Abstract
Interpretation of the cosmological red shift as light retardation with the amount of $\dot{c} = -Hc$ yields a photon rest mass $hH/c^2$. A system of natural units is introduced, in which the Planck mass is the geometric average of the photon rest mass and the universal mass. It is shown that the equivalence of expansion and light retardation results in a Cosmologic Uncertainty Principle (CUP), which determines the Heisenberg Principle. Within the Retarded Light Model (RLM) the Dirac “coincidences” are found to be systematic, and an explanation is provided.
1 Introduction

The Retarded Light Model (RLM) as presented in (Huber 1992, Huber 1993 and Huber 2002) proceeds from the fact that a cosmological decrease of the velocity of light is possible within the Friedmann model. It has been found a deceleration rate of

\[ \dot{c} = -Hc \]  

(1)

in order to explain the observed cosmological red shift by light retardation. Since the Hubble parameter \( H \) is associated with the relative expansion \( \dot{R}/R \), eq. (1) can be written

\[ \frac{\dot{R}}{R} = H = -\frac{\dot{c}}{c} \]  

(2)

With a little rearrangement we find

\[ \dot{R}c + R\dot{c} = 0 \]  

(3)

Integration yields the so-called Indiscernibility Principle (IP)

\[ Rc = \text{const.} \]  

(4)

which states that the universe expands only in terms of a decreasing velocity of light. This occurs according to the conveyor belt model: In the frame of the light source the emitting frequency \( \nu \) remains constant in

\[ c = \lambda \nu \]  

(5)

while \( \lambda \) decreases with \( c \). However, a light wave, once emitted, remains constant while travelling through the universe and does not participate in the cosmic expansion rate. A remote receiver finds the frequency \( \nu \) decreasing with \( c \). Since light is subject to gravitation it is suggested that light retardation follows from the \( \text{eigen} \) gravitation of the universe. While in General Relativity, which deals with local gravitational fields, the deceleration of light is transformed into a temporal delay, this transformation does not make sense when the universe as a whole is considered, since it has been shown that the emission frequencies of electromagnetic waves are constant in the frame of the model. Thus a defined emission frequency serves as a standard clock of the Robertson-Walker-time (the time which appears in the RWM). With this preconditions the RLM yields a startling consequence: If the expansion of
the universe is caused by light retardation and light retardation is caused by
gravitation, then the \textit{expansion is caused by gravitation}. This equivalence of
expansion and gravitation is referred to as Generalized Equivalence Principle
(GEP). With the GEP it is obvious, why the observed expansion rate and
the assumed proper gravitation of the universe seem to be in perfect equilib-
rium. Furthermore, the RLM is able to explain all the classical problems of
the standard model of cosmology easily.

While part 1 of the series deals with purely cosmological questions, this part is
devoted to small-scale and quantum aspects as implications of the presented
model. Hereby “quantum aspects” is meant in a wide sense; it mainly denotes
the appearence of the Planck constant $h$ which was spared out in the first
part.

2 The Interaction Between the Photon and
the Universe

In Special Relativity the photon has a rest mass of zero. This is concluded
from the fact, that any finite value of mass will approach infinity while ac-
celerating towards $c$. The situation in General Relativity should be different,
since light is subject to gravitation. Thus the photon has a mass proportional
to its frequency. But where is the frame in Special Relativity at which a pho-
ton is “at rest”? In the RLM there is no rest mass of the photon but rather
a “minimal mass” $m_{ph}$, which follows from

$$m_{ph} = \frac{h\nu}{c^2}$$ \hspace{1cm} (6)

and the consideration that the lowest possible circular frequency $\omega$ is one
photon per universal age $1/H$. We then obtain with $\nu = \omega/2\pi = H/2\pi$ for
the photon mass a value of

$$m_{ph} = \frac{hH}{c^2}$$ \hspace{1cm} (7)

Conceding a non-zero rest mass $m_{ph}$ to the photon it can be shown that the
gravitational impact $F$ of the universe on the photon reproduces the correct
amount of light retardation:

$$-F = -\frac{m_{ph}MG}{R^2} = m_{ph}(-H\dot{c}) = m_{ph}\dot{c}$$ \hspace{1cm} (8)
This equation, where \( M = c^3/GH \) is the universal mass (see part 1), \( G \) the gravitational “constant”, and \( R = c/H \) the radius of the universe, reveals again the identity of the gravitational interaction between the universe and the photon on the one side and the deceleration of the photon on the other side.

