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An universe age of 13.807 billion years would fit perfectly Dirac's Large Number Hypothesis

Abstract

Paul Dirac noticed that the ratio between the dimensions of the universe (visible size and age) and the protons (diameter, duration of the passage of light through the proton) constitutes a large number of about 10^40. And that the ratio of the gravitational force and the electromagnetic force between an electron and a proton is roughly the same [1]. From this he deduced that the strength of gravity is inversely proportional to the age of the universe. He could only make a rough estimate, because of course he did not yet know the more precise value of 13.8 billion years world age assumed today. Especially the evaluation of the data from the Planck space telescope has produced this value in the last 10 years [2][3].

So today we are in a position for a more detailed evaluation.

We will show that gravity could result from an universal time-energy uncertainty relation if we assume that the universe's age is 13.8 billion years. Furthermore we will give by this approach a precise and straightforward formula for the gravitational constant G without magic factors, powers or roots.

Finally, we want to describe an approach with which the gravity can be explained as an asymmetry of attractive and repulsive electromagnetic forces by the fact that in a finite universe with age T_u there can be no electromagnetic interactions with frequencies smaller than the reciprocal of T_u .

The fine-structure constant says hello

Because of the energy-time-uncertainty 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.

If we put ΔE(min) in relation to the rest energy of the electron, then we get:

$$\frac{\Delta E_{min}}{E_e} >= \frac{h}{4\pi T_u \cdot m_e c^2} \qquad (2)$$

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

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

This relation (2) provides a value of 1,47815*10^39.
Not surprisingly: This is also a value that corresponds to the order of magnitude in Dirac's hypothesis.

It is particularly noticeable here that this value is very close to the ratio between the gravitational and electromagnetic force that exists between a proton and an electron. Because with

$$\frac{F(G)_{e,p}}{F(E)_{e,p}} = \frac{Gm_e m_p \cdot 4\pi\epsilon_0}{e^2} \qquad (3)$$

we get in relation with (2):

$$\frac{h \cdot e^2}{16\pi^2 T_u \cdot m_e c^2 \cdot Gm_e m_p \epsilon_0} = 3.3534 \qquad (4)$$

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

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

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

G: gravitational constant = 6.6743 m³ / kg*s²

Spoiler: We will see below that this value of 3.3534 can be represented by a combination of the fine structure constant α and and the ratio of proton mass and electron mass.

Now we consider the absolute values of the electromagnetic and gravitational forces that exist between two hydrogen atoms. For this we add the absolute values of the repulsive and attractive e-forces (otherwise we would have the value 0 and would not need to continue calculating).

The idea is that the gravitational force may result from the energy uncertainty of the electromagnetic interaction in such a way that in a finite universe, there is an asymmetry in the repulsive component and the attractive component. Hydrogen atoms make up 90% of the known matter in the universe.

So:

$$\frac{F(G)\ \ between\ \ two\ \ H-atoms}{(absolute\ \ repulsive F(E) + absolute\ \ attractive\ \ F(E))\ \ between\ \ two\ \ H-atoms}$$

=

$$\frac{F(G)_H}{\sum |F(E)_H|} = \frac{G(m_e + m_p)^2 \cdot 4\pi\epsilon_0}{4e^2} = \frac{G(m_e + m_p)^2 \pi\epsilon_0}{e^2} \qquad (5)$$

Now we do this: We are looking for the factor *x* between two ratios: the ratio of the minimum energy uncertainty to the rest energy of the electron - formula (2) - and the ratio of the gravitational force value of two hydrogen atoms and the summed absolute electromagnetic forces value between the two atoms (5). So:

$$\frac{h}{4\pi T_u \cdot m_e c^2} = x \cdot \frac{G(m_e + m_p)^2 \pi \epsilon_0}{e^2} \qquad (6)$$

If we rearrange this equation to find x and set T_u = 13.8 Gyr then we get:

x ≈ 1/137

So – this is the well known value of the fine structure constant α .
Well, everyone has certainly already experienced the craziest numerical coincidences, but the fact that α comes out as a relation factor in the above equation is a pretty strong link between the electromagnetic and the gravitational interaction.

