The Mass of the Higgs Boson

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The Bohr radius is equal to the Planck length multiplied by the 125th power of π/2. The reduced Compton wavelength of the Higgs boson is equal to the Bohr radius divided by the 25th power of 2, meaning the Higgs boson is of mass 125.1224±0.0014 GeV; the Particle Data Group's 2019 evaluation is 125.10±0.14 GeV. The total mass/energy (Planck cosmological parameters 2018) of the observable universe is equal to the Planck mass multiplied by the 125th power of π. In Planck units, the total mass/energy of the observable universe is equal numerically to the Bohr radius multiplied by the 125th power of 2 and also to the reduced Compton wavelength of the Higgs boson multiplied by the 150th power of 2. The spin angular momentum of the mid-Main Sequence sun is equal to the 250th power of 2 in units of ħ. These and other equalities arise in an analysis of the Quantum/Classical connection. The new results suggest an explanation for the accelerating expansion of space.

The mass/energy density of space is scaled down from Planck scale by a factor of ~$2(a_0/l_\mathrm{P})^5$ [1] and equivalently ~$(R_\mathrm{OU}/l_\mathrm{P})^2$ [2], where a_0 is the Bohr radius, R_OU is the radius of the observable universe and l_P is the Planck length. Generalising the relationship between a_0 and R_OU, the 'Quantum/Classical connection' is written, using Planck units, as

$$2{r_\mathrm{Q}}^5 = {R_\mathrm{C}}^2 \qquad (1)$$

Specific 'quantum' length (radius) scales r_Q map onto specific 'classical' length (radius) scales R_C by way of the connection. The mapping is bidirectional: quantum and classical scales are in one-to-one correspondence.

Planck units (ħ = c = G = 1) are used throughout the paper which explains the apparently unbalanced equations. Note that 'quantum' mass scales m_Q are smaller than the Planck mass while cosmological and astrophysical mass scales M_C are greater than the Planck mass. All length scales, r_Q and R_C, are greater than the Planck length. The values of Planck length, Planck mass and Bohr radius used in the calculations are 2018 CODATA recommended values. Planck cosmological parameters 2018 are also used: $H_0 = 67.4\pm0.5$ km.s^{-1}.Mpc^{-1} (Hubble length 14.5 x 10^9 light years) and $\Omega_\mathrm{m} = 0.315\pm0.007$ [3].

From (1), with r_Q equal to the Bohr radius a_0, we find that $R_\mathrm{C} = 14.37$ x 10^9 Gpc. Since the radius of the observable universe $R_\mathrm{OU} \approx 14.3$ Gpc [4],

$$R_\mathrm{OU} \approx 2^{1/2}{a_0}^{5/2} \qquad (2)$$

using Planck units and since $a_0 = (\pi/2)^{125.0005}\, l_\mathrm{P}$, we can write

$$a_0 \approx (\pi/2)^{125} \qquad (3)$$

and therefore

$$R_{\mathrm{OU}} \approx 2^{1/2}(\pi/2)^{625/2} \tag{4}$$

The total mass/energy of the observable universe, E_{OU}, is of value 3.06±0.05 x 10^{54} kg (mass equivalent). In Planck units, $E_{\mathrm{OU}} = \pi^{125.01\pm0.01}$, so we write

$$E_{\mathrm{OU}} \approx \pi^{125} \tag{5}$$

which is equal to 3.03 x 10^{54} kg. Equations (4) and (5) inform us that the observable universe, being now of constant radius and constant mass/energy, is of constant mass/energy density. As space expands and matter passes beyond the particle horizon, sufficient vacuum energy is created to maintain constant mass/energy density. The energy density of space increases as the matter density decreases and accelerating expansion results.

