# Units and Constants:

# About Their Coherency and Cosmological Consequences


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**Abstract:**

By his paper "Units and Reality" (see [1]) the author has shown, that the transformation of the fundamental physical constants c, h, G, $e^2/k_c$ into systems of units, which differ from the International System of Units (SI), is a powerful tool to uncover correlations - sought for a long time – between the important dimensionless constants $137.036 = \frac{2\epsilon_0 ch}{e^2}$ and $1836.15 = \frac{m_p}{m_e}$ on the one hand and the numeric values of the constants with dimensions on the other hand.

The author discovered amongst others the following examples of fascinating numeric value correlations: $|c| \approx \frac{(2\pi/\alpha)^4}{m_p/m_e}$ , $|h| \approx \frac{(m_p/m_e)^6}{(2\pi/\alpha)^{18}}$ , $|G| \approx \frac{2\pi/\alpha}{(m_p/m_e)^4}$ , $\left|\frac{e^2}{4\pi\epsilon_0}\right| \approx \frac{(m_p/m_e)^5}{(2\pi/\alpha)^{15}}$ .

These numeric value correlations become exact equations if one transfers the physical constants c, h, G, $e^2/k_c$ into a system with a length unit of 1.0128 m, a time unit of 1.0112 s and a mass unit of 1.1531 kg.

During the last years the author consequently continued his previous investigations and discovered a new numeric correlation between the Hubble radius and the number 1836.15: $|R| \approx (m_p/m_e)^8$ .

The numeric correlations in combination with the equation $m_e^3 * m_p^3 = [\frac{e^2 h}{4\pi\epsilon_0 cGR}]^2$ , which the author found 2012 through systematic numerical investigations (see [2] and [3]) lead to a new cosmological model which is based only on powers of

$\frac{2\pi}{\alpha} = \frac{4\pi\epsilon_0 ch}{e^2} = \frac{2\pi * 137.036}{1} = 861.023$ and $\frac{m_p}{m_e} = 1836.153$ .


$$|R| \approx (m_p/m_e)^8 \qquad 1m \sim R^{29/48} \qquad 1s \sim R^{35/48} \qquad 1kg \sim R^{13/48}$$

$$|c(R)| = const. \qquad |h(R)| = const.$$

$$|G(R)|_{m^3/kgs^2} \; / \; |G(R_0)|_{m_0^3/kg_0 s_0^2} = (R_0 / R)^{7/12}$$

$$|e^2/4\pi\epsilon_0 (R)| = const. \qquad |m_e(R)| = const.$$

$$\alpha \approx 1/\sqrt{2}\pi^4 = 1/137.757 \qquad m_x^3 = \alpha/2\pi * (h^2/GR)$$

## Introduction:

As already investigated systematically in the author's previous work "The Code of Nature", the values of the electron mass and the proton mass ($m_e$ and $m_p$) can be represented in a convincing manner by five physical constants plus a time-varying parameter. The five constants are the elementary electric charge e, the vacuum electric permittivity $\epsilon_o$, the Planck constant h, the speed of light c and the gravitational constant G (see [2] and [3]). As a time-varying parameter, either the Hubble radius R or the Hubble constant H can be used. The straightforwardness and simplicity of the relation as found by the author in 2012 speak for themselves:

$$m_x{}^6 = m_e{}^3 * m_p{}^3 = [\frac{e^2 h}{4\pi\epsilon_o cGR}]^2 = [\frac{e^2 Hh}{4\pi\epsilon_o c^2 G}]^2 \quad \text{or}$$

$$m_x{}^3 = \frac{e^2 h}{4\pi\epsilon_o cGR} = \frac{\alpha}{2\pi} * \frac{h^2}{GR} = \frac{1}{861.023} * \frac{h^2}{GR} \qquad (1)$$

In the past few years it was the author's intention to derive and interpret this relation systematically.

## Abbreviations:

Speed of light $c = 2.9979 * 10^8 \frac{m}{s}$

Gravitational constant $G = 6.6743 * 10^{-11} \frac{m^3}{kgs^2}$

Planck constant $h = 6.6261 * 10^{-34} \frac{kgm^2}{s}$

Electron mass $m_e = 9.1094 * 10^{-31}$ kg

Proton mass $m_p = 1.6726 * 10^{-27}$ kg

Mass $m_x = [m_e * m_p]^{\frac{1}{2}} = 3.9034 * 10^{-29}$ kg

Elementary electric charge $e = 1.6022 * 10^{-19}$ As

Coulomb constant $k_c = \frac{1}{4\pi\epsilon_0} = 8.9876 * 10^9 \frac{kgm^3}{A^2 s^4}$

Hubble constant $H = 2.3337 * 10^{-18} \frac{1}{s}$

Hubble radius $R = \frac{c}{H} = 1.2846 * 10^{26}$ m

Fine-structure constant $\alpha = \frac{e^2}{2\epsilon_0 ch} = \frac{1}{137.036}$

$\frac{2\pi}{\alpha} = \frac{4\pi\epsilon_o ch}{e^2} = \frac{2\pi*137.036}{1} = 861.023$

$\frac{m_p}{m_e} = 1836.153$

## Definitions:

If a physical constant or another quantity is placed between two vertical lines in this paper, it is meant that the pure numerical value of this quantity without its unit of measurement corresponds to another quantity.

For example, the numerical value of the speed of light (determined in m/s) corresponds approximately to the dimensionless term $\frac{\left(\frac{2\pi}{\alpha}\right)^4}{\frac{m_p}{m_e}}$ : $\quad |c| \approx \frac{\left(\frac{2\pi}{\alpha}\right)^4}{\frac{m_p}{m_e}} = 2.993 * 10^8$.

If the system of measurement in which the relevant numerical value was determined is also to be indicated, the right-hand vertical line is given a corresponding index:

$$|c|_{\frac{m}{s}} \approx \frac{\left(\frac{2\pi}{\alpha}\right)^4}{\frac{m_p}{m_e}}$$

**Investigation:**

The following numerical correlations are the starting point for our investigation:

$$|c| \approx \frac{\left(\frac{2\pi}{\alpha}\right)^4}{\frac{m_p}{m_e}} = 2.993 * 10^8 \qquad (2)$$

$$|h| \approx \frac{\left(\frac{m_p}{m_e}\right)^6}{\left(\frac{2\pi}{\alpha}\right)^{18}} = 5.665 * 10^{-34} \qquad (3)$$

$$|G| \approx \frac{\frac{2\pi}{\alpha}}{\left(\frac{m_p}{m_e}\right)^4} = 7.575 * 10^{-11} \qquad (4)$$

$$\left|\frac{e^2}{4\pi\epsilon_0}\right| \approx \frac{\left(\frac{m_p}{m_e}\right)^5}{\left(\frac{2\pi}{\alpha}\right)^{15}} = 1.969 * 10^{-28} \qquad (5)$$

$$|R| \approx \left(\frac{m_p}{m_e}\right)^8 = 1.292 * 10^{26} \qquad (6)$$

With the unit of length $l_x$ = 1.0128 m, the unit of time $t_y$ = 1.0112 s and the unit of mass $m_z$ = 1.1531 kg, the correlations (2) to (5) become exact equations:

$$c = 2.9979 * 10^8 \ \frac{m}{s} = 2.9979 * 10^8 * \frac{l_x * 1.0112}{1.0128 * t_y} = 2.993 * 10^8 \frac{l_x}{t_y};\ |c|_{\frac{1.0128m}{1.0112s}} = \frac{\left(\frac{2\pi}{\alpha}\right)^4}{\frac{m_p}{m_e}} = 2.993 * 10^8$$

$$h = 6.6261 * 10^{-34} \ \frac{kgm^2}{s} = 6.6261 * 10^{-34} * \frac{m_z * {l_x}^2 * 1.0112}{1.1531 * 1.0128^2 * t_y} = 5.665 * 10^{-34} \ \frac{m_z {l_x}^2}{t_y}$$

$$G = 6.6743 * 10^{-11} \frac{m^3}{kgs^2} = 6.6743 * 10^{-11} * \frac{1.1531 * {l_x}^3 * 1.0112^2}{m_z * 1.0128^3 * {t_y}^2} = 7.575 * 10^{-11} * \frac{{l_x}^3}{m_z {t_y}^2}$$

$$\frac{e^2}{4\pi\epsilon_0} = 2.307 * 10^{-28} \ \frac{kgm^3}{s^2} = 2.307 * 10^{-28} * \frac{m_z * {l_x}^3 * 1.0112^2}{1.1531 * 1.0128^3 * {t_y}^2} = 1.969 * 10^{-28} * \frac{m_z {l_x}^3}{{t_y}^2}$$

The fact that the numerical values of the physical constants c, h, G, $e^2/4\pi\epsilon_o$ in the system of units $l_x$ = 1.0128 m, $t_y$ = 1.0112 s and $m_z$ = 1. 1531 kg can be represented in integer powers of $\frac{2\pi}{\alpha} = 861.023$

and $\frac{m_p}{m_e} = 1836.153$ is more than astounding and puzzling and is a very strong indication that there must be a numerical relationship between the physical constants.

Formula (1) can at least be seen as an essential part of such a correlation. We therefore do not have to be satisfied with the view that the physical constants assumed random values in the context of the Big Bang. On the contrary: there seem to be a lot of hidden inner connections in the universe that need to be decoded step by step.

An important tool for this could be the discovery that the numerical value of the Hubble radius R corresponds very well with the eighth power of $\frac{m_p}{m_e} = 1836.153$. If we take this correlation between the numerical value of the Hubble radius and the number 1836.153 (= ratio of proton to electron mass) seriously, this would mean - since the Hubble radius R is known to increase with the age of the universe - that the ratio of proton to electron mass also increases with the age of the universe and is proportional to $\sqrt[8]{R}$. So if R increases tenfold, $m_p/m_e$ would only increase by a factor of 1.334.

However, this would only be one consequence among many others. The values of the physical constants c, h, G and $e^2/4\pi\epsilon_o$ would then also be variable over time according to the correlations (2) to (5). The only real physical constant for which there is no indication of a temporal change would then be the fine-structure constant $\alpha = \frac{e^2}{2\epsilon_0 ch} = \frac{1}{137.036}$ or the term $\frac{2\pi}{\alpha} = 861.023$ that appears in the correlations (2) to (5).

Before you start to resist considering this as a real physical possibility, you should bear in mind that this would actually be the ideal physical state: one scale or one quantity would be enough to measure and quantitatively describe all other quantities. Isn't this exactly what many physicists have wished for and what many still dream of, albeit perhaps in a different form than the one presented here? But nature has little regard for our aesthetic prejudices. The author also imagined things to be quite different when he first entered the unknown land of physical constants. Every (natural) scientist must be open to such surprises, whether biologist, geologist or cosmologist. Those who shy away from the unknown are unlikely to discover anything new. With this in mind, you are invited to continue along the path unknown to you in the land of physical constants.

Speaking of paths: Whether the path with the fine-structure constant as the one fundamental constant now chosen is the only way to describe the land of physical constants or one of several possibilities that are equivalent to each other cannot be clarified in the context of this work. Both are imaginable. However, one path must first be discovered before any others can be sought.