In addition this relation seems to suggest that the ratio of gravitation and electromagnetism in a very young universe (T_u smaller the reciprocal of electron's compton frequency) corresponds the ratio of the electromagnetic and the strong nuclear force. (A trivial description of this idea was made in [4].)

So we formulate the conjecture:

$$\frac{h}{4\pi T_u \cdot m_e c^2} = \alpha \cdot \frac{G(m_e + m_p)^2 \pi \epsilon_0}{e^2}$$

or rearranged:

$$\alpha = \frac{he^2}{4\pi^2 T_u \cdot m_e c^2 \cdot G(m_e + m_p)^2 \epsilon_0} \qquad (7)$$

If we insert the known value of the fine structure constant α = 1/137.035999 in (7), then we can calculate an exact value for the age of universe:

$$T_u = \frac{he^2}{4\pi^2\alpha \cdot m_e c^2 \cdot G(m_e + m_p)^2 \epsilon_0} \qquad (8)$$

By using the well known definition

$$\alpha = \frac{e^2}{2ch\epsilon_0}$$

this can be simplified to:

$$T_u = \frac{h^2}{2\pi^2 \cdot m_e c \cdot G(m_e + m_p)^2} \qquad (9)$$

For this combination of known physical constants we get a value of **T_u = 13.807 billion years**. (If you calculate with 1 year = 365.25 days it's a little bit below, if 1 year=365.2422 it's a little above)

This value fits to the current accepted assumption made in the final report of the Planck telescope collaboration of T_u = 13.772±0.040 Gyr [3]. In their 2015 interim report [2], the match was even more accurate. There T_u was given as 13.813±0.038 Gyr .

A straightforward formula for G

Our assumption leads us into the same dilemma as Dirac: An equation with only one parameter (T_u), of which we know for sure that it changes over time and otherwise only constants, inevitably leads to at least one of these constants needs to be reinterpreted as a time-variable parameter.
And the main suspect is still the one that Dirac had identified: The gravitational - still - constant G.

If we rearrange (9) to find G we get:

$$G = \frac{h^2}{2\pi^2 \cdot T_u \cdot m_e c \cdot (m_e + m_p)^2} \qquad (10)$$

That's a pretty straightforward equation for G. With T_u = 13.807 billion years it provides the accepted value of 6.674*10^-11 m³ / kg*s².

It is in contrast to several other works, e.g. [5][6], in which it is attempted to represent G only by other natural constants. All of these attempts relied on raising a constant to an unexplained higher power or using corrective prefactors.

The mysterious 3.3534

With the knowledge of this coincidence, we now try to fathom the ominous value of 3.3534, which we encountered in equation (3) when we determined the factor between Δ E(min)/E(e) and the relation F(G) / F(E) between proton and electron.
So we repeat our approach and we are looking for a new factor x.
With equation (3) we get:

$$\frac{h}{4\pi T_u \cdot m_e c^2} = \alpha \cdot \frac{G(m_e + m_p)^2 \pi \epsilon_0}{e^2} = x \cdot \alpha \cdot \frac{G m_e m_p 4\pi\epsilon_0}{e^2} \qquad (11)$$

From this we can extract:

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

Rearranging:

$$x = \frac{\frac{m_p}{m_e} + 2 + \frac{m_e}{m_p}}{4} \tag{13}$$

So we've got it:

$$\alpha \cdot \frac{\frac{m_p}{m_e} + 2 + \frac{m_e}{m_p}}{4} = 3.3534 \tag{14}$$

So we have an interesting rearrangement of the relational equation (7):

$$\frac{h}{4\pi T_u \cdot m_e c^2} = \alpha \cdot (\frac{m_p}{m_e} + 2 + \frac{m_e}{m_p}) \cdot \frac{G m_e m_p \pi \epsilon_0}{e^2} \tag{15}$$

Approach to deriving this numerical coincidence

The starting point of our solution approach is the simple statement that in a finite universe with age T_u there can be no electromagnetic interactions with frequencies smaller than the reciprocal of T_u . So we formulate

Postulate 1: All (electromagnetic) frequencies in the universe can only be positive integer multiples of the reciprocal of the universe's age.

