between astronomical objects were judged to take special values that evidence of human influence was found in the value of a physical quantity [10].

[1] Here, special integers are multiples of 5 and, in most cases, of 25.

3 The Judgements

3.1 The masses of the light quarks

Expressed in Planck units, the closely related and particularly significant up quark mass (2.16 MeV) and down quark mass (4.70 MeV) have been judged with numerical values equal to closely-coincident special integer powers of α and e, as shown in Figure 1, i.e., $m_{\mathrm{up}} \sim \mathrm{e}^{-50}\, m_{\mathrm{Planck}}$ and $m_{\mathrm{down}} \sim \alpha^{10}\, m_{\mathrm{Planck}}$ (actually, $\mathrm{m_{up}} = \mathrm{e}^{-50.1}\ \mathrm{m_{Planck}}$ and $\mathrm{m_{down}} = \alpha^{10.0}\ \mathrm{m_{Planck}}$) [11, 12].

The mass of the lightest quark (up) has also been judged to be $\sim\alpha(\pi/2)^{-100}\ \mathrm{m_{Planck}}$ (actually, $\alpha(\pi/2)^{-100.0}\ m_{\mathrm{Planck}}$) and $\sim(\pi/2)^{-150}$ kg (actually, $(\pi/2)^{-150.0}$ kg).

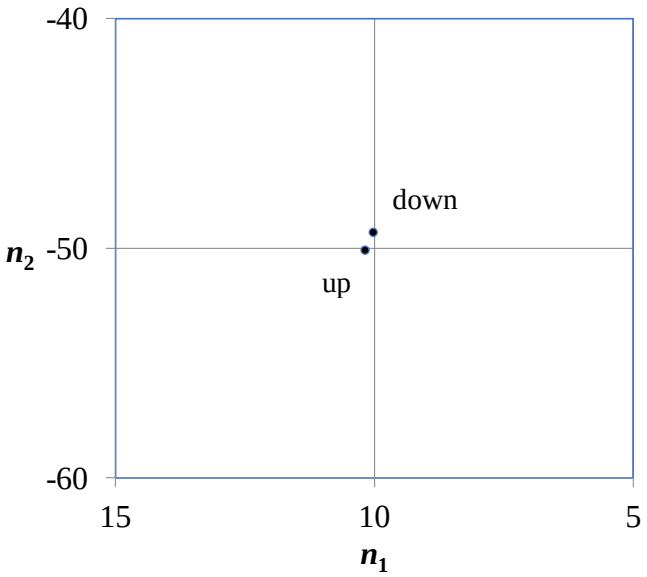


Figure 1: Values of n_1 and n_2 for the up and down quark masses, where each quantity is equal to both $\alpha^{n_1} m_{\mathrm{Planck}}$ and $\mathrm{e}^{n_2} m_{\mathrm{Planck}}$.

The series of judgements below was produced after Figure 1 was constructed and a review was made of [13], in which the ratios of various astronomical and cosmological quantities were shown to be equal to integer and half-integer powers of α^5. In what follows, the numerical value of each judgement is shown to be equal to an integer or half-integer power of either α^{25} or e^{125}.

3.2 Two atomic energy units

The Rydberg energy[2], Ry (13.606 eV), and Hartree energy[3], E_h (27.211 eV) when expressed in Planck units have each been judged with a numerical value equal to an integer power of either α or e, as shown in Figure 2. Because the two quantities are closely related and deemed significant, their numerical values have been judged equal to closely coincident special half-integer powers of α and e, i.e., $Ry \sim \mathrm{e}^{-125/2}\, E_\mathrm{Planck}$ and $E_\mathrm{h} \sim \alpha^{25/2}\, E_\mathrm{Planck}$ (actually, $Ry = \mathrm{e}^{-62.1}\, E_\mathrm{Planck}$ and $E_\mathrm{h} = \alpha^{12.5}\, E_\mathrm{Planck}$).