The Planck constant \( h \) is independent of the cosmological “constants” \( c, G \) and \( H \), which vary with time. In the frame of the RLM it is set constant. The cosmological term \( H/c^2 \), as it appears in eq. (7), is also constant, because \( c \) varies with \( \sqrt{t} \) while \( H \) varies with \( t \) (see part 1). That means, \( m_{ph} \) does not increase its mass with cosmic expansion. With this suggested mass definition a contradiction to Special Relativity can be avoided, since the constant \( m_{ph} \) does not participate in mass increase due to acceleration like the regular mass, the university is composed of. (It is just that fact of mass increase during acceleration which forbids a non-zero photon mass in SR.)

There is another strong argument in ascribing a rest mass of \( hH/c^2 \) to the photon. Because SR has \( m_{ph} = 0 \), the Yukawa radius of light (i.e. its range) is infinite. In the RLM we obtain a Yukawa radius \( r_Y \) of

\[
r_Y(m_{ph}) = \frac{h}{m_{ph}c} = \frac{c}{H} = R
\]

(9)

This result, that light cannot reach further than the “boundaries” of the universe, makes certainly more sense than infinity: What happens, for example, when the extension of the universe is slower than the speed of light? In fact, all the horizon problems of the standard model result from this question. As pointed out in part 1, the extension of the universal radius \( R \) occurs in the RLM always with \( c \).

### 3 Metrics, Natural Scales, and the ”Origin” of the Universe

Since the Retarded Light model is based on Friedmann’s equations, its metrics should be closely related to Robertson-Walker-metrics (RWM). The original form of the RWM is

\[
ds^2 = c^2 dt^2 - R(t)^2 f(r)
\]

(10)
with $f(r) = dr^2/(1 - kr^2) + r^2(d\vartheta^2 + \sin^2 \vartheta d\varphi^2)$. The only change we have to make is to replace $c^2$ by $c(t)^2$ in (15). Then we get with $c = c_0/\sqrt{1 + 2H_0t}$ and $R = R_0\sqrt{1 + 2H_0t}$ (see part 1):

$$ds'^2 = \frac{c_0^2 dt^2}{1 + 2Ht} - R_0^2(1 + 2Ht)f(r)$$

The two metrics deviate from each other for a large $t$. The endeavours towards establishing metrics with the line element $ds$ in the vicinity of our galaxy (cluster) will lead to systematic distortions at larger distances, as seen from $ds'$-metrics.

Beside $R$ there exist two more natural length scales in the universe. For the sake of distinction $R = c/H$ will be referred to as $R_H$ from now on, where die Index $H$ can be associated with the name of Hubble. Besides, there is the Planck length $R_P$ which is given by

$$R_P = \sqrt{\frac{\hbar G}{c^3}}$$

Finally we can define a length from the “momentum” of the universe $Mc = c^4/GH$ and the Planck constant

$$R_B = \frac{\hbar}{Mc} = \frac{\hbar GH}{c^4}$$

which can be according to the de Broglie relation interpreted as the wave length of the universe. (The index $B$ stands for the name of the French physicist.) These three natural units are related to each other:

$$R_H R_B = R_P^2$$

The Planck length $R_P$ can be interpreted as the geometric average of the Hubble radius $R_H$ and the de Broglie wave-length of the universe $R_B$. With a constant $\hbar$ and the variation laws for $c$, $G$ and $H$ we obtain for the temporal variation of $R_B$

$$\dot{R}_B = -HR_B$$

and

$$R_B(t) = \frac{R_B(t_0)}{\sqrt{1 + 2H_0t}}$$
Differentiation of the Planck length $R_P$ gives

$$R_P(t) = \text{const.} \quad (17)$$

We find $R_H$ and $R_B$ varying inversely to keep $R_P$ constant. The divergence of the introduced natural scales indicates that atomic and cosmological processes evolve with different “speed”. This was already presumed by Dirac (1937, 1938, 1979).

