On the Proton Radius Puzzle: A Proton Radius of 0.8403 fm Would Fit Perfectly Dirac/Eddington's Large Number Hypothesis

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Abstract

In recent years there has been a lot of guesswork about the size of the proton radius. It was triggered in 2010 by the measurements at the Swiss Paul Scherrer Institute, which measured approx. 0.84 femtometers, a radius value that is around 4 percent smaller than the independent measurements previously made. But in the meantime, this smaller value has been confirmed by several other independent measurements and is now considered the more accepted value[2].

We are sure that the value of 0.84 femtometers will soon be rid of any last doubts.

Because in our previous work[1] we have set out that gravity results from the electromagnetic interaction, since in a finite-time universe there can be no frequencies smaller than the reciprocal of the universe age T_u and accordingly all energy values in the universe must be an integer multiple of h / (2pi*T_u). Thus all electromagnetic energy amounts must be rounded down by half of this value on average. We will show that for a proton radius of 0.84 femtometers, that energy value rounding is exactly in the same ratio as the gravitational force between proton and electron. So we will derive a simple equation for the proton radius from other fundamental constants. And we will show that the ratio between the Hubble radius (radius of observable universe) and the proton radius is obviously a constant that gives the appearance of being invariant in time.

Nothing in our universe is infinitely accurate

All established models in fundamental physics, including Einstein's General Relativity, assume that energy values in our universe can in principle become infinitely accurate.

The quantum mechanics itself says that energies can be exchanged only in discrete form (E=n*hf). But the range of values of these energies is regarded as continuous, because quantum mechanics is currently not interested in whether there can be frequencies f at all, which are infinitely close to 0.

However, a simple consideration of the Heisenberg energy-time uncertainty relation is enough to realize that in a universe that is not infinitely old, infinite energy precision is not possible.

Because of this relation and the obvious assumption that no particle can have a longer lifespan than the universe, we can specify a minimum possible energy uncertainty with

$$\Delta E_{min} >= \frac{h}{4\pi \cdot T_u} \qquad (1)$$

h: Planck's constant = 6.626*10^-34 J*s

T_u: age of the universe ≈ 13.8 billion years ≈ 4.35495*10^17s

(The value T_u = 13.8 Gyr was confirmed very precisely by evaluating the data from the Planck telescope several times.)

As we have shown in our previous work[1], this universal energy uncertainty relation also follows from the consideration that in our finite-time universe there can be no frequencies smaller than the reciprocal of the universe age T_u and accordingly all energy values in the universe must be an integer multiple of h / (2pi*T_u). Because of this and because of the consideration of the speed of light as the maximum speed of transmission, all electromagnetic energy amounts must be rounded down on the average to half of this value. This way of looking at it also leads us to the same equation in (1).

Now let's take a closer look at the proton. What electromagnetic energy is in the proton? No matter which substructure the proton has, we can consider quite classically that the proton is a spherical charge whose energy depends on the elementary charge and its expansion, the proton radius:

$$E_p = \frac{e^2}{4\pi \cdot \epsilon_0 \cdot r_p} \qquad (2)$$

e: elementary charge = 1,6*10^-19 C

ϵ_0: vacuum permittivity = 8.854*10^-11 F/m

Now we consider the relation between the minimum energy uncertainty of the universe (1) and this proton energy (2). According to the considerations from our previous work [1], we now assume that it corresponds exactly to the ratio of the Coulomb force and the gravitational force between protons and electrons. The energy uncertainty of the universe leads to the fact that the repulsive Coulomb forces between the sub-elements of the proton weaken to the same extent while the attractive forces to the electrons, which are in a completely different inertial frame, are nearly preserved:

$$\frac{\Delta E_{min}}{E_p} = \frac{F(G)_{e,p}}{F(E)_{e,p}} \qquad (3)$$

This with (1) and (2) and

$$\frac{F(G)_{e,p}}{F(E)_{e,p}} = \frac{G m_e m_p \cdot 4\pi\epsilon_0}{e^2} \qquad (4)$$

m_e: mass of electron = 9.1*10^-31 kg

m_p: mass of proton = 1,67*10^-27 kg

G: gravitational constant = 6.6743 m³ / kg*s²

we get:

$$\frac{h \cdot 4\pi \cdot \epsilon_0 \cdot r_p}{4\pi \cdot T_u \cdot e^2} = \frac{G m_e m_p \cdot 4\pi \cdot \epsilon_0}{e^2} \qquad (5)$$