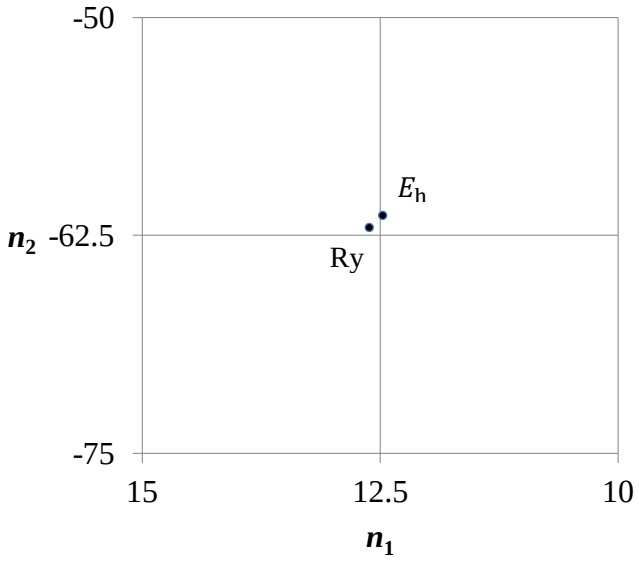


Figure 2: Values of n_1 and n_2 for the Hartree energy, E_h, and the Rydberg energy, Ry, where each quantity is equal to both $\alpha^{n_1} E_\mathrm{Planck}$ and $\mathrm{e}^{n_2} E_\mathrm{Planck}$.

[2] $Ry \sim$ ionisation energy of the ground state hydrogen atom.
[3] $E_\mathrm{h} \sim$ magnitude of the potential energy of the electron in the ground state hydrogen atom ($\approx 2\, Ry$)

3.3 The masses of Jupiter and Saturn

The masses of Jupiter (1.898×10^{27} kg) and Saturn (5.683×10^{26} kg), when expressed in SI units have been judged with numerical values equal to powers of α and e, as shown in Figure 3. Because the two quantities are deemed closely related and significant, their numerical values have been judged to be equal to closely coincident special half-integer powers of α and e, i.e., $M_{\text{Jupiter}} \sim \text{e}^{125/2}$ kg (actually, $\text{e}^{62.8}$ kg) and $M_{\text{Saturn}} \sim \alpha^{-25/2}$ kg (actually, $\alpha^{-12.5}$ kg).

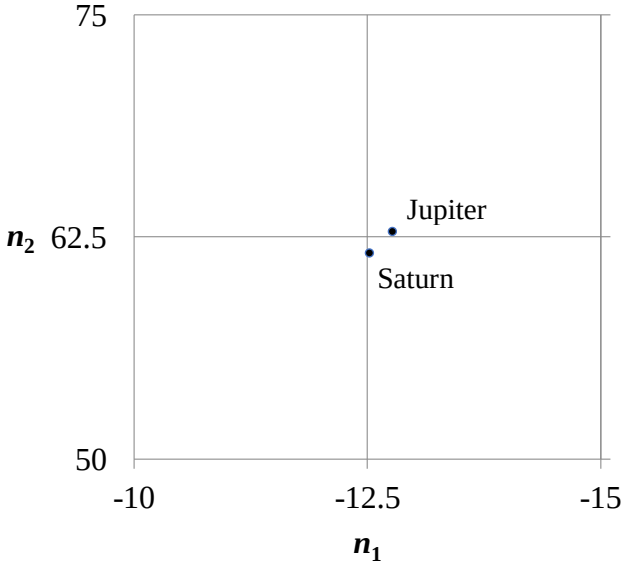


Figure 3: The numerical values of Jupiter's mass and Saturn's mass expressed in kilograms, as the powers α^{n_1} and e^{n_2}.

3.4 Parameters of the Sun

Although the *mass* of the Sun (1.988×10^{30} kg) is $\sim \text{e}^{70}$ kg (actually, $\text{e}^{69.8}$ kg), it is the volume of the Sun (1.412×10^{27} m^3) expressed in cubic metres and the luminosity of the star (3.828×10^{26} W) that have been (newly) judged to take closely-coincident special numerical values, as shown in Figure 4. Note that $V_{\text{Sun}} \sim \text{e}^{125/2}$ m^3 (actually, $\text{e}^{62.5}$ m^3) and $L_{\text{Sun}} \sim \alpha^{-25/2}$ W (actually, $\alpha^{-12.4}$ W). This surprising result – one might have expected the surface area and luminosity of the sun to be related within the scheme used here – reflects the fact that the luminosity of the sun had previously been judged in terms of the radius and surface temperature of the star, i.e., $L_\odot \sim 2{R_\odot}^2{T_\odot}^4$ in Planck units [14].