The idea of the fine-structure constant as the fundamental physical constant on which everything is based should also not be misunderstood in that it must assume a constant value for all cosmic times. It should only be understood to mean that there is currently no evidence that the fine-structure constant α had a different value in the near cosmic past or that it will assume a different value in the near future. However, it is by no means impossible that it was a so-called "running coupling constant" in a very early phase of the universe at the high energy densities assumed there and changed its value with the expansion of the cosmos until it adjusted to the value that can be measured today. The majority of particle physicists assume this to be the case [see 4].

Before continuing along the path with the fine-structure constant, we have now chosen, however, we should briefly recheck the existing equipment. We intend to base our expedition on a dimensionless constant, i.e. a number, the fine-structure constant. This has the advantage over a dimensioned quantity as a possible basis, the value of which depends on the chosen system of units, that the value of a dimensionless quantity is at least immune to a change in the physical units for length, time and mass. As we shall see, the application of the correlations (2) to (6) also causes a temporal change for the SI units metre, second and kilogram, although this is partially compensated for by the change in the numerical values of the physical constants.

But now we continue on the path we have taken. To do this, we apply the correlations (2) to (6) to the formula (1)

$$\left|{m_x}^3\right| = \left|\frac{e^2h}{4\pi\epsilon_o cGR}\right| \approx \frac{\left(\frac{m_p}{m_e}\right)^5}{\left(\frac{2\pi}{\alpha}\right)^{15}} * \frac{\left(\frac{m_p}{m_e}\right)^6}{\left(\frac{2\pi}{\alpha}\right)^{18}} * \frac{\frac{m_p}{m_e}}{\left(\frac{2\pi}{\alpha}\right)^4} * \frac{\left(\frac{m_p}{m_e}\right)^4}{\frac{2\pi}{\alpha}} * \frac{1}{\left(\frac{m_p}{m_e}\right)^8} = \frac{\left(\frac{m_p}{m_e}\right)^8}{\left(\frac{2\pi}{\alpha}\right)^{38}} \quad ==>$$

$$\left|{m_x}^3\right| \approx \frac{\left(\frac{m_p}{m_e}\right)^8}{\left(\frac{2\pi}{\alpha}\right)^{38}} \text{ or } \left|m_x\right| \approx \frac{\left(\frac{m_p}{m_e}\right)^{8/3}}{\left(\frac{2\pi}{\alpha}\right)^{38/3}} \quad (7)$$

Taking into account $m_x = [\,m_e * m_p\,]^{\frac{1}{2}} = [\,{m_e}^2 * \frac{m_p}{m_e}]^{\frac{1}{2}} = m_e * (\frac{m_p}{m_e})^{\frac{1}{2}}$ we have:

$$\left|m_e\right| \approx \frac{\left(\frac{m_p}{m_e}\right)^{13/6}}{\left(\frac{2\pi}{\alpha}\right)^{38/3}} \approx \frac{\left|R\right|^{13/48}}{\left(\frac{2\pi}{\alpha}\right)^{38/3}} \quad (8) \qquad \text{and} \qquad \left|m_p\right| \approx \frac{\left(\frac{m_p}{m_e}\right)^{19/6}}{\left(\frac{2\pi}{\alpha}\right)^{38/3}} \approx \frac{\left|R\right|^{19/48}}{\left(\frac{2\pi}{\alpha}\right)^{38/3}} \quad (9)$$

If $\frac{m_p}{m_e} = 1836.153$ and $\frac{2\pi}{\alpha} = 861.023$ are inserted into (8), the result is:

$\left|m_e\right| \approx \frac{1836.153^{\frac{13}{6}}}{861.023^{\frac{38}{3}}} = 7.8514 * 10^{-31}$. With the unit of mass $m_z$ = 1.1531 kg already applied to the correlations (2) to (5), the correlation (8) also becomes an almost exact equation

$$m_e = 9.1094 * 10^{-31}\,\text{kg} = 9.1094 * 10^{-31}\,\frac{m_z}{1.1531} = 7.8999 * 10^{-31} m_z$$

The ratio of the value from (8), $7.8514 * 10^{-31}$ to the exact value of $7.8999 * 10^{-31}$ both measured in $m_z$ is 99.39 %. The inaccuracy of 0.61 %, which results from the combination of equation (1) with the correlations (2) to (6), can have various causes. Since (1) effectively contains the 8 values of the physical quantities $m_e$, $m_p$, e, h, $\epsilon_0$, c, G, R (partly in exponentiated form), it could be the cumulative inaccuracy of these values. Another possibility could be that the correlation (6), which links the atomic quantity $\frac{m_p}{m_e} = 1836.153$ with the cosmic value of the Hubble radius R, does not apply exactly.

The second possibility is supported by the fact that the correlation (6) results in

$$\left|R\right| \sim \left(\frac{m_p}{m_e}\right)^8 = 1.292 * 10^{26}.$$

The value of $R = 1.2846 * 10^{26}\text{m}$, which results from equation (1)

$R = \frac{e^2h}{4\pi\epsilon_o cG{m_x}^3} = \frac{\alpha}{2\pi} * \frac{h^2}{G{m_x}^3} = \frac{(6.6261*10^{-34})^2}{861.023*6.6743*10^{-11}*(3.9034*10^{-29})^3} = 1.2846 * 10^{26}$ is 99.43 % of this value.

The fact that the correlations (2) to (6), which were discovered independently of equation (1), nevertheless correlate so well with (1) speaks in favour of both equation (1), which links the values of the physical constants, and the correlations (2) to (6), which effectively reduce the physical constants to the values of $\frac{2\pi}{\alpha} = 861.023$ and $\frac{m_p}{m_e} = 1836.153$, provided that they are measured with a system of units that corresponds approximately to the usual SI system ($l_x$ = 1.0128 m, $t_y$ = 1.0112 s, $m_z$ = 1.1531 kg). Don't you think that all these numerical correlations should be good reasons to think intensively about the essence of nature and constants?

What effect does the power representation of the physical constants have on the SI units of measurement metre, second and kilogram?

It must be taken into account that the second is defined by the period of the radiation, which corresponds to the transition between the two hyperfine-structure levels of the ground state of atoms of the nuclide caesium 133. It is therefore necessary to examine how the hyperfine transition depends on the power representation of the physical constants. According to the literature [see 5], the hyperfine transition is proportional to the spin-orbit coupling constant a. The spin-orbit coupling constant $a \sim \frac{e^2\mu_0\hbar^2}{8\pi {m_e}^2{r_B}^3} \sim \frac{e^2\mu_0 h^2}{32\pi^3{m_e}^2{r_B}^3} \sim \frac{e^2h^2}{32\pi^3\varepsilon_0 c^2{m_e}^2{r_B}^3}$ , where $r_B$ is proportional to the Bohr radius, i.e $r_B \sim \frac{4\pi\varepsilon_0\hbar^2}{e^2 m_e} \sim \frac{\varepsilon_0 h^2}{\pi e^2 m_e}$.

Accordingly: $a \sim \frac{e^2h^2}{32\pi^3\varepsilon_0 c^2{m_e}^2{r_B}^3} = \frac{8\pi^4 e^8 m_e c^2}{4^4\pi^4{\varepsilon_0}^4c^4h^4} = \frac{8\pi^4 m_e c^2}{\left(\frac{2\pi}{\alpha}\right)^4}$ . This results in the power representation of $|a| \sim \frac{8\pi^4}{\left(\frac{2\pi}{\alpha}\right)^4} * \frac{\left(\frac{m_p}{m_e}\right)^{\frac{13}{6}}}{\left(\frac{2\pi}{\alpha}\right)^{\frac{38}{3}}} * \frac{\left(\frac{2\pi}{\alpha}\right)^8}{\left(\frac{m_p}{m_e}\right)^2} = 8\pi^4 * \frac{\left(\frac{m_p}{m_e}\right)^{\frac{1}{6}}}{\left(\frac{2\pi}{\alpha}\right)^{\frac{26}{3}}}$ . The frequency $\nu_{hf}$ of the hyperfine transition is proportional to $\frac{a}{h}$, thus $|\nu_{hf}| \sim \frac{a}{h} \sim 8\pi^4 * \frac{\left(\frac{m_p}{m_e}\right)^{\frac{1}{6}}}{\left(\frac{2\pi}{\alpha}\right)^{\frac{26}{3}}} * \frac{\left(\frac{2\pi}{\alpha}\right)^{18}}{\left(\frac{m_p}{m_e}\right)^6} \sim 8\pi^4 * \frac{\left(\frac{2\pi}{\alpha}\right)^{\frac{28}{3}}}{\left(\frac{m_p}{m_e}\right)^{\frac{35}{6}}}$.

$$|\nu_{hf}| \sim 8\pi^4 * \frac{\left(\frac{2\pi}{\alpha}\right)^{\frac{28}{3}}}{\left(\frac{m_p}{m_e}\right)^{\frac{35}{6}}} \quad \Rightarrow \quad |\nu_{hf}| \sim \frac{1}{\left(\frac{m_p}{m_e}\right)^{\frac{35}{6}}} \sim \frac{1}{R^{\frac{35}{48}}} \qquad (10)$$

With the power representation of the hyperfine frequency $\nu_{hf}$, we are prepared for the further investigation concerning the dependence of the SI units metre, second and kilogram.

Firstly, we want to analyse the unit of time. To do this, we will look at the SI definition of the second: one second is 9 192 631 770 times the period of the radiation corresponding to the transition between the two hyperfine-structure levels of the ground state of atoms of the nuclide caesium 133, i.e.

$$1s = \frac{9\,192\,631\,770}{\nu_{hf}} \sim \left(\frac{m_p}{m_e}\right)^{\frac{35}{6}} \sim R^{\frac{35}{48}} \qquad (11)$$

The duration of a second therefore increases with the Hubble radius on the basis of the power representation.

Next we come to the metre as a unit of length. The SI definition of the metre is: one metre is the length of the distance travelled by light in a vacuum for 1/299 792 458 seconds, i.e

$$1\text{m} = \frac{1}{299\,792\,458} * \text{c} * 1\text{s} = \frac{9\,192\,631\,770}{299\,792\,458} * \frac{\text{c}}{\nu_{\text{hf}}} \sim \frac{1}{\frac{\text{m}_\text{p}}{\text{m}_\text{e}}} * \frac{\left(\frac{\text{m}_\text{p}}{\text{m}_\text{e}}\right)^{\frac{35}{6}}}{1} \sim \left(\frac{\text{m}_\text{p}}{\text{m}_\text{e}}\right)^{\frac{29}{6}} \sim \text{R}^{\frac{29}{48}} \qquad (12)$$

The metre also grows on the basis of the power representation with the Hubble radius.

Finally, let us turn our attention to the unit of mass.