From (3) and (5),

$$E_{\mathrm{OU}}/a_0 \approx 2^{125} \tag{6}$$

Integer powers of 2 have featured previously in our work [5]. The spin angular momenta J_* of nearby GKM Main Sequence stars with confidently-measured radius, mass and rotation period equal 2^N ħ, where *N* is an integer close to 250. The spin angular momentum J_{Sun} of the sun is equal to 1.93±0.03 x 10^{41} kg.m^2.s^{-1}, which equals $2^{250.02\pm0.02}$ ħ. That is

$$J_{\mathrm{Sun}} \approx 2^{250}\ \hbar \tag{7}$$

The geometric-mean spin angular momentum J_{AC} of Alpha Centauri A and B is equal to $2^{250.0\pm0.4}$ ħ. That is

$$J_{\mathrm{AC}} \approx 2^{250}\ \hbar \tag{8}$$

The geometric-mean orbital angular momentum $L_{\mathrm{P,GM}}$ of the eight planets of the solar system equals $2^{249.9\pm0.1}$ ħ. That is

$$L_{\mathrm{P,GM}} \approx 2^{250}\ \hbar \tag{9}$$

By way of the Quantum/Classical connection, in the form

$$2{m_{\mathrm{Q}}}^{-5} = {R_{\mathrm{C}}}^{2} \tag{10}$$

we have found that the radius of a mid-Main Sequence star maps onto the mass of a stable Period 4 transition metal nuclide [6]. For example, the radius of the sun, 6.957 x 10^8 m [7], maps onto a mass of 52.98 u. This mass is close to the mass, 52.94 u, of the stable nuclide ^{53}Cr. By way of the Quantum/Classical connection in the form

$$2{r_Q}^5 = (a_0 M_c)^2 \quad (11)$$

the mass of the sun maps onto a radius of 138 pm [6]. The empirical atomic radius of chromium is ≈140 pm [8]. We see that by way of the Quantum/Classical connection the radius and mass of the sun map onto the mass and atomic radius, respectively, of ^{53}Cr. In Planck units, the atomic radius and mass of ^{53}Cr are related by the equation $r_{53} = 2^{25.0}/m_{53}$. In general, the atomic radius and mass of a stable Period 4 transition metal nuclide are related by

$$r_{\mathrm{P4}} \sim 2^{25}/m_{\mathrm{P4}} \quad (12)$$

The atomic radius, r_{P4},of the Period 4 transition metal nuclide is approximately equal to the reduced Compton wavelength, $1/m_{\mathrm{P4}}$, of the nucleus multiplied by 2^{25}. Motivated by the presence in (12) of a 25th power, which is a common feature of the overarching model [9], we calculated the mass m_{X} in the equation $m_{\mathrm{X}} = 2^{25}/a_0$, the Bohr radius a_0 being known with high precision. We found that m_{X} =125.1224±0.0014 GeV, which is consistent with the mass 125.10±0.14 GeV [10] of the Higgs boson, and we can write

$$m_{\mathrm{Higgs}} = 2^{25}/a_0 \quad (13)$$

From (13), the Bohr radius is equal to the reduced Compton wavelength ($1/m_{\mathrm{Higgs}} = 1.58 \times 10^{-18}$ m) of the Higgs boson multiplied by 2^{25}. Since $a_0 = 1/\alpha m_{\mathrm{electron}}$, the Bohr radius is also equal to the reduced Compton wavelength of the electron ($1/m_{\mathrm{electron}}$) divided by α. It follows that

$$m_{\mathrm{Higgs}}/m_{\mathrm{electron}} \approx 2^{25}\alpha \quad (14)$$

and since $a_0 \approx (\pi/2)^{125}$ in Planck units, it follows that

$$m_{\mathrm{Higgs}} \approx 2^{25}(\pi/2)^{-125} \quad (15)$$

$$m_{\mathrm{electron}} \approx \alpha^{-1}(\pi/2)^{-125} \quad (16)$$

From (5) and (15), one may write down an equation for the total mass/energy of the observable universe in terms of the mass of the Higgs boson:

$$E_{\mathrm{OU}} \approx 2^{150}/m_{\mathrm{Higgs}} \quad (17)$$

The mass of the Higgs boson maps by way of (10) onto a ‘classical’ length scale (radius) of 6.80 x 10^7 m (= 0.098 R_{Sun}), which is close to the volumetric mean radius, 6.99 x 10^7 m [7], of Jupiter and is the radius of a small red dwarf [11], the smallest and least massive of hydrogen-fusing stars. The