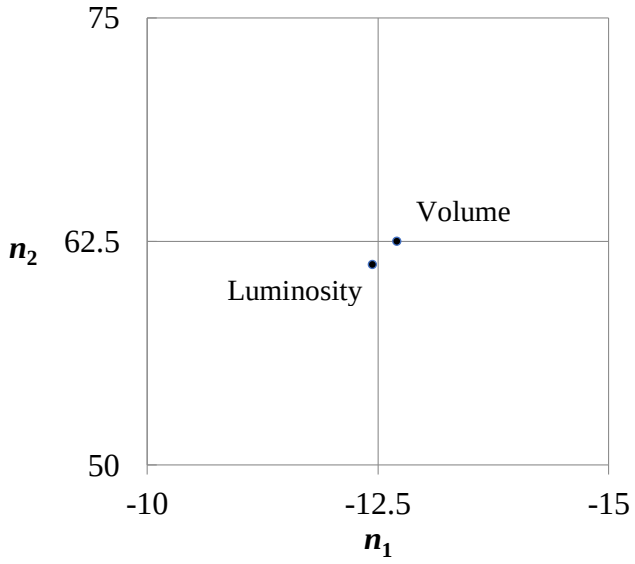


Figure 4: The numerical values of the Sun's volume expressed in cubic metres and luminosity expressed in watts, as the powers α^{n_1} and e^{n_2}.

3.5 Cosmological parameters

The radius of the observable universe, R_{OU}, of value 46.5 Glyr, has been judged to be $\sim \alpha^{-25/2}$ m (actually, $R_{\mathrm{OU}} = \alpha^{-12.5}$ m), as shown in Figure 5. Although the radius of the Hubble sphere (14.4 Glyr) has been judged to be $\sim e^{60}$ m (actually, $e^{60.2}$ m), this value is not in line with the special values in the series of judgements here. Rather, it is the surface area of the Hubble sphere that has been judged to take a special value, as shown below.

The light matter content of the (critically dense) observable universe ($\sim 1.5 \times 10^{53}$ kg) has been judged to be $\sim \alpha^{-25}$ kg (actually, $\alpha^{-24.9}$ kg), and the dark energy content[4] ($\sim 2.1 \times 10^{54}$ kg) had previously been judged to be $\sim e^{125}$ kg (actually, $e^{125.1}$ kg) [15]. The numerical values of the radius, dark energy content and light matter content of the observable universe are shown as powers of α and e in Figure 5. Incidentally, the dark matter content ($\sim 8.1 \times 10^{53}$ kg) had previously been judged to be $\sim (\pi/2)^{275}$ kg (actually, $(\pi/2)^{274.9}$ kg) [15].

[4] The density of dark energy is expressed in units of g cm^{-3} [5].