The SI definition of the kilogram is: A kilogram is defined by specifying the numerical value of $6.626\,070\,15 * 10^{-34}\ \frac{\text{kgm}^2}{\text{s}}$ for the Planck constant h, whereby the metre and the second are defined by means of the speed of light and the hyperfine frequency. The magnitude of the Planck constant should therefore be measured constantly over the eons at $6.626\,070\,15 * 10^{-34}$. The requirement is therefore

$$|\text{h(R)}| = \text{h} = 6.626\,070\,15 * 10^{-34} = \text{const.} \qquad (13)$$

Expressed in words, this means that even if the units metre, second and kilogram change with the Hubble radius R, i.e. the unit $\frac{\text{kg}_0 \text{m}_0{}^2}{\text{s}_0}$ becomes the unit $\frac{\text{kgm}^2}{\text{s}}$, the value of h should always be $6.626\,070\,15 * 10^{-34}$. According to the correlations (3) and (6)

$|\text{h(R)}| \approx \frac{\left(\frac{\text{m}_\text{p}}{\text{m}_\text{e}}\right)^6}{\left(\frac{2\pi}{\alpha}\right)^{18}} \sim \frac{\text{R}^{\frac{3}{4}}}{\left(\frac{2\pi}{\alpha}\right)^{18}}$ on the other hand, the Planck constant - measured in the unit of measurement associated with the respective Hubble radius R - changes with the Hubble radius R. From this we have $\frac{\text{h}*\frac{\text{kgm}^2}{\text{s}}}{\text{h}*\frac{\text{kg}_0\text{m}_0{}^2}{\text{s}_0}} = \left(\frac{\text{R}}{\text{R}_0}\right)^{\frac{3}{4}}$ and with (13) $\frac{\frac{\text{kgm}^2}{\text{s}}}{\frac{\text{kg}_0\text{m}_0{}^2}{\text{s}_0}} = \left(\frac{\text{R}}{\text{R}_0}\right)^{\frac{3}{4}}$ or

$$1\,\frac{\text{kgm}^2}{\text{s}} \sim \text{R}^{\frac{3}{4}} \qquad (14)$$

The unit of measurement $\frac{\text{kgm}^2}{\text{s}}$ of the Planck constant grows with the Hubble radius R, but not the measured value for h, unless the scale is kept constant, as can be seen in the following 2 examples:

Example 1:

$$\text{h(R)} = 6.626\,070\,15 * 10^{-34}\,\frac{\text{kgm}^2}{\text{s}} = 6.626\,070\,15 * 10^{-34} * \left(\frac{\text{R}}{\text{R}_0}\right)^{\frac{3}{4}} * \frac{\text{kg}_0\text{m}_0{}^2}{\text{s}_0} = \text{h}'(\text{R}) * \frac{\text{kg}_0\text{m}_0{}^2}{\text{s}_0}$$

$\text{h}(\text{R}_0) = 6.626\,070\,15 * 10^{-34}\,\frac{\text{kg}_0\text{m}_0{}^2}{\text{s}_0}$ and so $\frac{\text{h}'(\text{R})\,\frac{\text{kg}_0\text{m}_0{}^2}{\text{s}_0}}{\text{h}(\text{R}_0)\,\frac{\text{kg}_0\text{m}_0{}^2}{\text{s}_0}} = \left(\frac{\text{R}}{\text{R}_0}\right)^{\frac{3}{4}}$ and

$$|\text{h}'(\text{R})|_{\frac{kg_0 m_0{}^2}{s_0}} = |\text{h}(\text{R}_0)|_{\frac{kg_0 m_0{}^2}{s_0}} * \left(\frac{\text{R}}{\text{R}_0}\right)^{\frac{3}{4}}$$

Example 2:

$$\text{h(R)} = 6.626\,070\,15 * 10^{-34}\,\frac{\text{kgm}^2}{\text{s}}$$

$$h(R_0) = 6.626\ 070\ 15 * 10^{-34} \frac{kg_0 {m_0}^2}{s_0} = \frac{6.626\ 070\ 15*10^{-34}}{\left(\frac{R}{R_0}\right)^{\frac{3}{4}}} * \frac{kgm^2}{s} = h''(R_0) * \frac{kgm^2}{s}$$

Therefore $\frac{h(R)\frac{kgm^2}{s}}{h''(R_0)\frac{kgm^2}{s}} = \left(\frac{R}{R_0}\right)^{\frac{3}{4}}$ and $\left|h''(R_0)\right|_{\frac{kgm^2}{s}} = \frac{\left|h(R)\right|_{\frac{kgm^2}{s}}}{\left(\frac{R}{R_0}\right)^{\frac{3}{4}}}$

From equation (14) $1\frac{kgm^2}{s} \sim R^{\frac{3}{4}}$, the dependence of the kg on the Hubble radius can be calculated using (11) $1s \sim R^{\frac{35}{48}}$, (12) $1m \sim R^{\frac{29}{48}}$ , $1m^2 \sim R^{\frac{58}{48}}$ and $1\frac{m^2}{s} \sim \frac{R^{\frac{58}{48}}}{R^{\frac{35}{48}}} \sim R^{\frac{23}{48}}$, because

$$1kg \sim R^{\frac{3}{4}} * \frac{s}{m^2} \sim R^{\frac{36}{48}} * \frac{1}{R^{\frac{23}{48}}} \sim R^{\frac{13}{48}} \qquad (15)$$

Verification: $1\frac{kgm^2}{s} \sim R^{\frac{13}{48}} * R^{\frac{23}{48}} = R^{\frac{36}{48}} = R^{\frac{3}{4}}$

According to the definition in the SI system, the kilogram, the metre and the second grow with the Hubble radius, albeit in different ways.

What about the value of the speed of light measured in the SI system?

Using equations (11) and (12), the following results: $1\frac{m}{s} \sim \frac{R^{\frac{29}{48}}}{R^{\frac{35}{48}}} \sim \frac{1}{R^{\frac{1}{8}}}$ (16)

The unit of measurement for the speed therefore decreases as the Hubble radius increases. According to the correlations (2) and (6) $\left|c(R)\right| \approx \frac{\left(\frac{2\pi}{\alpha}\right)^4}{\frac{m_p}{m_e}} \approx \frac{\left(\frac{2\pi}{\alpha}\right)^4}{R^{\frac{1}{8}}}$, the speed of light measured in the variable unit of measurement ($1\frac{m}{s} \sim \frac{1}{R^{\frac{1}{8}}}$) also decreases with the Hubble radius R.

$$\frac{c(R)*\frac{m}{s}}{c(R_0)*\frac{m_0}{s_0}} = \frac{1}{\left(\frac{R}{R_0}\right)^{\frac{1}{8}}} \quad \Rightarrow \quad \frac{c(R)*1}{c(R_0)*\left(\frac{R}{R_0}\right)^{\frac{1}{8}}} = \frac{1}{\left(\frac{R}{R_0}\right)^{\frac{1}{8}}} \quad \Rightarrow \quad \left|c(R)\right|_{\frac{m}{s}} = \left|c(R_0)\right|_{\frac{m_0}{s_0}}$$

If the correlations (2) to (6) apply, then with the valid SI definitions for the metre and the second, the speed of light is determined to be constant with the increasing Hubble radius R (with an expanding universe), although the unit of measurement for the speed decreases with the increasing Hubble radius.

$$\left|c(R)\right| = c = 2.9979 * 10^8 = const \qquad (17)$$

Now to the numerical value of the gravitational constant measured in the SI system!

Using equations (11), (12) and (15), we have:

$$1\frac{m^3}{kgs^2} \sim R^{\frac{87}{48}} * \frac{1}{R^{\frac{13}{48}}} * \frac{1}{R^{\frac{70}{48}}} \sim R^{\frac{4}{48}} \sim R^{\frac{1}{12}}$$

The unit of measurement for the gravitational constant therefore increases as the Hubble radius increases. According to the correlations (4) and (6) $\left|G(R)\right| \approx \frac{\frac{2\pi}{\alpha}}{\left(\frac{m_p}{m_e}\right)^4} \approx \frac{\frac{2\pi}{\alpha}}{R^{\frac{1}{2}}}$ , however, the gravitational constant measured in the variable unit of measurement ($1\frac{m^3}{kgs^2} \sim R^{\frac{1}{12}}$) decreases with the Hubble radius R.

$$\frac{G(R)*\frac{m^3}{kgs^2}}{G(R_0)*\frac{{m_0}^3}{kg_0\,{s_0}^2}} = \frac{1}{\left(\frac{R}{R_0}\right)^{\frac{1}{2}}} \Rightarrow \frac{G(R)}{G(R_0)} * \left(\frac{R}{R_0}\right)^{\frac{1}{12}} = \frac{1}{\left(\frac{R}{R_0}\right)^{\frac{1}{2}}} \Rightarrow \frac{\left|G(R)\right|_{\frac{m^3}{kgs^2}}}{\left|G(R_0)\right|_{\frac{{m_0}^3}{kg_0\,{s_0}^2}}} = \frac{1}{\left(\frac{R}{R_0}\right)^{\frac{1}{12}} * \left(\frac{R}{R_0}\right)^{\frac{6}{12}}} = \frac{1}{\left(\frac{R}{R_0}\right)^{\frac{7}{12}}} \qquad \textbf{(18)}$$

If the correlations (2) to (6) apply, then with the valid SI definitions for the metre, the second and the kilogram, the gravitational constant is determined as decreasing in proportion to $\frac{1}{R^{\frac{7}{12}}}$ as the Hubble radius R increases (with an expanding universe), while the unit of measurement for the gravitational constant increases in proportion to $R^{\frac{1}{12}}$ as the Hubble radius increases.

Now to the value of the term $\frac{e^2}{4\pi\epsilon_0}$ measured in the SI system, which describes the strength of the electromagnetic force!

Equations (11), (12) and (15) give the following result:

$$1\frac{kgm^3}{s^2} \sim R^{\frac{13}{48}} * R^{\frac{87}{48}} * \frac{1}{R^{\frac{70}{48}}} \sim R^{\frac{5}{8}}$$

The unit of measurement for the term $\frac{e^2}{4\pi\epsilon_0}$ therefore increases as the Hubble radius increases. According to the correlations (5) and (6) $\left|\frac{e^2}{4\pi\epsilon_0}(R)\right| \approx \frac{\left(\frac{m_p}{m_e}\right)^5}{\left(\frac{2\pi}{\alpha}\right)^{15}} \approx \frac{R^{\frac{5}{8}}}{\left(\frac{2\pi}{\alpha}\right)^{15}}$ , the term $\frac{e^2}{4\pi\epsilon_0}$ measured in the variable unit of measurement ($1\frac{kgm^3}{s^2} \sim R^{\frac{5}{8}}$) also increases with the Hubble radius R.

$$\frac{\frac{e^2}{4\pi\epsilon_0}(R)*\frac{kgm^3}{s^2}}{\frac{e^2}{4\pi\epsilon_0}(R_0)*\frac{kg_0{m_0}^3}{{s_0}^2}} = \left(\frac{R}{R_0}\right)^{\frac{5}{8}} \Rightarrow \frac{\frac{e^2}{4\pi\epsilon_0}(R)}{\frac{e^2}{4\pi\epsilon_0}(R_0)} * \left(\frac{R}{R_0}\right)^{\frac{5}{8}} = \left(\frac{R}{R_0}\right)^{\frac{5}{8}} \Rightarrow \left|\frac{e^2}{4\pi\epsilon_0}(R)\right|_{\frac{kgm^3}{s^2}} = \left|\frac{e^2}{4\pi\epsilon_0}(R_0)\right|_{\frac{kg_0{m_0}^3}{{s_0}^2}} \qquad \textbf{(19)}$$

If the correlations (2) to (6) apply, then the term $\frac{e^2}{4\pi\epsilon_0}$ is determined to be constant with the increasing Hubble radius R (with an expanding universe) using the valid SI definitions for the metre, the second and the kilogram, although the unit of measurement for the term increases proportionally to $R^{\frac{5}{8}}$ with the increasing Hubble radius. The strength of the electromagnetic force is therefore determined as constant with the power representation using the SI system.