Equation (14) can be generalized as follows:

$$X_HX_B = X_P^2, \quad (X \in \{R, T, M\}) \quad (18)$$

where $R$ stands for radii, $T$ for time and $M$ for masses. This covers all possible natural units. Their definitions are:

- **Hubble units:**
  $$R_H = c/H, \quad T_H = 1/H, \quad M_H = c^3/GH$$

- **Planck units:**
  $$R_P = (\hbar G/c^3)^{1/2}, \quad T_P = (\hbar G/c^5)^{1/2}, \quad M_P = (\hbar c/G)^{1/2} \quad (19)$$

- **de Broglie units:**
  $$R_B = \hbar GH/c^4, \quad T_B = \hbar GH/c^5, \quad M_B = \hbar H/c^2$$

where the Planck units are the geometric averages of the others. The indices can be associated with numbers like

$$H := 1 \quad P := 0 \quad B := -1, \quad (H, P, B) \in i \quad (20)$$

Then we obtain the relation

$$\hbar = |c| R_i T_i M_i \quad \text{for} \quad \sum i = 1 \quad (21)$$

This means that the Planck constant $\hbar$ can be defined by the absolute value of light retardation and a certain combination of elementary units, for instance $(R_H, T_H, M_B)$ or $(R_P, T_P, M_H)$. It looks like $\hbar$ is rather a magnitude appearing with the general problem of measuring and not primarily a constant of the physics of elementary particles.
Because of the variation of $R_H$ and $R_B$ there must exist a time $\tau_\alpha$ where $R_H = R_B = R_P$. Applying $R_H = R_0\sqrt{1 + 2H_0\ell}$ and (16) we find

$$\tau_\alpha = \frac{hGH}{2c^5} - \frac{1}{2H} = \frac{1}{2}(T_B - T_H)$$

(22)

On the other hand, at time $\tau_\alpha$ there is also $T_B = T_H$, so that, according to (22), $\tau_\alpha = 0$ in the natural units. Thus we can regard the time $\tau_\alpha$, at which the natural units equalled each other, as the origin of the universe.

4 Uncertainties

In part 1, section 3 we have deduced a relation for the propagation of light in the RWM, which differs from the standard model. Equation (8) of part 1: $R(t_0)\nu_0c(t_1) = R(t_1)\nu_1c(t_0)$ can be written

$$R(t)\nu(t) = c(t)$$

(23)

Replacing the photon frequency $\nu$ by the momentum $p_{ph} = \hbar/\nu/c$ we obtain

$$R_Hp_{ph} = \hbar$$

(24)

This relation solved to $m_{ph} = h/R_Hc$ yields the photon mass $m_{ph} = M_B = \hbar H/c^2$ as defined above. We see that $m_{ph}$ follows directly from RWM in the interpretation of the RLM. There is no choice of assuming other values. It can be shown that this relation also holds for the relativistic momentum $p(t) = mv/\sqrt{1 - v^2/c^2}$ of free falling massive particles. We replace the wavelength $\lambda_B$ by the frequency $\nu_B$ and obtain the altered de Broglie relation

$$\nu_B = mvc/\hbar$$

(25)

and insert the expression for $\nu_B$ in eq. (23). We then obtain again with $mv = p$

$$R(t)p(t) = \hbar$$

(26)

where the momentum $p$ is now generalized for photons and massive particles. The relation (26) can be referred to as the Cosmological Uncertainty Principle (CUP). What does it say? Let there be a non-expanding rod at defined coordinates in an expanding universe at time $t_0$. Where is the rod at time
$t_1$, when the coordinates do not co-expand with the universe? Obviously, the universe has gained some more units of length. How to distribute them? It is by no means a general solution to define the rod in the old and new system as sticking to the point $(0,0,0)$, because any other object in relation to the rod must change its coordinates. Howsoever the new coordinate system will be defined in homogeneous space, there is a uncertainty in location of any cosmic object. And even more: because of the uncertain location it is not at all clear, whether a change in coordinates results by an arbitrary change of the coordinate system or by a real physical movement. Therefore the velocity is also uncertain. So is, after SR, the mass of the object, since it depends on its velocity. So the CUP does not only say that the momentum $p(t)$ decreases continuously with expanding $R(t)$, it also says that the location and the momentum of an object in the universe can not be measured more accurately than $\hbar$.