Simplified, rearranged to r_p and using

$$\hbar = \frac{h}{2 \cdot \pi}$$

we get:

$$\boxed{r_p = \frac{2 \cdot G m_e m_p \cdot T_u}{\hbar}} \qquad (6)$$

In (6) we can insert the equation for T_u which we have already derived in [1]:

$$T_u = \frac{2 \cdot \hbar^2}{m_e c \cdot G \cdot m_H^2} \qquad (7)$$

m_H = mass of hydrogen atom = $m_p + m_e$

Thus we get a simple, clear equation for the proton radius, which one does not see at all that we have derived it over the way of the universe's age:

$$\boxed{r_p = \frac{4 \cdot \hbar \cdot m_p}{c \cdot m_H^2} \approx \frac{4 \cdot \hbar}{c \cdot m_p}} \qquad (8)$$

This gives us a proton radius value of r_p = **$8.403 \cdot 10^{-16}$ m** (or $8{,}412 \cdot 10^{-16}$ m with the simplified rounding $m_H = m_p$).

Let's now compare this value with what the experimentalists and data analysts have published in recent years:

Publisher	**Year published**	**value**	**Deviation from $8.403 \cdot 10^{-16}$ m**
Pohl et al. [3]	2010	0.84184 fm	0.18%
Antognini et al. [4]	2013	0.84087 fm	0.066%
Griffioen et al. [5]	2015	0.840 ±0.016 fm	0.036%
Bezginov et al [6]	2019	0.833 ±0.010 fm	0.88%

The first two measurements listed, which were carried out as part of the CREMA project and which triggered the proton radius puzzle, are very close to our theoretical value. The same applies to an external analysis of measurement data from the University of Mainz, which is listed in the third line. The latest measurement listed confirm the value of 0.84 fm rather than 0.88 fm and their measurement error range includes the predicted value of 0.8403.

A new fundamental constant?

We now want to compare the smallest world with the largest world and form the ratio between the proton radius and the Hubble radius r_U, the radius of the observable universe. With $r_U = c \cdot T_U$ and rearrangement of the equation (6) we get:

$$\boxed{\frac{r_p}{r_u} = \frac{2 \cdot G m_e m_p}{\hbar \cdot c}} \qquad (9)$$

c: speed of light in vacuum = 299792458 m/s

The equation for this size ratio is reminiscent of an old acquaintance, the fine structure constant α. The following figure is intended to illustrate this:

$$\frac{r_p}{r_u} = \frac{2 \cdot \boxed{Gm_e m_p}}{\boxed{\hbar \cdot c}}$$

$$\alpha = \frac{\boxed{e^2}}{\boxed{4\pi\epsilon_0} \cdot \boxed{\hbar \cdot c}}$$

If this similarity should mean that also the relation between proton radius and Hubble radius is like the fine structure constant a fixed value, which is assumed not to have changed over a long period of time, then this would have serious consequences for the existing world view in physics. In our previous paper we indicated that, like Paul Dirac, we believe a time-varying gravitational constant is possible. However, such a single variation would now no longer be sufficient to explain a constant proton radius to Hubble radius ratio.

The mysterious 3.3534

"The mysterious 3.3534" was already a headline in our previous paper [1]. Here we already noticed the following numerical connection:

$$\frac{\Delta E_{min}}{E_e} = 3.3534 \cdot \frac{F(G)_{e,p}}{F(E)_{e,p}} \qquad (10)$$

$E_e = m_e c^2$ – rest energy of the electron

or

$$\frac{\hbar}{2 \cdot T_u \cdot m_e c^2} = 3.3534 \cdot \frac{Gm_e m_p \cdot 4\pi\epsilon_0}{e^2} \qquad (11)$$

We were then able to deduce how this value can be derived from the fine structure constant α and the ratio between proton mass and electron mass:

$$\alpha \cdot \frac{\frac{m_p}{m_e} + 2 + \frac{m_e}{m_p}}{4} = 3.3534 \qquad (12)$$

What is now striking is that this value is also the factor between the classical electron radius $r_{classic}$ and the predicted proton radius r_p.

$$\frac{r_{classic}}{r_p} = \frac{e^2}{4\pi\epsilon_0 \cdot m_e c^2 \cdot r_p} = 3.3534 \qquad (13)$$

And numerically, of course, it is noticeable that the value is close to 10/3, a factor that is not unusual when considering a homogeneous distribution in a sphere:

$$\frac{r_{classic}}{r_p} : \frac{10}{3} = \frac{3 \cdot 3.3534}{10} = 1.00602 \qquad (14)$$

So if the ratio between the predicted proton radius and classical radius would be exactly 10/3, i.e. the proton radius would be larger by about 0.6%, then according to equation (7) the Hubble radius and the age of the universe would also be 0.6% larger. For the universe's age a value of nearly 13.89 billion years would result.