Let us assume for our further investigations that the correlations (2) to (6) would also describe the temporal behaviour of the particle masses. Then we see that, according to (8) and (9) [$\left|m_e\right| \approx \frac{\left(\frac{m_p}{m_e}\right)^{13/6}}{\left(\frac{2\pi}{\alpha}\right)^{38/3}}$ ; $\left|m_p\right| \approx \frac{\left(\frac{m_p}{m_e}\right)^{\frac{19}{6}}}{\left(\frac{2\pi}{\alpha}\right)^{\frac{38}{3}}}$ ] in conjunction with (6) [$\left|R\right| \approx \left(\frac{m_p}{m_e}\right)^8$], the values of the electron and proton masses would change with the Hubble radius as follows:

$$\frac{m_e(R)*kg}{m_e(R_0)*kg_0} = \left(\frac{R}{R_0}\right)^{\frac{13}{48}} \qquad \frac{m_p(R)*kg}{m_p(R_0)*kg_0} = \left(\frac{R}{R_0}\right)^{\frac{19}{48}}$$

If we take into account that the unit of measurement kilogram also changes with the Hubble radius ( $1kg \sim R^{\frac{13}{48}}$ ) then we have:

$$\frac{m_e(R)*kg}{m_e(R_0)*kg_0} = \left(\frac{R}{R_0}\right)^{\frac{13}{48}} \rightarrow \frac{m_e(R)}{m_e(R_0)} * \left(\frac{R}{R_0}\right)^{\frac{13}{48}} = \left(\frac{R}{R_0}\right)^{\frac{13}{48}} \rightarrow |m_e(R)|_{kg} = |m_e(R_0)|_{kg_0} \quad \textbf{(20)}$$

If the correlations (2) to (6) apply, then with the valid SI definitions for the metre, the second and the kilogram, the electron mass is determined to be constant with the increasing Hubble radius R (with an expanding universe), although the unit of measurement for the mass increases proportionally to $R^{\frac{13}{48}}$ with the increasing Hubble radius.

For the proton mass, on the other hand, the result is

$$\frac{m_p(R)*kg}{m_p(R_0)*kg_0} = \left(\frac{R}{R_0}\right)^{\frac{19}{48}} \rightarrow \frac{m_p(R)}{m_p(R_0)} * \left(\frac{R}{R_0}\right)^{\frac{13}{48}} = \left(\frac{R}{R_0}\right)^{\frac{19}{48}} \rightarrow \frac{|m_p(R)|_{kg}}{|m_p(R_0)|_{kg_0}} = \left(\frac{R}{R_0}\right)^{\frac{1}{8}} \quad \textbf{(21)}$$

This must be the case insofar as, according to the correlation (6) [ $|R| \approx \left(\frac{m_p}{m_e}\right)^8$ ], the ratio of proton to electron mass should increase in proportion to the eighth root of the Hubble radius:

$$\frac{\frac{m_p}{m_e}(R)}{\frac{m_p}{m_e}(R_0)} = \left(\frac{R}{R_0}\right)^{\frac{1}{8}}$$

How can the temporal evolution of the electron mass be reconciled with the cosmic redshift?

The Rydberg frequency

$$\nu_R = \frac{m_e e^4}{8\varepsilon_0{}^2 h^3} = \frac{9.1094*10^{-31}\ kg*(1.6022*10^{-19})^4 A^4 s^4}{8*(8.8542*10^{-12})^2 \frac{A^4 s^8}{kg^2 m^6}*(6.6261*10^{-34})^3 \frac{kg^3 m^6}{s^3}} = 3.2899 * 10^{15}\ \frac{1}{s}$$

can be used to describe the frequency ν of the light emission of hydrogen:

$$\nu = \left(\frac{1}{n^2} - \frac{1}{m^2}\right) * \nu_R$$

$\nu$ is the frequency of the light that is emitted when a hydrogen electron changes from the $m^{th}$ to the $n^{th}$ shell [see 6].

Let us first consider the change in the Rydberg frequency over time by also converting the Rydberg frequency $\nu_R = \frac{m_e e^4}{8\varepsilon_0{}^2 h^3}$ into a power representation. To do this, we use the power representations already obtained $|m_e| \approx \frac{\left(\frac{m_p}{m_e}\right)^{13/6}}{\left(\frac{2\pi}{\alpha}\right)^{38/3}}$ , $\left|\frac{e^2}{4\pi\varepsilon_0}\right| \approx \frac{\left(\frac{m_p}{m_e}\right)^5}{\left(\frac{2\pi}{\alpha}\right)^{15}}$ => $\left|\frac{e^4}{\varepsilon_0{}^2}\right| \approx \frac{16\pi^2\left(\frac{m_p}{m_e}\right)^{10}}{\left(\frac{2\pi}{\alpha}\right)^{30}}$ and $|h^3| \approx \frac{\left(\frac{m_p}{m_e}\right)^{18}}{\left(\frac{2\pi}{\alpha}\right)^{54}}$.

Therefore $|\nu_R| \approx \frac{1}{8} * \frac{\left(\frac{m_p}{m_e}\right)^{\frac{13}{6}}}{\left(\frac{2\pi}{\alpha}\right)^{\frac{38}{3}}} * \frac{16\pi^2\left(\frac{m_p}{m_e}\right)^{10}}{\left(\frac{2\pi}{\alpha}\right)^{30}} * \frac{\left(\frac{2\pi}{\alpha}\right)^{54}}{\left(\frac{m_p}{m_e}\right)^{18}} = 2\pi^2 * \frac{\left(\frac{2\pi}{\alpha}\right)^{\frac{34}{3}}}{\left(\frac{m_p}{m_e}\right)^{\frac{35}{6}}} = 2\pi^2 * \frac{861.023^{\frac{34}{3}}}{1836.153^{\frac{35}{6}}} = 3.306 * 10^{15}$

$$\left|\nu_R\right| \approx 2\pi^2 * \frac{\left(\frac{2\pi}{\alpha}\right)^{\frac{34}{3}}}{\left(\frac{m_p}{m_e}\right)^{\frac{35}{6}}} = 3.3065 * 10^{15} \qquad (22)$$

With the time unit of $t_y$ = 1.0112 s already used above, the exact value measured in $t_y$ is:

$$\nu_R = 3.2899 * 10^{15}\ \frac{1}{s} = 3.2899 * 10^{15}\ * \frac{1.0112}{t_y} = 3.3267 * 10^{15}\ \frac{1}{t_y}$$

The ratio of the value from (22), $3.3064 * 10^{15}$ to the exact value of $3.3267 * 10^{15}$ both measured in $1/t_y$ is 99.39%, exactly the same as the accuracy of 99.39 % determined above for the power representation of the electron mass. This is to be expected insofar as the Rydberg frequency is proportional to the electron mass.

Correlation (6) $\frac{m_p}{m_e} \approx \left|R\right|^{\frac{1}{8}}$ turns equation (22) into:

$$\left|\nu_R\right| \approx 2\pi^2 * \frac{\left(\frac{2\pi}{\alpha}\right)^{\frac{34}{3}}}{\left(\frac{m_p}{m_e}\right)^{\frac{35}{6}}} \approx \frac{\left(\frac{2\pi}{\alpha}\right)^{\frac{34}{3}}}{\left|R\right|^{\frac{35}{48}}}. \qquad (23)$$

If one compares the power representation of the Rydberg frequency $\nu_R$ with that of the hyperfine frequency $\nu_{hf}$, it is interesting to note that the latter has the same dependence on R:

$$\left|\nu_{hf}\right| \sim 8\pi^4 * \frac{\left(\frac{2\pi}{\alpha}\right)^{\frac{28}{3}}}{\left(\frac{m_p}{m_e}\right)^{\frac{35}{6}}} \quad \left|\nu_R\right| \sim 2\pi^2 * \frac{\left(\frac{2\pi}{\alpha}\right)^{\frac{34}{3}}}{\left(\frac{m_p}{m_e}\right)^{\frac{35}{6}}} \quad \rightarrow \quad \left|\nu_{hf}\right| \sim \left|\nu_R\right| \sim \frac{1}{\left(\frac{m_p}{m_e}\right)^{\frac{35}{6}}} \sim \frac{1}{R^{\frac{35}{48}}}$$

The numerical value of the wavelength λ of the emitted light is proportional to $\left|R\right|^{\frac{29}{48}}$, taking into account correlation (2):

$$\left|\lambda\right| \sim \frac{c}{\nu_R} \sim \frac{\left(\frac{2\pi}{\alpha}\right)^4}{\frac{m_p}{m_e}} * \frac{\left(\frac{m_p}{m_e}\right)^{\frac{35}{6}}}{2\pi^2*\left(\frac{2\pi}{\alpha}\right)^{\frac{34}{3}}} = \frac{\left(\frac{m_p}{m_e}\right)^{\frac{29}{6}}}{2\pi^2*\left(\frac{2\pi}{\alpha}\right)^{\frac{22}{3}}} \sim \frac{\left|R\right|^{\frac{29}{48}}}{2\pi^2*\left(\frac{2\pi}{\alpha}\right)^{\frac{22}{3}}} \qquad (24)$$

If we take into account that the metre measure also changes with the Hubble radius ($1\text{m} \sim R^{\frac{29}{48}}$ ) it follows:

$$\frac{\lambda(R)*m}{\lambda(R_0)*m_0} = \left(\frac{R}{R_0}\right)^{\frac{29}{48}} \rightarrow \frac{\left|\lambda(R)\right|_m}{\left|\lambda(R_0)\right|_{m_0}} * \left(\frac{R}{R_0}\right)^{\frac{29}{48}} = \left(\frac{R}{R_0}\right)^{\frac{29}{48}} \rightarrow$$

$$\frac{\left|\lambda(R)\right|_m}{\left|\lambda(R_0)\right|_{m_0}} = 1 \qquad (25)$$

If the correlations (2) to (6) apply, then with the valid SI definitions for the metre, the second and the kilogram, the value of the wavelength λ of the emitted light is determined to be constant with the increasing Hubble radius R (with an expanding universe), because the unit of measurement for the length increases proportionally to $R^{\frac{29}{48}}$ in the same way as the value of the wavelength λ with increasing Hubble radius.

However, this fact should not lead to the misconception that the temporal change in electron mass has no influence on the cosmic redshift. When measuring the cosmic redshift, the wavelength of the old, previously emitted light is compared with the wavelength of currently emitted light, both on the metre scale currently available. From $\frac{|\lambda(R)|_m}{|\lambda(R_0)|_{m_0}} = 1$ and $m_0 = \frac{m}{\left(\frac{R}{R_0}\right)^{\frac{29}{48}}}$ we have:

$$\frac{|\lambda(R)|_m}{|\lambda(R_0)|_m} = \left(\frac{R}{R_0}\right)^{\frac{29}{48}} \qquad (26)$$

This means that the temporal development of the wavelength since the emission of the old light does not explicitly emerge from (25) but from (26). The increase of the wavelength in the temporal comparison according to (26) (this would cause a cosmic blueshift) however must be (over)compensated by the expansion of space.