Bohr radius (= 52.9 pm) maps by way of (11) onto a 'classical' mass scale of 1.82 x 10^{29} kg (= 0.092 M_{Sun}), which is the mass of a small red dwarf. With $R_{\mathrm{RD}} = 0.098\, R_{\mathrm{Sun}}$ and $M_{\mathrm{RD}} = 0.092\, M_{\mathrm{Sun}}$, we find that, in Planck units, $R_{\mathrm{RD}}/2M_{\mathrm{RD}} = \alpha^{-2.50}$. That is

$$R_{\mathrm{RD}}/2M_{\mathrm{RD}} = \alpha^{-5/2} \tag{18}$$

The quantity $R_*/2M_*$ compares the radius R_* of a star to its Schwarzschild radius, $R_{\mathrm{S},*} = 2M_*$. We have shown in [12] that for the nearest six G and K-type mid-Main Sequence stars, all with confidently-measured radius in the range 0.7 – 1.25 R_{Sun} and mass in the range 0.75 – 1.1 M_{Sun}, $R_*/2M_* \approx \alpha^{-5/2}$. Many cosmological and astrophysical scales are related through multiplication by integer powers of $\alpha^{-5/2}$. Evidently, the relationship between the Higgs boson and the red dwarf is of a similar nature to the relationship between the Period 4 transition metal nuclide and the mid-Main Sequence star. The mass of the red dwarf maps onto the Bohr radius, a_0, which from (13) equals $2^{25}/m_{\mathrm{Higgs}}$, and the mass of a mid-Main Sequence star maps onto the atomic radius of a stable Period 4 transition metal nuclide, r_{P4}, which from (12) is $\sim 2^{25}/m_{\mathrm{P4}}$. Each of the G and K-type mid-Main Sequence stars is the 'classical' counterpart of a stable Period 4 transition metal nuclide. The red dwarf, specifically a red dwarf of radius 0.098 R_{Sun} and mass 0.092 M_{Sun}, is the 'classical' counterpart of the Higgs boson.

References

1. B. F. Riley, 'The cosmological constant from AdS_5 x S^5', viXra:1307.0107
2. B. F. Riley, 'The cosmological constant from a distant boundary', viXra:1502.0017
3. Planck Collaboration, 'Planck 2018 results. VI. Cosmological parameters', arXiv:1807.06209v1
4. J. R. Gott III et al, 'A map of the universe', arXiv:astro-ph/0310571; Astrophys. J. 624:463, 2005
5. B. F. Riley, 'The quantised angular momenta of astronomical bodies', viXra:1811.0232
6. B. F. Riley, 'The Quantum/Classical connection', viXra:1809.0329
7. NASA Space Science Data Coordinated Archive; https://nssdc.gsfc.nasa.gov/planetary/planetfact.html
8. J.C. Slater, J Chem Phys, 1964, 41(10), 3199-3205. DOI:10.1063/1.1725697
9. B. F. Riley, 'The Planck Model', viXra:1311.0053
10. M. Tanabashi et al (Particle Data Group), Phys. Rev. D 98, 030001 (2018) and 2019 update
11. L. Kaltenegger and W. A. Traub, 'Transits of earth-like planets', arXiv:0903.3371v2, Astrophys. J. 698: 519-527, 2009
12. B. F. Riley, 'The length and mass scales of cosmology and astrophysics from quantum scales', viXra:1909.0065