$$f(u) \in \frac{n}{T_u}, n \in \mathbb{N}$$
$$or$$
$$\omega(u) \in \frac{2\pi \cdot n}{T_u}, n \in \mathbb{N} \qquad (16)$$

Furthermore, we postulate that the space and thus the (electromagnetic) wavelengths can take on significantly finer values. That means there can be longer wavelengths than c^*T_u and many possible wavelength values in between $c^* T_u / (n+1)$ and than $c^* T_u / n$. This is in accordance with the inflation theory of the universe, which states that the visible universe had a significantly larger diameter immediately after the Big Bang than the product of $2^*c^* T_u$.

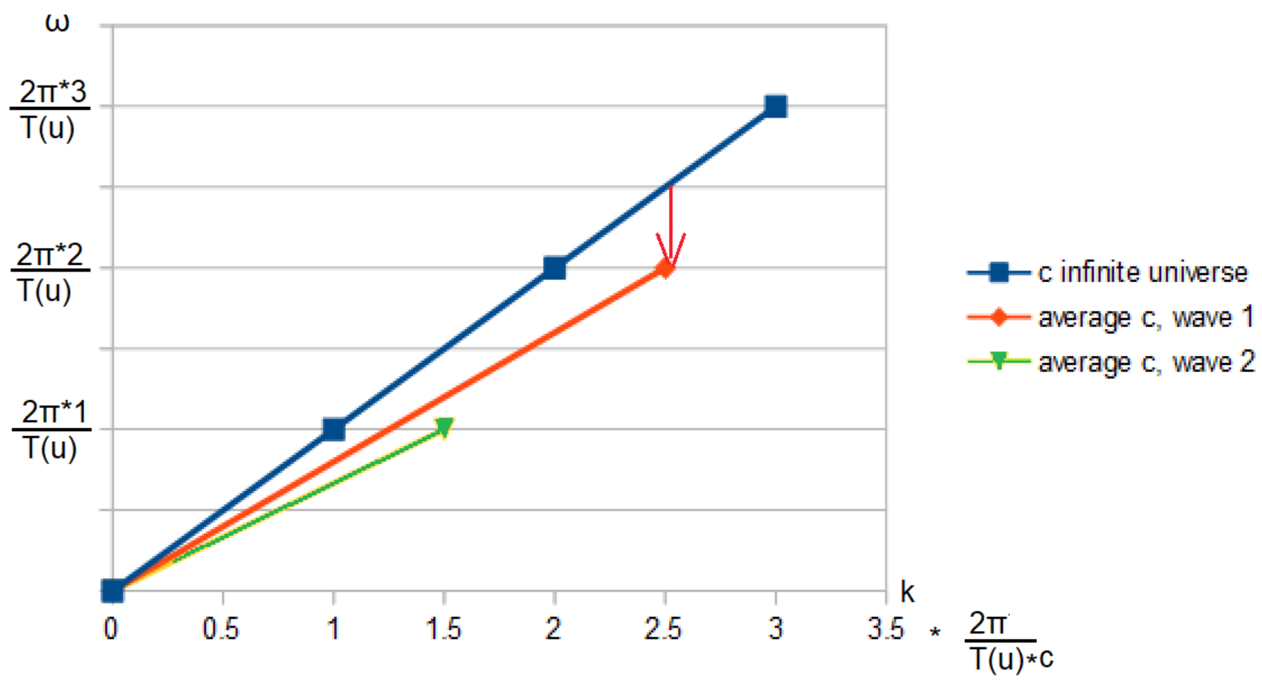
So we can define postulate 2:

$$\lambda(u) \in m * \frac{c \cdot T_u}{n}, n, m \in \mathbb{N}, m \gg 1$$

$$k(u) \in \frac{1}{m} * \frac{2\pi \cdot n}{c \cdot T_u}, n, m \in \mathbb{N}, m \gg 1 \qquad (17)$$

In accordance with the special theory of relativity, we define that no (electromagnetic) wave can travel faster than the speed of light. For all wavelengths not equal to any n*c*T_u this means that their value for the velocity of propagation must be rounded down to a value below c.