Since the so-called last scattering, according to standard cosmology the space and thus the wavelength of the light emitted at that time has expanded by a factor of 1089 [see 7, p. 179 and p. 334]. From a temperature of below 3000 Kelvin, the atomic nuclei capture the free electrons, causing the photon-electron scattering processes to come to a standstill. The photons decouple from the matter and the light can propagate unhindered. Since the end of the scattering processes (last scattering), the temperature of the universe and the background radiation has cooled by a factor of 1089 to 2.725 K and the wavelength of the background radiation has been redshifted into the millimetre range. This is the narrative of standard cosmology in [7].

But how can the power representation and the dependence of the physical constants on the Hubble radius be harmonised with the measured cosmic redshift? According to (26), the wavelength of the emitted light - provided it is measured with a constant or current metre scale - increases with the Hubble radius: $|\lambda| \sim |R|^{\frac{29}{48}}$. The light emitted today therefore has a longer wavelength than the light emitted at the time of last scattering. This cosmic blueshift caused by the decrease in the Rydberg frequency $|\nu_R| \sim \frac{1}{|R|^{\frac{35}{48}}}$ must therefore be overcompensated by the expansion of space to a redshift. If $\lambda_0$ was the wavelength at the time of last scattering, then it must be stretched by a factor $\frac{R}{R_0}$ so that it is 1089 times the current wavelength λ in order to be consistent with the observed redshift:

$$\lambda(R_0) * m * \frac{R*m}{R_0*m} = 1089 * \lambda(R) * m \quad \rightarrow$$

$$\frac{|\lambda(R_0)|_m}{|\lambda(R)|_m} * \frac{|R|_m}{|R_0|_m} = 1089 \qquad (27)$$

To determine the factor $\frac{R}{R_0}$, which forms the basis of the power representation, it is assumed that R is measured in metre m and $R_0$ in $m_0 = \frac{m}{\left(\frac{R}{R_0}\right)^{\frac{29}{48}}}$. $\frac{R}{R_0}$ is therefore specified as $\frac{|R|_m}{|R_0|_{m_0}}$. Consequently, the change of the metre scale is specified as $m_0 = \frac{m}{\left(\frac{|R|_m}{|R_0|_{m_0}}\right)^{\frac{29}{48}}}$ .This corresponds to the development of the metre according to the SI definition as a function of the Hubble radius R.

However, since the term $\frac{|R|_m}{|R_0|_m}$ appears in equation (27), it must be represented as a function of $\frac{|R|_m}{|R_0|_{m_0}}$: $\frac{|R|_m}{|R_0|_{m_0}} = \frac{|R|_m}{|R_0|_m * \left(\frac{|R|_m}{|R_0|_{m_0}}\right)^{\frac{29}{48}}}$ ➔ $\frac{|R|_m^{\frac{48}{48}} * |R|_m^{\frac{29}{48}}}{|R_0|_{m_0}^{\frac{48}{48}} * |R_0|_{m_0}^{\frac{29}{48}}} = \frac{|R|_m}{|R_0|_m}$ ➔

$$\frac{|R|_m}{|R_0|_m} = \frac{|R|_m^{\frac{77}{48}}}{|R_0|_{m_0}^{\frac{77}{48}}} \quad ➔ \quad \frac{|R|_m}{|R_0|_{m_0}} = \frac{|R|_m^{\frac{48}{77}}}{|R_0|_m^{\frac{48}{77}}} \qquad (28)$$

Equation (26) is also specified with $\frac{|R|_m}{|R_0|_{m_0}}$ to $\frac{|\lambda(R)|_m}{|\lambda(R_0)|_m} = \left(\frac{|R|_m}{|R_0|_{m_0}}\right)^{\frac{29}{48}}$ and then results with (28) in: $\frac{|\lambda(R)|_m}{|\lambda(R_0)|_m} = \left(\frac{|R|_m}{|R_0|_m}\right)^{\frac{48}{77}*\frac{29}{48}} = \left(\frac{|R|_m}{|R_0|_m}\right)^{\frac{29}{77}}$. Equation $\frac{|\lambda(R)|_m}{|\lambda(R_0)|_m} = \left(\frac{|R|_m}{|R_0|_m}\right)^{\frac{29}{77}}$ can be inserted in (27). This equation then becomes $\left(\frac{|R_0|_m}{|R|_m}\right)^{\frac{29}{77}} * \frac{|R|_m}{|R_0|_m} = 1089$ and thus

$$\frac{|R|_m}{|R_0|_m} = 1089^{\frac{77}{48}} = 74455.86 \qquad (29)$$

(29) inserted in (28) results in $\frac{|R|_m}{|R_0|_{m_0}} = \frac{|R|_m^{\frac{48}{77}}}{|R_0|_m^{\frac{48}{77}}} = 1089$ (30)

$$\text{The factor } \left(\frac{|R|_m}{|R_0|_{m_0}}\right)^{\frac{29}{48}} = 1089^{\frac{29}{48}} = 68.371$$

Based on the power representation of the physical constants, the Hubble radius has increased by a factor of 74 455.86 since the last scattering and was $R_0 = \frac{R}{74455.86} = \frac{1.292*10^{26}}{74455.86} = 1.735 * 10^{21}\text{m}$ at the time of the last scattering. The wavelength at the time of the respective emission has increased by a factor of $\frac{|\lambda(R)|_m}{|\lambda(R_0)|_m} = \left(\frac{|R|_m}{|R_0|_{m_0}}\right)^{\frac{29}{48}} = (1089)^{\frac{29}{48}} = 68.371$ since the last scattering, resulting in a net ratio of $\frac{|\lambda(R_0)|_m}{|\lambda(R)|_m} * \frac{|R|_m}{|R_0|_m} = \frac{74455.86}{68.371} = 1089 = \left(\frac{|R_0|_{m_0}}{|R|_m}\right)^{\frac{29}{48}} * \frac{|R|_m}{|R_0|_m} = (74455.86)^{\frac{48}{77}}$, which is decisive for the redshift.

According to the power representation the ratio of the proton mass to the electron mass has increased by the factor $\frac{\frac{m_p}{m_e}}{\frac{m_{p_0}}{m_{e_0}}} = \left(\frac{|R|_m}{|R_0|_{m_0}}\right)^{\frac{1}{8}} = 1089^{\frac{1}{8}} = 2.397$ .

Accordingly, at the time of last scattering, it was $\frac{m_{p_0}}{m_{e_0}} = \frac{1836.153}{2.397} = 766.091$ .

The ratio of the metre measure $m_0$ at the time of last scattering to the current metre measure m is $m_0 = \frac{m}{\left(\frac{|R|_m}{|R_0|_{m_0}}\right)^{\frac{29}{48}}} = \frac{m}{68.371}$ .

If we compare the Hubble radius according to (30) ( $\frac{|\mathrm{R}|_m}{|\mathrm{R}_0|_{m_0}} = 1089$ ) at the time of the last scattering with the current Hubble radius in the respective metre scale resulting from the power representation in combination with the SI definition, then this ratio corresponds to the elongation factor of 1089 determined from the measured redshift of the cosmic background radiation.

Using (30) and taking equation (25) ( $\frac{|\lambda(\mathrm{R})|_m}{|\lambda(\mathrm{R}_0)|_{m_0}} = 1$) into account, equation (27) becomes

$$\frac{|\lambda(\mathrm{R}_0)|_{m_0}}{|\lambda(\mathrm{R})|_m} * \frac{|\mathrm{R}|_m}{|\mathrm{R}_0|_{m_0}} = 1089 \qquad \text{resp.} \qquad 1 * \frac{|\mathrm{R}|_m}{|\mathrm{R}_0|_{m_0}} = 1089 \qquad (31)$$

Equation (31) describes the perspective of a fictitious ancient observer who measured the Hubble radius and the wavelength of the background radiation with an ancient metre scale according to the SI definition at the time of the last scattering and relates the old values to the current values of the Hubble radius and the wavelength of the background radiation measured with the current metre scale.

The next exciting question is how the power representation of the physical constants affects the ratio of the apparent brightness to the redshift of distant cosmic objects such as type 1a supernovae (keyword: Supernova Cosmology Project).

The starting point is the definition of the redshift: $\mathrm{z} = \frac{\Delta\lambda}{\lambda_0} = \frac{\lambda_\mathrm{B} - \lambda_0}{\lambda_0} = \frac{\lambda_\mathrm{B}}{\lambda_0} - 1$ , where $\lambda_\mathrm{B}$ is the wavelength measured by the observer and $\lambda_0$ is the original wavelength given by the cosmic object at the time of emission. While $\lambda_\mathrm{B}$ can be measured very precisely, $\lambda_0$ must be determined by making certain (cosmological) assumptions. Standard cosmology, for example, assumes that type 1a supernovae emitted billions of years ago in the same way as they still emit today. They therefore represent standard candles postulated for the standard model, on the basis of which the distances in the universe have so far been determined. However from the relationships derived by means of power representation of the physical constants, the assumption of the standard cosmology that these objects emitted with constant wavelengths over billions of years is no longer given within the framework of the power representation.

According to (26) — $\frac{|\lambda(\mathrm{R})|_m}{|\lambda(\mathrm{R}_0)|_m} = \left(\frac{|\mathrm{R}|_m}{|\mathrm{R}_0|_{m_0}}\right)^{\frac{29}{48}}$ —, in the power representation the emitted wavelength, measured on a constant metre scale, is a function of the Hubble radius and thus a quantity dependent on the expansion of the universe and time. In standard cosmology, the emitted wavelength measured with a constant metre scale would be constant $\frac{|\lambda_{\text{standard model}}(\mathrm{R})|_m}{|\lambda_{\text{standard model}}(\mathrm{R}_0)|_m} = 1$. In the power representation, the emitted wavelength is only constant if one takes into account that the metre itself changes according to the SI definition ( $\frac{\mathrm{m}}{\mathrm{m}_0} = \left(\frac{|\mathrm{R}|_m}{|\mathrm{R}_0|_{m_0}}\right)^{\frac{29}{48}}$ ). Then $\frac{|\lambda(\mathrm{R})|_m}{|\lambda(\mathrm{R}_0)|_{m_0}} = 1$ applies.

When measuring the cosmic redshift, the wavelength of the old, previously emitted light is compared with the wavelength of currently emitted light, both on the metre scale currently available. The redshift in the power representation is therefore made up of two parts: First the redshift according to the temporal change of the physical constants according to the power representation and second the redshift due to space expansion (increase of the Hubble radius).