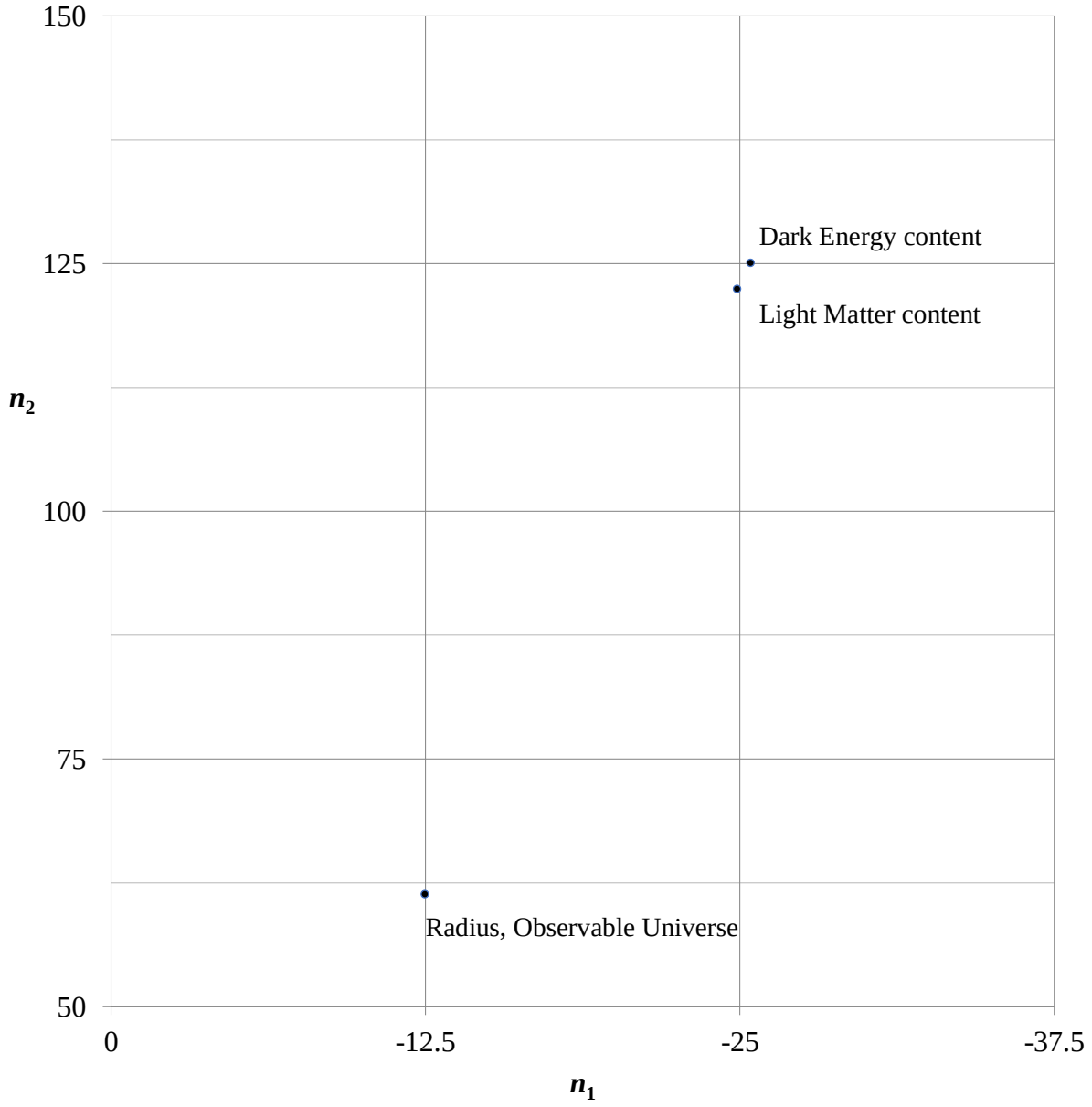


Figure 5: The numerical values of the radius of the observable universe expressed in metres, the light matter content of the observable universe expressed in kilograms and the dark energy content of the observable universe expressed in kilograms, shown as the powers α^{n_1} and e^{n_2}.

Noting that $R_{\mathrm{OU}} \sim \alpha^{-25/2}$ m and the dark energy content of the observable universe ($\sim e^{125}$ kg) is of the order of, but somewhat greater than, α^{-25} kg, and with thoughts of the holographic principle in mind, the cogniser calculated the surface area of the observable universe to be $\sim e^{125}$ m^2 (actually, $e^{125.2}$ m^2), as shown in Figure 6. One can see the numerical values of the dark energy content expressed in kg and the surface area of the observable universe expressed in square metres have been judged equal in numerical value. This judgement reflects the thinking of the observer: the entropy

associated with the dark energy causing the expansion of the universe to accelerate is encoded on the surface of the observable universe, in a manifestation of the holographic principle.