This fact should be illustrated in the following diagram:



For the wavelength marked red with lambda = 2.5 c * T_u, the frequency 2.5 / T_u would actually be provided for a continuous frequency range. However, since only discrete values are allowed for the frequencies (n / T_u, n natural number), it must be rounded down to 2*c*T_u, because at f=3*c* T_u the wave would have faster than light speed.

That means: The speed of light c is an upper limit that can only be reached in an infinite universe for the entirety of all wavelengths. In a finite universe all electromagnetic waves with wavelength <> n*c* T_u , that means almost all waves move at a speed below the speed of light even in the purest vacuum and even without the assumption of the interactions with „virtual particles“ in the vacuum. We will therefore refer to c as c_∞ from now on and c_max(T_u,lambda) as the average of the maximal speed of a wave with the length lambda in a universe with the age of T_u .

So we can make postulate 3:

$$c_{max}(T_u, \lambda) = c_\infty - \Delta\, c(T_u, \lambda)$$

$$\Delta\, c(T_u, \lambda) = \frac{\lambda}{4\pi * T_u} \qquad (18)$$

->

$$\boxed{c_{max}(T_u, \lambda) = c_\infty - \frac{\lambda}{4\pi * T_u}}$$

This equation shows that energy states with low frequencies have a higher deviation from c than energies with high frequencies.

Now we can see: the relation $\Delta\, c(\lambda) / c_\infty$ for a Compton wavelength λ_c corresponds to the relation for the minimum energy uncertainty of the equivalent particle, as we calculated it for the electron in (2):

$$\frac{\Delta\, c(T_u, \lambda_c)}{c_\infty} = \frac{\lambda_c}{4\pi * T_u * c_\infty} \qquad (19)$$

With the definition of the Compton wavelength of electron:

$$\lambda_c = \frac{h}{m_e * c_\infty}$$

we get:

$$\frac{\Delta\, c(T_u, \lambda_c)}{c_\infty} = \frac{h}{4\pi T_u \cdot m_e c_\infty^2} = \frac{\Delta\, E_{min}}{E_e} \qquad (20)$$

Now we have everything together to be able to explain an asymmetry in the attractive and repulsive components of the electromagnetic force: Our matter is structured in such a way that elementary particles with opposite charges are in very different inertial systems, in contrast to particles with the same charges.

As a result, particles with the opposite charge have a higher wavelength and thus, according to (13), a smaller Δ c than particles with the same charge. The larger Δ c for particles with the same charge lead to a higher weakening of their repulsive interaction than that of the attractive interaction with the opposite particles (with higher wavelength).

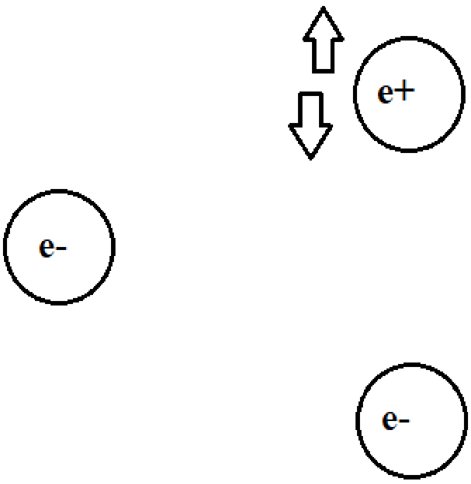


Illustration: In the intertial system of the electrons the moving positron has a higher wavelength and consequently a smaller Δ c and so a higher c_max. Therefore the attractive interaction between the moving positron and an electron is higher than the repulsive interaction between the two electrons.

In the following work we will try to use this approach to derive the relational formula (7) directly from the described postulate 3 (equation (18).

Discussion

In this work we have made a claim that is falsifiable. And time will tell whether we are correct or not with our assumption made here. The longer and more often the universe's age value of 13.8 Gyr is confirmed by astronomical measurements, the more our assumption will be strengthened, otherwise it will turn out to be wrong.

Should it stay with the 13.8 billion years as the age of the universe accepted by the mainstream, we are convinced that little by little more and more physicists will take up Dirac's Large Number Hypothesis and possibly our approach described here.

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