Using the example of cosmic background radiation - for the redshift of the last scattering the following applies: 1089=(z+1) - equation (29) results in $\frac{|R|_m}{|R_0|_m} = 1089^{\frac{77}{48}} = (z+1)^{\frac{77}{48}}$. So while the power representation gives the following relationship between redshift and Hubble radius:

$$z = \left(\frac{|R|_m}{|R_{0\ \text{power}}|_m}\right)^{\frac{48}{77}} - 1 \qquad \text{or} \qquad \frac{|R|_m}{|R_{0\ \text{power}}|_m} = (z+1)^{\frac{77}{48}} \qquad (32)$$

, the connection according to standard cosmology at a constant expansion rate (flat, non-accelerated universe) would be: $z_{\text{ref}} = \frac{|R|_m}{|R_{0\ \text{ref}}|_m} - 1$ or $\frac{|R|_m}{|R_{0\ \text{ref}}|_m} = z_{\text{ref}} + 1$.

With the same redshift ($z_{\text{ref}} = z$), the observed astronomical object is therefore further away in the power representation than in the standard reference case:

$$\frac{\frac{|R|_m}{|R_{0\ \text{power}}|_m}}{\frac{|R|_m}{|R_{0\ \text{ref}}|_m}} = \frac{|R_{0\ \text{ref}}|_m}{|R_{0\ \text{power}}|_m} = \frac{(z+1)^{\frac{77}{48}}}{z+1} = (z+1)^{\frac{29}{48}} \qquad (33),$$

as the ratio $\frac{|R|_m}{|R_{0\ \text{power}}|_m}$ is greater than the ratio $\frac{|R|_m}{|R_{0\ \text{ref}}|_m}$, i.e. the light has already travelled longer in the power representation. In the case of last scattering (z = 1088), this results in:

$$\frac{\frac{|R|_m}{|R_0|_m}}{\frac{|R|_m}{|R_{0\ \text{ref}}|_m}} = \frac{74455.86}{1089} = 1089^{\frac{29}{48}} = 68.371$$

As the actual distance of a distant astronomical object determines its apparent brightness, it appears closer than it actually is due to the measured redshift. Due to this fact, an accelerated expansion of the universe was assumed within the framework of standard cosmology and dark energy was postulated as the cause of this accelerated expansion. However, it is still not clear what the nature of this dark energy is.

In order to be able to derive the exact relationship between apparent brightness and redshift within the framework of the power representation, an exact explicit relationship between the luminosity of a type 1a supernova and the physical constants (c, h, G, α) would be required in order to be able to create a power representation of the luminosity. However, as the author was unable to find such an explicit equation in the literature, only a rough estimate of the dependence of the luminosity on the Hubble radius is made in this paper. But the author has found some critical remarks (Six indications of radical new physics in supernovae 1a - [see 8]) on the nature of the standard candle supernova type 1a.

A first step in estimating the dependence of the luminosity on the Hubble radius is the dependence of the photon energy $E = h\nu = \frac{ch}{\lambda}$ on the Hubble radius.

To do this, it must be remembered that $|c| \sim \frac{1}{|R|^{\frac{1}{8}}}$, $|h| \sim |R|^{\frac{3}{4}}$ and $|\lambda| \sim |R|^{\frac{29}{48}}$ and therefore $|E| \sim \frac{|R|^{\frac{3}{4}}}{|R|^{\frac{1}{8}} * |R|^{\frac{29}{48}}} = |R|^{\frac{1}{48}}$ applies. The luminosity corresponds to a power, i.e. the total photon energy emitted per second $L = \frac{E_{total}}{s}$ . Due to a lack of further information (such as the number of photons emitted per time unit), for the estimation of the luminosity here, it is also assumed:

$|L| \sim |R|^{\frac{1}{48}}$ . Then the following applies to the light flux density, which is inversely proportional to the square of the Hubble radius ( $f \sim \frac{L}{R^2}$ ) : $|f| \sim \frac{|R|^{\frac{1}{48}}}{|R|^2} = \frac{1}{|R|^{\frac{95}{48}}}$ and it follows from (32):

$$\frac{f(R)_{Power}}{f(R_0)} = (\frac{|R_0|_m}{|R|_m})^{\frac{95}{48}} = (\frac{1}{(z+1)^{\frac{77}{48}}})^{\frac{95}{48}} = \frac{1}{(z+1)^{3.1749}} \qquad (34)$$

For the light flux density with non-accelerated expansion in standard cosmology, however, the following applies: $\frac{f(R)_{Reference}}{f(R_0)} = (\frac{|R_0|_m}{|R|_m})^2 = \frac{1}{(z+1)^2}$

If the light flux density of the power representation is compared with that of the non-accelerated reference with the same reference value $f(R_0)$, we have the ratio:

$$\frac{f(R)_{Power}}{f(R)_{Reference}} = \frac{(z+1)^2}{(z+1)^{3.1749}}$$

The difference in apparent brightness is usually defined as $\Delta m = -\frac{5}{2}\log\frac{f(R)}{f(R_0)}$ .

If this relationship is applied to the difference between power representation and non-accelerated expansion in standard cosmology, an estimate is obtained for the difference in apparent brightness as a function of the value of the redshift: $\Delta m \approx -\frac{5}{2}\log\frac{f(R)_{Power}}{f(R)_{Reference}} = -\frac{5}{2}\log\frac{(z+1)^2}{(z+1)^{3.1749}}$ .

A redshift of 1 results in a difference of $\Delta m(z = 1) \approx -\frac{5}{2}\log\frac{(2)^2}{(2)^{3.1749}} = 0.8842$ .

Although it must be emphasised here that this value can only be a rough estimate due to a lack of detailed information, it corresponds in terms of magnitude to what is known from the Supernova Cosmology Project and is assigned to an accelerated expansion of the universe within the framework of standard cosmology [see 9].

Another interesting question is how the power representation affects the Hubble constant itself. Assuming that $H \sim \frac{c}{R} \sim \frac{1}{R^{\frac{1}{8}} * R} \sim \frac{1}{R^{\frac{9}{8}}}$, the result is

$$\frac{|H(R)|_{\frac{1}{s}}}{|H(R_0)|_{\frac{1}{s}}} = \left(\frac{|R_0|_{m_0}}{|R|_m}\right)^{\frac{9}{8}} \qquad (35)$$

Taking into account that for the time scale $s \sim R^{\frac{35}{48}}$ applies, then we have

$$\frac{s}{s_0} = \left(\frac{|R|_m}{|R_0|_{m_0}}\right)^{\frac{35}{48}} \Rightarrow \frac{\frac{1}{s_0}}{\frac{1}{s}} = \left(\frac{|R|_m}{|R_0|_{m_0}}\right)^{\frac{35}{48}} \Rightarrow \frac{1}{s} = \frac{\frac{1}{s_0}}{\left(\frac{|R|_m}{|R_0|_{m_0}}\right)^{\frac{35}{48}}} \Rightarrow$$

$$\left|H(R_0)\right|_{\frac{1}{s}} = \left|H(R_0)\right|_{\frac{1}{s_0}} * \left(\frac{|R|_m}{|R_0|_{m_0}}\right)^{\frac{35}{48}}$$ ➔ (35) then becomes

$$\frac{|H(R)|_{\frac{1}{s}}}{|H(R_0)|_{\frac{1}{s_0}} * \left(\frac{|R|_m}{|R_0|_{m_0}}\right)^{\frac{35}{48}}} = \left(\frac{|R_0|_{m_0}}{|R|_m}\right)^{\frac{9}{8}} \Rightarrow \frac{|H(R)|_{\frac{1}{s}}}{|H(R_0)|_{\frac{1}{s_0}}} * \left(\frac{|R_0|_{m_0}}{|R|_m}\right)^{\frac{35}{48}} = \left(\frac{|R_0|_{m_0}}{|R|_m}\right)^{\frac{54}{48}} \Rightarrow$$

$$\frac{|H(R)|_{\frac{1}{s}}}{|H(R_0)|_{\frac{1}{s_0}}} = \left(\frac{|R_0|_{m_0}}{|R|_m}\right)^{\frac{19}{48}} \qquad (36)$$

As can be seen from (35) ( $\frac{|H(R)|_{\frac{1}{s}}}{|H(R_0)|_{\frac{1}{s}}} = \left(\frac{|R_0|_{m_0}}{|R|_m}\right)^{\frac{9}{8}}$ ) , the value of the Hubble constant measured in a constant second scale decreases faster than the magnitude of R - measured in the metre scale resulting in each case according to the SI definition - increases. Without the power representation, the change in the Hubble constant $\frac{H(R)}{H(R_0)_{\text{Reference}}} = \frac{|R_0|_m}{|R|_m}$ would be inversely proportional to the change in R, measured in fixed metres. The power representation results in larger values for the Hubble constant for earlier times. This corresponds to the fact that the power representation also results in a higher speed of light for earlier times, provided it is represented in the fixed unit of measurement m/s:

$$\left|c(R_0)\right|_{\frac{m}{s}} = \left|c(R)\right|_{\frac{m}{s}} * \left(\frac{|R|_m}{|R_0|_{m_0}}\right)^{\frac{1}{8}}.$$

This speed is used to calculate the Hubble constant in power notation $\left|H(R_0)_{\text{Power}}\right|_{\frac{1}{s}} = \frac{|c(R_0)|_{\frac{m}{s}}}{|R_0|_m} = \frac{|c(R)|_{\frac{m}{s}}}{|R_0|_m} * \left(\frac{|R|_m}{|R_0|_{m_0}}\right)^{\frac{1}{8}}$ . Without power representation, the result is $\left|H(R_0)_{\text{Reference}}\right|_{\frac{1}{s}} = \frac{|c(R)|_{\frac{m}{s}}}{|R_0|_m}$ and we have

$$\frac{|H(R_0)_{\text{Power}}|_{\frac{1}{s}}}{|H(R_0)_{\text{Reference}}|_{\frac{1}{s}}} = \left(\frac{|R|_m}{|R_0|_{m_0}}\right)^{\frac{1}{8}}.$$

How does the ratio of $H(R_0)_{\text{Power}}$ to $H(R_0)_{\text{Reference}}$ depend on the redshift? Let us recall (33) in a slightly different form: $\left|R_{0\,\text{pow}}\right|_m = \frac{|R_{0\,\text{ref}}|_m}{(z+1)^{\frac{29}{48}}}$ . The following applies to the reference Hubble constant: $\frac{|H(R_0)_{\text{Reference}}|_{\frac{1}{s}}}{|H(R)|_{\frac{1}{s}}} = \frac{|R|_m}{|R_{0\,\text{ref}}|_m} = z + 1$ .