On the basis of the above finding, the surface area of the Hubble sphere[5] (radius 14.4 Glyr) has been judged to be $\sim \alpha^{-25}\ \mathrm{m}^2$ (actually, $\alpha^{-25.0}\ \mathrm{m}^2$), as shown in Figure 6. This judgement reflects the thinking of the observer, that it is the smaller surface area of the Hubble sphere that is paired with the surface area of the observable universe.

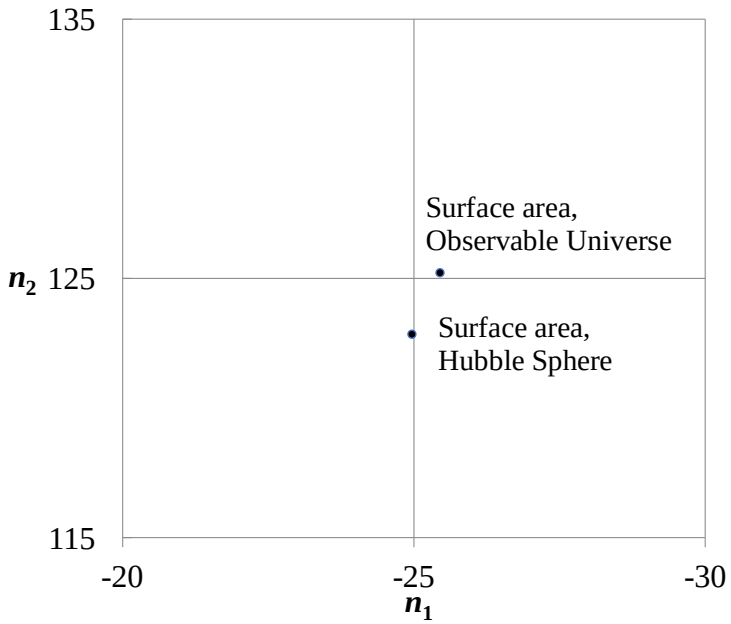


Figure 6: The numerical values of the surface areas of the Hubble sphere ($2.37 \times 10^{53}\ \mathrm{m}^2$) and the observable universe ($2.43 \times 10^{54}\ \mathrm{m}^2$) expressed in square metres are shown as the powers α^{n_1} and e^{n_2}.

4 Discussion

Knowledge of the value of a physical quantity is acquired in the union of an observation of the *appearance* of an expression of the value and a mathematical concept deemed to explain the value. In the present investigation, the concept is framed in such a way that the value of the quantity is explained in terms of the concept by the value of a single rational number.

In the series of paired judgements shown here, the numerical value of one member of a pair of quantities is judged equal to a special rational power of α, while the numerical value of the other member is judged equal to a special rational power of e. These judgements build on those made on the subatomic and cosmic parameters that were reviewed immediately beforehand. As always, one's judgements are grounded in experience.

[5] A spherical region of space centred on an observer, beyond which objects recede faster than the speed of light as the universe expands.

When a judgement is made of the value of a physical quantity (by the first cogniser), it holds for all observers because the judgement is sound: the value of the quantity is explained, in terms of a mathematical concept known from experience to be applicable in such circumstances, by a rational number, whose value reflects the significance of the physical quantity. So cognised, the value is consistent with all other values in a self-consistent system of values, the Mathematical World, which underlies the phenomenal world [2]. The value of a physical quantity established today in judgement is the value it takes today. In this logical world, though, the value of a physical *constant* established today in judgement – some have been considered here – will be equal to the value it has been universally known to take in the past. One's judgements apply to the values of all quantities, regardless of the period the value relates to. There is a compelling evidence to support this statement, e.g., see [16].

5 Conclusions

1. The value of a physical quantity arises in the judgement of the first cogniser, in the union of observation and concept. The cognised value is objectively and universally valid.
2. In the series of judgements described here, the members of pairs of related quantities take closely coincident special values that reflect the thinking of the first cogniser: the numerical value of one member is equal to an integer or half-integer power of α^{-25}, while the numerical value of the other member is equal to an integer or half-integer power of e^{125}.
3. The value of a physical constant established in judgement today is equal to the value it was universally known to take in the past.
4. A self-consistent Mathematical World underlies the phenomenal world, and is governed by logic.

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