There is yet another aspect to be mentioned. The Indiscernibility Principle (IP) as introduced in section 3 of part 1 states that space expansion and light retardation cannot be distinguished from each other. Its quantitative expression is $\dot{R}c = \text{const.}$ Multiplied with the photon mass $m_{\text{ph}} = M_B$ we have

$$Rcm_{\text{ph}} = Rp_{\text{ph}} = \hbar$$

This implies that IP and CUP are mathematically identical, which means in words that space expansion is identical with an uncertainty in location while light retardation implies an uncertainty in velocity and mass respectively in momentum.

In the standard model there is no CUP, and even if it would exist, there would not be a connection to Heisenberg’s Uncertainty Principle (UP). The reason is once again that electromagnetic waves expand in the empty cosmic space, however, not in matter conglomerations like galaxy clusters, which are tied together by gravitation. So the CUP would not have any effect on observations and measurements made on earth. In the RLM, on the other hand, there are no “raisins in the pie”. The cosmological light retardation takes place anywhere. (It has to be kept in mind, however, that, like in the standard model, the light delay of local gravitational fields is transformed into a temporal delay.) So the cosmic expansion takes place on earth just as well as anywhere in empty space. The CUP must therefore be also effective on earth. This implies a connection to the UP. Because of this cosmological
uncertainty in location and velocity, measurements on earth or elsewhere cannot surpass the limits stated by the CUP. Thus we will have in general Heisenberg’s UP

\[ \Delta x \Delta p_x \geq \hbar \]  

(28)

In eq. (21) we have found a relation for \( \hbar \), which is composed of the amount of light retardation and a certain combination of natural units with the restriction that the sum of indices must be 1. Theoretically, there are possible combinations of natural units from \( \sum i = -3 \) to \( \sum i = 3 \). What can be said about the cases \( \sum i \neq 1 \)? Introducing the quantity of the universal impact \( h_u \), which shall have the definition

\[ h_u := E_H T_H = \frac{c^5}{G H^2} \]  

(29)

and which implies, analogously to the uncertainty relations, for any processes in the universe

\[ \Delta E \Delta t \leq h_u \]  

(30)

then eq. (21) yields for any indices \( -3 \leq \sum i \leq 3 \) the generalized relation

\[ |Hc|R_iT_iM_i = \sqrt{h_u^{\sum i - 1}h^{3-\sum i}} \]  

(31)

These considerations imply that there may be universes possible with other measurement restrictions than the UP.

5 Dirac Numbers and Other “Coincidences”

The quantities \( G, \hbar, c \) and \( H \) can be combined to a mass, which has the magnitude of a typical elementary particle, such as the pion:

\[ \left( \frac{\hbar^2 H}{Gc} \right)^{1/3} \approx m_\pi \]  

(32)

(In the following we will use \( m_\pi \) with the mean value of eq. (32) as a symbol for the average meson in particular and the average elementary particle in general.) This relation indicates that microphysical quantities may be influenced by the temporal state of the universe, which is represented by the Hubble parameter \( H \). This consideration led to certain cosmological models like Dirac’s
ansatz from 1937 and 1938, in which he proposed that relations like (32) are fundamental though as yet unexplained truths. To keep the expression constant Dirac assumed a varying $G$ with $\dot{G} = -3GH$ (cf. also Weinberg 1972, p. 622). This is exactly the value the RLM obtains from keeping the total energy of the universe constant (see part 1, section 7). However, the numerical equality of $\dot{G}$ in Dirac’s approach and in the suggested model follows from independent considerations, since Dirac, for instance, assumed a constant $c$. Nevertheless, the RLM is able to explain the existence of large numbers as will be shown in the following.