By transforming (35) and inserting (28) and (33), we have:

$\frac{|H(R)|_{\frac{1}{s}}}{|H(R_0)_{Power}|_{\frac{1}{s}}} = \left(\frac{|R_{0\,pow}|_{m_0}}{|R|_m}\right)^{\frac{9}{8}} = \left(\frac{|R_{0\,pow}|_m^{\frac{48}{77}}}{|R|_m^{\frac{48}{77}}}\right)^{\frac{9}{8}} = \left(\frac{|R_{0\,pow}|_m}{|R|_m}\right)^{\frac{54}{77}} = \left(\frac{|R_{0\,ref}|_m}{|R|_{m}*(z+1)^{\frac{29}{48}}}\right)^{\frac{54}{77}} =$

$\left(\frac{1}{(z+1)*(z+1)^{\frac{29}{48}}}\right)^{\frac{54}{77}} = \left(\frac{1}{(z+1)^{\frac{77}{48}}}\right)^{\frac{54}{77}} = \frac{1}{(z+1)^{\frac{54}{48}}} = \frac{1}{(z+1)^{\frac{9}{8}}}$ . $H(R_0)_{Reference}$ and $H(R_0)_{Power}$ in relation to each other results in $\frac{|H(R_0)_{Reference}|_{\frac{1}{s}}}{|H(R_0)_{Power}|_{\frac{1}{s}}} = \frac{z+1}{(z+1)^{\frac{9}{8}}} = \frac{1}{(z+1)^{\frac{1}{8}}}$ .

$$\frac{|H(R_0)_{Power}|_{\frac{1}{s}}}{|H(R_0)_{Reference}|_{\frac{1}{s}}} = (z+1)^{\frac{1}{8}} \qquad (37)$$

According to (37), the Hubble constant for the same redshift is therefore greater for the power representation than without the power representation. For example, at z =1, the ratio is 1.0905. Could this be the reason why slightly different values are obtained for the Hubble constant in the frame of standard cosmology depending on which method is used or which redshifts are included in the calculation? Some people refer to this as the "Hubble Tension", i.e. the tension caused by the different values for the Hubble constant within the framework of standard cosmology [see 10].

Until now, we have explicitly managed our calculations without the parameter time in our equations. This is due to the fact that our equations always refer to the Hubble radius, which naturally grows with time and therefore implicitly contains the parameter time. But what is the exact relationship between the Hubble radius and time in the power representation? In order to roughly analyse this in advance, it is best to start from the Hubble time $\tau = \frac{R}{c}$ and consider the correlation (2) $|c(R)| \approx \frac{\left(\frac{2\pi}{\alpha}\right)^4}{R^{\frac{1}{8}}}$.

This results in the power representation for the Hubble time $|\tau(R)| \approx \frac{R^{\frac{9}{8}}}{\left(\frac{2\pi}{\alpha}\right)^4}$. If we take into account that the unit of measurement second also changes with the Hubble radius (1s $\sim R^{\frac{35}{48}}$ ) , and thus:

$$\frac{\tau(R)*s}{\tau(R_0)*s_0} = \left(\frac{|R|_m}{|R_0|_{m_0}}\right)^{\frac{9}{8}} \rightarrow \qquad \frac{|\tau(R)|_s}{|\tau(R_0)|_{s_0}} * \left(\frac{|R|_m}{|R_0|_{m_0}}\right)^{\frac{35}{48}} = \left(\frac{|R|_m}{|R_0|_{m_0}}\right)^{\frac{9}{8}} \rightarrow$$

$$\frac{|\tau(R)|_s}{|\tau(R_0)|_{s_0}} = \left(\frac{|R|_m}{|R_0|_{m_0}}\right)^{\frac{19}{48}} \qquad \text{resp.} \qquad |R|_m \sim |\tau(R)|_s^{\frac{48}{19}} \qquad (38)$$

If the correlations (2) to (6) apply, then with the valid SI definitions for the metre, the second and the kilogram, the value of the Hubble time with the increasing Hubble radius R (with an expanding universe) is determined to be proportional to $R^{\frac{19}{48}}$ , while the units of measurement for length and time also increase with the increasing Hubble radius.

A comparison of (36) ( $\frac{|H(R)|_{\frac{1}{s}}}{|H(R_0)|_{\frac{1}{s_0}}} = \left(\frac{|R_0|_{m_0}}{|R|_m}\right)^{\frac{19}{48}}$ ) with (38) shows that, as expected, the Hubble time is also inversely proportional to the Hubble constant in the power representation

$$\frac{|H(R_0)|_{\frac{1}{s_0}}}{|H(R)|_{\frac{1}{s}}} = \frac{|\tau(R)|_s}{|\tau(R_0)|_{s_0}} = \left(\frac{|R|_m}{|R_0|_{m_0}}\right)^{\frac{19}{48}}$$

In our considerations so far, we have ignored the dynamic effect of gravity on the universe, which results from the general theory of relativity. The exciting question now is how the power representation of the physical constants affects the dynamics of the universe. To investigate this, we must first remember that according to standard cosmology the temporal development of the universe is described by the Friedmann equation according to standard cosmology based on the general theory of relativity.

$$\frac{R'^2}{R^2} + \frac{kc^2}{R^2} = \frac{8\pi G}{3}\rho \qquad (39)$$

The term k in equation (39) stands for the basic curvature of the empty universe, where k = 0 corresponds to a flat geometry, k = 1 to a spherical geometry and k = -1 to a hyperbolic geometry. ρ stands for the mean density of the universe. As the observations so far show that the geometry of the universe appears to be flat, we will assume in the following that k = 0. For our further calculations, we assume that the value of the mean density of the universe is equal to the critical density $\rho_c$, which results in a flat geometry of the universe. This assumption does not mean that we want to claim that the density of the universe must correspond exactly to the critical density, but rather serves to demonstrate how the power representation of the physical constants affects a possibly flat universe. If the density of the universe is possibly not exactly critical, the power representation of the physical constants would tend to have a similar effect as on a flat universe. According to the theory of relativity the following applies to the critical density [see 11]:

$$\rho_c = \frac{3H^2}{8\pi G} = \frac{3c^2}{8\pi R^2 G} \qquad (40)$$

If equation (40) and k = 0 are inserted into (39), the result is

$$R' = \frac{dR}{dt} = c \quad \text{resp.} \quad dR = c * dt \qquad (41)$$

Without taking the power representation into account, this would correspond to a constant, non-accelerated expansion. But corresponding to observations an accelerated expansion was assumed. According to the power representation, however, both the speed of light c and the time scale (the second) are a function of R: $\frac{|c(R)|_{\frac{m}{s}}}{|c(R_0)|_{\frac{m}{s}}} = \frac{1}{\left(\frac{|R|_m}{|R_0|_{m_0}}\right)^{\frac{1}{8}}} = \left(\frac{|R_0|_{m_0}}{|R|_m}\right)^{\frac{1}{8}}$ and $\frac{1s}{1s_0} = \left(\frac{|R|_m}{|R_0|_{m_0}}\right)^{\frac{35}{48}}$

Accordingly $|c(R)|_{\frac{m}{s}} = \left(\frac{|R_0|_{m_0}}{|R|_m}\right)^{\frac{1}{8}} * |c(R_0)|_{\frac{m}{s}}$ . Since the duration of a second is a function of R, the differential of time is also a function of R: $\frac{|dt|_s}{|dt|_{s_0}} = \left(\frac{|R|_m}{|R_0|_{m_0}}\right)^{\frac{35}{48}}$ .

$|dt|_{s_0}$ is the value of the differential of time, measured with a fixed second scale, which corresponds to the Hubble radius $|R_0|_{m_0}$ and the metre $m_0$ at a certain point in time.

The Friedmann equation for a flat universe of critical density according to (41) in the power representation then results in:

$$\left|\mathrm{dR}\right|_m = \left|\mathrm{c(R)}\right|_{\frac{m}{s}} * \left|\mathrm{dt}\right|_s = \left|\mathrm{c(R_0)}\right|_{\frac{m}{s}} * \left(\frac{\left|\mathrm{R_0}\right|_{m_0}}{\left|\mathrm{R}\right|_m}\right)^{\frac{1}{8}} * \left(\frac{\left|\mathrm{R}\right|_m}{\left|\mathrm{R_0}\right|_{m_0}}\right)^{\frac{35}{48}} * \left|\mathrm{dt}\right|_{s_0} = \left(\frac{\left|\mathrm{R}\right|_m}{\left|\mathrm{R_0}\right|_{m_0}}\right)^{\frac{29}{48}} * \left|\mathrm{c(R_0)}\right|_{\frac{m}{s}} * \left|\mathrm{dt}\right|_{s_0} \quad \Rightarrow$$

$$\frac{\left|\mathrm{dR}\right|_m}{\left|\mathrm{R}\right|_m^{\frac{29}{48}}} = \frac{\left|\mathrm{c(R_0)}\right|_{\frac{m}{s}} * \left|\mathrm{dt}\right|_{s_0}}{\left|\mathrm{R_0}\right|_{m_0}^{\frac{29}{48}}} \qquad (42) \Rightarrow$$

$$\left|\mathrm{dt}\right|_{s_0} = \frac{\left|\mathrm{R_0}\right|_{m_0}^{\frac{29}{48}}}{\left|\mathrm{c(R_0)}\right|_{\frac{m}{s}}} * \frac{\left|\mathrm{dR}\right|_m}{\left|\mathrm{R}\right|_m^{\frac{29}{48}}} \qquad (43)$$

Integration of (43) results in $\left|\mathrm{t}\right|_{s_0} = \frac{48}{19} * \frac{\left|\mathrm{R_0}\right|_{m_0}^{\frac{29}{48}}}{\left|\mathrm{c(R_0)}\right|_{\frac{m}{s}}} * \left|\mathrm{R}\right|_m^{\frac{19}{48}} + \mathrm{b}$

If, according to the general theory of relativity, the universe expands out of a singularity whose extreme minimum dimension is not exactly known, the boundary condition R $\sim$ 0 at t = 0 can be formulated approximately without accepting a relevant inaccuracy. This results in b = 0 for the integration constant and

$$\left|\mathrm{t}\right|_{s_0} = \frac{48}{19} * \frac{\left|\mathrm{R_0}\right|_{m_0}^{\frac{29}{48}}}{\left|\mathrm{c(R_0)}\right|_{\frac{m}{s}}} * \left|\mathrm{R}\right|_m^{\frac{19}{48}} \qquad (44)$$

For R = $R_0$ (44) results in $\left|\mathrm{t}\right|_s = \frac{48}{19} * \frac{\left|\mathrm{R_0}\right|_m}{\left|\mathrm{c(R_0)}\right|_{\frac{m}{s}}}$ resp. $\left|\mathrm{R_0}\right|_m = \frac{19}{48} * \left|\mathrm{c(R_0)}\right|_{\frac{m}{s}} * \left|\mathrm{t}\right|_s$ if one takes into account that then R = $R_0$, m = $m_0$ and s = $s_0$. (44) expressed by $\left|\mathrm{R}\right|_m$ gives

$$\left|\mathrm{R}\right|_m = \frac{\left(\frac{19}{48} * \left|\mathrm{c(R_0)}\right|_{\frac{m}{s}} * \left|\mathrm{t}\right|_{s_0}\right)^{\frac{48}{19}}}{\left|\mathrm{R_0}\right|_{m_0}^{\frac{29}{19}}} \qquad (45) \quad \text{and}$$

$$\left|\mathrm{R}\right|_m \sim \left|\mathrm{t}\right|_{s_0}^{\frac{48}{19}} \sim \left|\mathrm{t}\right|_{s_0}^{2.526} \qquad \text{resp.} \qquad \left|\mathrm{t}\right|_{s_0} \sim \left|\mathrm{R}\right|_m^{\frac{19}{48}} \qquad (46)$$

The term $\left|\mathrm{c(R_0)}\right|_{\frac{m}{s}} * \left|\mathrm{dt}\right|_{s_0}$ in (42) results in a differentially small distance with a fixed value, since $\left|\mathrm{c(R_0)}\right|_{\frac{m}{s}}$ is the speed of light at a certain point in time with the Hubble radius $R_0$ and the differential $\left|\mathrm{dt}\right|_{s_0}$ also has a fixed value. If we take into account that the integration represents a "summation" of the differentially small fixed portions of the distance $\left|\mathrm{dR}\right|_m = \left|\mathrm{c(R_0)}\right|_{\frac{m}{s}} * \left|\mathrm{dt}\right|_{s_0}$, we understand that, because of the non-linear power representation term $\left|\mathrm{R}\right|_m^{\frac{29}{48}}$ in (42), there is a non-linear relationship between the Hubble radius $\left|\mathrm{R}\right|_m$, measured in the respective metre scale according to the SI definition and the elapsed cosmic time $\left|\mathrm{t}\right|_{s_0}$ , measured on a fixed scale for all times. Although our starting point was a linear form of the Friedmann equation for a flat universe of critical density in (41), the power representation of the physical constants with their dependence on the Hubble radius R thus brings non-linearity into the result (46) of the integrated Friedmann equation.