For this value Kirov [7] has found an interesting numerical connection:

$$13.89\ Gyr \cdot f_c(e) = 2^{128} \qquad (15)$$

where $f_c(e)$ is the reduced compton wavelength of the electron.

As noted in the previous paper, we are not fans of looking for numerical relationships in magic higher powers, roots, and prefactors. Much of this reminds of Kees de Jager's „Cyclosophy“[1] and usually raises more open questions instead of solving any. But here we

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[1] https://en.wikipedia.org/wiki/Kees_de_Jager#Cyclosophy

want to make an exception, because the magic number 2^128 is somehow something special. Everybody who is a little bit engaged in computer science knows what we mean („digital physics“).

So to conclude this work, let's play around with this number a bit. With (13), (14), (15) and $f_c(e) = 2\pi \cdot m_e \cdot c^2 / h$ we get:

$$\frac{3 \cdot e^2 \cdot T_u}{2 \cdot 10 \cdot h \cdot \epsilon_0 \cdot r_p} = 2^{128} \qquad (16)$$

And with $r_U = c \cdot T_U$ and $\alpha = e^2 / (2 \cdot \epsilon_0 \cdot h \cdot c)$ finally:

$$\frac{3}{10} \cdot \alpha \cdot \frac{r_u}{r_p} = 2^{128} \qquad (17)$$

As mentioned above, we assume in the ratio of proton radius and Hubble radius a fundamental, time invariant constant equal to the fine structure constant. Both constants are united in (17).

If we replace r_u/r_p by the equivalent from (9) in (17) and rearrange to G, we also obtain the equation as Kirov [7] did:

$$G = \frac{3 \cdot e^2 \cdot 2^{-128}}{20 \cdot 4\pi\epsilon_0 \cdot m_p m_e} \qquad (18)$$

It yields a value of 6.67463*10^-11 m³/(kg·s²), slightly higher than the current CODATA-2018 value we calculated with in this and the previous work (6.67430*10^-11)

If this assumption with the 2^128 approach is correct, the slightly higher G-value would also mean that the value calculated by us for the universe age would drop slightly from somewhat under 13.807 Gyr to somewhat over 13.806 Gyr., thus around a few hundred thousand years.

Discussion

With our approach we predict a value of 0.8403 fm for the proton radius. At the moment, further precision experiments are underway to measure this property [8]. If these measurements should also yield a value around 0.84 fm (and T_u = 13.8 billion years remains consensus in established physics), then it would make more sense from our point of view to follow our solution approach instead of searching further in mathematical ivory towers (string theory et al.) for the connection between universe and elementary particles. Even if this would mean that many established models of thinking in physics, which have emerged in the last 106 years, would have to be questioned.

References

[1]	George Bailey, „An universe age of 13.807 billion years would fit perfectly Dirac's Large Number Hypothesis“, 18 May 2021, https://vixra.org/pdf/2105.0094v1.pdf
[2]	Edwin Cartlidge, „Has the proton radius puzzle been solved at last?“, 28 Nov. 2020, https://physicsworld.com/a/has-the-proton-radius-puzzle-been-solved-at-last/
[3]	Randolf Pohl et al., „The size of the proton“, July 2010, http://www.quantum.physik.uni-potsdam.de/teaching/ss2015/pqt/Pohl2010.pdf
[4]	Aldo Antognini et al., „Proton structure from the measurement of 2S − 2P transition frequencies of muonic hydrogen“, Science. 25th January 2013 – found via https://www.uni-stuttgart.de/en/university/news/press-release/International_team_of_scientists_confirms_surprisingly_small_proton_radius_with_laser_spectroscopy_of_exotic_hydrogen./

[5]	Keith Griffioen et al., „Are Electron Scattering Data Consistent with a Small Proton Radius“, 2015, https://arxiv.org/pdf/1509.06676.pdf
[6]	N. Bezginov et al., „A measurement of the atomic hydrogen Lamb shift and the proton charge radius“, https://science.sciencemag.org/content/365/6457/1007
[7]	Alex Kirov, „New Large Number Numerical Coincidences“, April 2013, https://www.researchgate.net/publication/331833008_New_Large_Number_Numerical_Coincidences
[8]	Livestream-Discussion „How big is the proton? with Jan C. Bernauer and Randolf Pohl from 16.12.2020 https://www.youtube.com/watch?v=C5B_ZfGy4d0