In 1972 Weinberg confirmed, that eq. (32) ”relates a single cosmological parameter, $H_0$, to the fundamental constants $\hbar, G, c$ and $m_\pi$, and is so far unexplained” (p. 620). Using the natural masses defined in (19) we can write (32) as

$$\left(\frac{\hbar^2 H}{Gc}\right)^{1/3} = (M_B M_P^2)^{1/3} = (M_B^2 M_H)^{1/3}$$

(33)

It follows that it is possible to construct an infinite number of masses derived from the natural masses, such as $(M_B^2 M_P)^{1/3}$, $(M_B^3 M_P M_H^{1/6})$, and so on. In general:

$$m(i, j, k) = (M_B^i M_P^j M_H^k)^{(i+j+k)^{-1}}, \quad i, j, k \in \mathbb{R}_0$$

(34)

With respect to (18) we can reduce (34) to

$$m(i, j, k) = (M_B^{(i+j/2)} M_H^{(k+j/2)})^{(i+j+k)^{-1}}, \quad i, j, k \in \mathbb{R}_0$$

(35)

With (34) we are able to approximate any particle mass if we use powers high enough. Eq. (33) is characterized by low powers. That low powers should be of high significance is obvious when we consider $M_B$, $M_H$, $M_P = (M_B M_H)^{1/2}$, and $m_\pi$. Let us, for instance, construct another combination characterized by low powers, such as $(M_P M_H^{1/3})$, which will be referred to as $M_{bl}$. With relation (32) this mass can be transformed into

$$M_{bl} = (M_P M_H^{1/3}) = m_\pi \left(\frac{hc}{Gm_\pi^2}\right)^{3/2}$$

(36)

There is an astonishing resemblance to the Chandrasekhar mass

$$M_c = m_n \left(\frac{hc}{Gm_n^2}\right)^{3/2}$$

(37)
where $m_n$ represents the neutron mass. In fact, $M_{bl}$ equals about 223 Chandrasekhar masses or 401 regular sun masses. Black holes have more than 30 sun masses. Should $M_{bl}$ represent the average mass of a black hole or even the average mass of “stars” in general, such as $m_\pi$ represents the average meson and particle mass? If so, then a great deal of the dark matter would be concentrated in super massive black holes. This would explain the lack of visible matter in the Retarded Light universe with its density $\rho_c$, which is twice the critical density of the standard model (see part 1, section 9). It has been often remarked, that the relation $\hbar c/Gm_n^2$ of the Chandrasekhar mass is in the order of $10^{40}$ and represents the relation of strong force and gravitation. In fact, its numerical value is $1.7 \times 10^{38}$. We get an even better value with the values appearing in $M_{bl}$:

$$\frac{\hbar c}{Gm_\pi^2} = 3.8 \times 10^{40}$$

with an assumed value for the Hubble parameter $H = 2.5 \times 10^{-18} \text{s}^{-1}$.

On the other hand we can describe particles as multiples of natural masses, such as the invariant quantity of $M_B$. Because of the constancy of $M_B$ and the temporal mass variation according to the law $M_H(t) = M_H(t_0)(1 + 2H_0t)$ the quantities of masses expressed in units of $M_B$ will vary with the age of the universe. In this sense we can assign another member to the $10^{40}$-family:

$$m_\pi = 10^{40}M_B$$

which says that the quotient of the mean particle mass and the photon mass is the Dirac number $\gamma = 10^{40}$.

With (32) we can write

$$\gamma = m_\pi/M_B = (M_P^2/M_B^2)^{1/3} = (M_H/M_B)^{1/3}$$

Because of

$$\frac{d}{dt} \left( \frac{\hbar H}{c^2} \right) = \dot{M}_B = 0$$

the value of $\gamma$ depends on the temporal variation of $M_H$. It may be useful to ask at what time there was $\gamma = 1$, which implies the equality of electromagnetic and gravitational force, Hubble horizon and classical electron radius as well as the equality of $m_\pi$ and $M_B$ on the one hand, $M_B$ and $M_H$ on the
other, and much more. Setting $M_B = M_H = M_0(1 + 2H_0t)$ we find with $M_0 = c^3_0/G_0H_0$ exactly the value of the turning point $\tau_\alpha$ as described in [22]. It turns out that the value of $\gamma$ is a consequence of the universal state of evolution, just as Dirac assumed, and in this sense even an absolute, though variable, quantity. So it is not a coincidence that the average particle mass represented by $m_\pi$ can be expressed by $M_B$ and the Dirac number $\gamma$.