The power representation of the physical constants therefore suggests an expansion of the universe that accelerates with time. Even with a flat universe of critical density, the non-linear relationship is: $\left|\mathrm{R}\right|_{m} \sim \left|\mathrm{t}\right|_{s_0}^{2.526}$ . So can the need to introduce dark energy be omitted when using the power representation for the physical constants? A good question, which we will leave open for the time being.

By the way: The exponent of $\frac{19}{48}$ in equation (44) or (46) has already appeared in the Hubble time in (38).

Overall, there is no cosmological argument for the time being why the very remarkable power representation of the physical constants should not apply. The numerical correlations that can be found between the physical constants and the fine-structure constant with the aid of the power representation are too astounding to be lightly dismissed or ignored.

So if, according to the power representation, the values of the fundamental physical constants can be traced back to one, namely the fine-structure constant, the question remains why this constant has the value 1/137.036?

Even the question of why the fine-structure constant has the value 1/137.036 could have an answer based on geometric considerations. Therefore imagine that space contains string-like entities whose volume corresponds closely to the wavelength that can be assigned to the mass $\mathrm{m_x} = [\,\mathrm{m_e} * \mathrm{m_p}\,]^{1/2}$. Let us therefore assign the wavelength $\lambda_\mathrm{x} = \mathrm{h}/2\pi\mathrm{c}\mathrm{m_x}$ to the mass $m_x$ and use $\lambda_x$ to calculate the spherical volume $\mathrm{V_O} = \frac{4\pi\lambda_\mathrm{x}{}^3}{3} = \frac{4\pi\mathrm{h}^3}{3*8\pi^3\mathrm{c}^3\mathrm{m_x}{}^3} = \frac{\mathrm{h}^3}{6\pi^2\mathrm{c}^3\mathrm{m_x}{}^3}$ . Then we take the value of the maximum packing density of spheres in space $\rho_\mathrm{O} = \frac{\pi}{3\sqrt{2}} = 0.74048$ and calculate the gross volume that each sphere with $V_O$ would occupy with the densest possible sphere packing in space: $\mathrm{V_B} = \frac{\mathrm{V_O}}{\rho_\mathrm{O}} = \frac{3\sqrt{2}\mathrm{h}^3}{\pi 6\pi^2\mathrm{c}^3\mathrm{m_x}{}^3} = \frac{\sqrt{2}\mathrm{h}^3}{2\pi^3\mathrm{c}^3\mathrm{m_x}{}^3}$ .

Now we take a circular cross-section $A_x$ with the radius of a Planck length ( $\mathrm{l_{pl}}{}^2 = \frac{\mathrm{Gh}}{\mathrm{c}^3}$ ) i.e. $\mathrm{A_x} = \pi\mathrm{l_{pl}}{}^2 = \frac{\pi\mathrm{Gh}}{\mathrm{c}^3}$ , and calculate the volume of a string of cross-section $A_x$ and the length of 2πR, i.e. the circumference of a circle with the Hubble radius: $\mathrm{V\_} = 2\pi\mathrm{R}\mathrm{A_x} = \frac{2\pi^2\mathrm{RGh}}{\mathrm{c}^3}$ .

If we set the two volumes to be equal ( $\mathrm{V_B} = \mathrm{V\_}$ ), we obtain the equation $\frac{\sqrt{2}\mathrm{h}^3}{2\pi^3\mathrm{c}^3\mathrm{m_x}{}^3} = \frac{2\pi^2\mathrm{RGh}}{\mathrm{c}^3}$ . This equation can be transformed into

$$\mathrm{m_x}{}^3 = \frac{\sqrt{2}}{4\pi^5} * \frac{\mathrm{h}^2}{\mathrm{RG}} \qquad (47)$$

If one compares equation (47) with equation (1), i.e. ${m_x}^3 = \frac{e^2 h}{4\pi\epsilon_o cGR} = \frac{\alpha}{2\pi} * \frac{h^2}{GR}$, one will immediately recognise the identical structure of the two. In order for the equations to be numerically identical, $\frac{\alpha}{2\pi} \approx \frac{\sqrt{2}}{4\pi^5}$ must apply, i.e.

$$\frac{1}{\alpha} \approx \sqrt{2} * \pi^4 = 137.7573 \qquad \text{resp.} \qquad \alpha \approx \frac{1}{\sqrt{2}*\pi^4} = \frac{1}{137.7573} \qquad (48)$$

By deriving the fine-structure constant $\alpha = \frac{e^2}{2\epsilon_0 ch} = \frac{1}{137.036}$ approximately geometrically (with an accuracy of 5.2 per mille, that the derived value is too small), we have also derived the formula (1) ${m_x}^3 = \frac{\alpha}{2\pi} * \frac{h^2}{GR}$ approximately geometrically. This is a more than astonishing fact that is very thought-provoking!

As a reminder: In 2022, the author carried out a quantum mechanical derivation of equation (1) entitled "Electron Mass and Proton Mass: The Derivation" (see [12]).

**Summary and conclusions:**

As we have seen, the values of the physical constants c, h, G, $e^2/4\pi\epsilon_o$ can be represented as integer powers of $\frac{2\pi}{\alpha} = \frac{4\pi\epsilon_o ch}{e^2} = 861.023$ and $\frac{m_p}{m_e} = 1836.15$ if a system of units with a unit of length of 1.0128 m, a unit of time of 1.0112 s and a unit of mass of 1.1531 kg is used. It is a clear and unsurprising fact that the system of units used determines the numerical values of the physical constants. But it was not to be expected that the fundamental physical constants could be represented as integer power values of $\frac{2\pi}{\alpha}$ and $\frac{m_p}{m_e}$ in a system of units that is very close to the SI system.

Of course, the physical constants c, h, G, $e^2/4\pi\epsilon_o$ can also assume other integer power values of $\frac{2\pi}{\alpha}$ and $\frac{m_p}{m_e}$, than those that result at $l_x$ = 1.0128 m, $t_y$ = 1.0112 s and $m_z$ = 1.1531 kg. However, this would require the use of a system of units that is numerically far removed from what we perceive as natural, because it corresponds to our familiar orders of magnitude. Can it really be random that a system of "emergence values" for the integer power representation exactly matches the orders of magnitude for our familiar units of measurement or is it not rather the case that we owe our existence and perspective on the world to these very specific "emergence values" and then naturally define our standards according to the dimensions of this value system?!

As we can observe every day, nature is subject to continuous change. The endeavour of the natural sciences is to describe this physically (insofar as it is not subject to pure physical randomness) and thus make it somewhat predictable and describable. In order to make such physical descriptions comprehensible, physical constants and standards for the basic units are required. Without such fixed reference points, a comprehensible description of nature, that extends beyond the human lifespan fails. But are the physical constants really constant in cosmic space and time dimensions and what about the constancy of our basic units of metres, seconds and kilograms according to the SI definition? If these were not constant, what fixed point(s) do we still have for our measurements in cosmic space and time dimensions? We must at least have a reference or fixed point for our measurements and descriptions, otherwise we will lose ourselves in arbitrariness.

Lo and behold! The power representation of the physical constants offers us such a fixed point, the fine-structure constant $\alpha = \frac{e^2}{2\epsilon_0 ch} = \frac{1}{137.036}$ . And where does the variability in the course of nature come from? Which quantity best describes the cosmic motor that drives everything? Here, the power representation of the physical constants offers us the Hubble radius R:

$$|R| \approx \left(\frac{m_p}{m_e}\right)^8 = 1.292 * 10^{26}$$

The Hubble radius grows over time, as we can see from cosmic observation, and according to the power representation the physical constants and scales grow or shrink with it, depending on whether they are proportional or inversely proportional to the Hubble radius. For some physical constants, such as the speed of light c, the electron mass $m_e$ or the term $\frac{e^2}{4\pi\epsilon_0}$ , the changes in the numerical value and the corresponding scale unit cancel each other out and we can observe them as constant.

The power representation of the physical constants therefore provides us with both, the temporal behaviour of the physical constants as well as the temporal behaviour of the units of measurement. From this point of view, there is no need to speculate about which physical constants in formula (1)

${m_x}^3 = \frac{e^2 h}{4\pi\epsilon_0 cGR} = \frac{\alpha}{2\pi} * \frac{h^2}{GR} = \frac{1}{861.023} * \frac{h^2}{GR}$ are really constant and which are actually variable.

When the author in his work "Cosmos 2.0 An Innovative Description of the Universe" [see 3] was not yet aware of the power representation of the physical constants, he instinctively decided on a variable gravitational constant G and variable particle masses ($m_e$ and $m_p$) to compensate for the obvious change of R in (1), which was not entirely wrong. Also from the perspective of the power representation of the physical constants, the gravitational constant G and the proton mass $m_p$ are the most variable physical constants. For these two quantities, the changes in scale do not compensate for the changes in the numerical value. This is not the case with the electron mass, where the changes in the numerical value and the change in the unit kilogramme compensate each other. If we start from the power representation of the physical constants, the cosmological consequences of the power representation of the physical constants with their special effects on the individual physical constants have to replace the Cosmos 2.0 model presented at that time.

As we have seen, the power representation of the physical constants can be well reconciled with the measured cosmic redshift. The cosmic redshift due to the power representation is then composed of two components, one component due to the temporal change in the wavelength of the emitted light and a second component due to the expansion of space.

Since the space expansion component overcompensates for the effects of the temporal increase in the wavelength of the emitted light, the space expansion according to the power representation is greater than that of standard cosmology. This could explain why the light of distant supernovae of type 1a is fainter than the measured redshift would suggest under the assumption of a non-accelerated expanding universe.

The increased expansion of space is also the reason why a larger Hubble constant results for the same redshift for the power representation than in standard cosmology. Could this be the cause of the "Hubble Tension", i.e. the tension among standard cosmologists caused by the range of values determined for the Hubble constant?

We have also shown that the power representation of the physical constants suggests an accelerated expansion of the cosmos by solving the Friedmann equation for a flat universe of critical density in power representation. All in all, there is much to be said in favour of a fundamental connection between the core physical constants via the fine-structure constant as the base constant or fixed point and the Hubble radius as a variable that determines the temporal development of the cosmos in the power representation.☺

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