According to the definitions of natural units (19) and $h_u$ (29) we have following relations:

$$\frac{R_H}{R_B} = \frac{M_H}{M_B} = \frac{T_H}{T_B} = \frac{h_u}{\hbar} = \frac{c^5}{hGH^2} \approx 5.5 \times 10^{121} \tag{42}$$

and

$$\frac{R_H}{R_P} = \frac{R_P}{R_B} = \frac{M_H}{M_P} = \frac{M_B}{M_P} = \frac{T_H}{T_P} = \frac{T_P}{T_B} = \sqrt{\frac{c^5}{hGH^2}} \approx 7.4 \times 10^{60} \tag{43}$$

($H = 2.5 \times 10^{-18} s^{-1}$). These relations imply following definition of $\gamma$:

$$\gamma := \left(\frac{c^5}{hGH^2}\right)^{1/3} = 3.8 \times 10^{40} \tag{44}$$

With $M_H/M_B \approx 10^{121}$ and (39) we obtain the slightly altered Dirac relation

$$\text{universal mass} \quad \text{average particle mass} = 2 \times 10^{81} \tag{45}$$

(Originally, Dirac used the proton mass and obtained the dimensionless relation $10^{78}$.) Within the RLM we can give an exact deduction:

$$\frac{M_H}{m_\pi} = \frac{c^3}{GH} \left(\frac{Gc}{h^2}\right)^{1/3} = \left(\frac{c^5}{hGH^2}\right)^{2/3} = \gamma^2 \tag{46}$$

Accordingly we can deduce Dirac’s distance relation $R_H/r_e \approx \gamma$, where $r_e$ is the radius of the electron. To do this we use the relations

$$m_e \approx \alpha m_\pi \tag{47}$$

where $\alpha$ is the fine structure constant, and

$$\alpha = \frac{e^2}{4\pi \varepsilon_0 \hbar c} \tag{48}$$
We then obtain
\[
\frac{R_H}{r_e} \approx \frac{c}{H} \frac{4\pi e^2 m_\pi \alpha}{e^2} = \left( \frac{c^5}{\hbar G \hbar^2} \right)^{1/3} = \gamma
\]  

(49)

There is no explanation hitherto why Dirac’s mass relation is \( \gamma^2 \) while the distance relation is only \( \gamma \). The RLM provides a good reason: Combining the Dirac relation with the laws of mass and distance variation we obtain
\[
M_H = M_0 (1 + 2H_0 t) \approx 2 \times 10^{81} m_\pi
\]  

(50)

and
\[
R_H = R_0 \sqrt{1 + 2H_0 t} \approx 5.9 \times 10^{40} r_e
\]  

(51)

We immediately see that the laws of temporal variation of \( M \) and \( R \) must yield \( \gamma^2 \) and \( \gamma \) because of the temporal variation according to \( t \) and \( \sqrt{t} \).

Another quantity which is related to \( \gamma \) is the fine structure constant of gravitation \( \alpha_G \), as it appears in the Chandrasekhar mass as a 10^{-40} -“coincidence”. It plays the same role in the composition of stars as Sommerfeld’s \( \alpha \) in the composition of atoms. It is usually defined inversely as 10^{-40}. Instead of \( \alpha_G = m^2 G/\hbar c \) we suggest the definition
\[
\alpha_G := \frac{m^2 G}{\hbar c} = \gamma^{-1}
\]  

(52)

It may be useful to ask if or how \( \alpha \) and \( \alpha_G \) vary with time. With the values for \( c, G \) and \( H \) as deduced in section 4 of part 1 the temporal variation of \( \gamma \) respectively \( \alpha_G^{-1} \) is
\[
\dot{\gamma} = \dot{\alpha_G}^{-1} = \frac{2}{3} H \gamma
\]  

(53)

and after integration
\[
\gamma(t) = \gamma_0 (1 + 2H_0 t)^{1/3}
\]  

(54)

Inserting \( \tau_\alpha = 1/2(T_B - T_H) \) we obtain exactly \( \gamma = 1 \), which yields the important result that gravitational force and strong force were equal in strength at the origin of the universe. Thus \( \gamma \) is indeed a function of the universal age as Dirac assumed.

On the other hand we find for \( \alpha = e^2/4\pi \varepsilon \hbar c \) with \( e = \text{const.}, \hbar = \text{const.} \) and \( \varepsilon \) varying inversely to \( c \) (see section 9 of part 1, Huber 2002, and Møller 1972, p.416) the result
\[
\alpha = \text{const.}
\]  

(55)
Although a constant $\alpha$ is expected by most theoretical physicists, this result is a little surprising because of the variation of $\alpha_G$ one could have expected a variation of $\alpha$ as well. Now we have to deal with the fact, that at a certain time in the early universe the gravitational force must have been stronger than the electromagnetical force. It is not the place here to speculate how the universe must have looked like then. If the pion is multiplicated with $\alpha$ as in (47) one roughly obtains the electron mass. If the pion is multiplicated with $\alpha_G$ one should accordingly obtain the graviton. Inserting the values we find

$$\alpha_G m_\pi = M_B$$  \hspace{1cm} (56)

or the other way round

$$\gamma M_B = m_\pi$$  \hspace{1cm} (57)

According to this the graviton and the de Broglie mass are equal and both identical with the photon rest mass. This had to be expected, though, because both the electromagnetic and the gravitational force spread through the whole universe. Inserting $R_H$ for the Yukawa radius as in (4) gives $M_B$ for the graviton mass as well as for the photon rest mass. This result casts a new light on the unsuccessful approach of Einstein and others to regard elementary particles as spacetime singularities in which energy is trapped inside the gravitational radius of the particle. It turned out that the gravitational radius of the electron mass is smaller than the actual radius by about $10^{40}$. This enormous discrepancy was never made plausible. For that reason Weyl (1923) even considered Einstein’s theory of gravitation as incomplete. As we have seen, towards the past or towards smaller regions of spacetime such as elementary particle size $\gamma$ converges against 1. This can be shown in general with the theoretical pion mass. Its gravitational radius $r_G$ is

$$r_G(m_\pi) = \frac{G m_\pi}{c^2} = \frac{1}{\gamma} \left( \frac{\hbar G}{c^2 H} \right)^{1/3} = \alpha_G (R_P R_H)^{1/3} = 2 \gamma \alpha_G$$  \hspace{1cm} (58)

In case of $\gamma = \alpha_G = 1$ the gravitational radius is identical with the particle radius. As we have seen, the creation of elementary particles was only possible at a time when the gravitation force was of the same order as the strong force. Since that time only transformations between elementary particles are possible. This provides a good explanation why the baryon number is constant.
Especially the last two decades possible differences between atomic time and gravitational time have been intensively discussed (Dirac 1978, Canuto and Goldman) again, and scale-covariant theories of gravitation have been formulated (Canuto, Adams, et al.). We can express the difference of gravitational time – or as Dirac (1978) calls it – “ephemeris time” $T_H = 1/H$ and atomic time

$$t_e = \frac{e^2}{4\pi \varepsilon m_e c^3} = \frac{\alpha \hbar}{m_e c^2} \approx \frac{\hbar}{m_\pi c^2} = (T^2 P T_H)^{1/3}$$  \hspace{1cm} (59)

with the relation

$$\frac{T_H}{t_e} = \frac{m_e c^2}{\alpha \hbar H} = \frac{m_e}{\alpha M_B} \approx \gamma$$  \hspace{1cm} (60)

Again we have used the numerical coincidence of relation (47).

6 Summary

The main result of this paper is the conclusion, that Friedmann expansion identified with light retardation yields Heisenberg’s Uncertainty Relations. On this base a unification of gravitational and quantum theory could be possible. It was further shown that the direction-independent eigen gravitation of the universe causes a temporal delay of photons. It was argued that the possible interpretations of this delay (space expansion, light or time retardation) are indiscernible and therefore equivalent. With the introduction of natural units the numerical “coincidences” resulting from relations of micro- and macro-physical quantities could be explained.

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