Analytical Solution for DESI Data Releases [1] via Quintessence
A Zero-Energy Universe by Free-Fall Expansion and Zero-G Acceleration

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Our project is motivated by the discovery of accelerated expansion by Adam G. Riess in 1998. As it happens, we now observe agreement with current measurement series on dark energy from the DESI project. We present an analytical solution for the most recent data releases of the Dark Energy Spectroscopic Instrument (DESI) within the framework of a self-induced cosmological model. Instead of the geometric standard approach of the ΛCDM model, this theory is based on the dynamics of free fall from Big Bang. Using the gravitational time dilation for weak fields according to Feynman (1964), we derive the time-dependent density parameters for matter $q(t)\Omega_b$ and dark energy $x(t)\Omega_b$ directly from the relativistic mass change via the energy balance of the free fall. The model resolves the cosmological Hubble tension analytically by showing that $H_{\mathrm{CMB}} = 67.4\,\mathrm{km/s/Mpc}$ and $H_{\mathrm{DL}} = 72.4\,\mathrm{km/s/Mpc}$ represent two distinct mathematical aspects of the same expansion history. Furthermore, the model predicts a dynamic spatial curvature ($\Omega_{k,0} = 0.0007 \pm 0.0019$), which points to a bursting of the early universe from a spherical spacetime, providing a causal explanation for the existence of fully formed galaxies at extreme redshifts of $z = 12.5$.

I. INTRODUCTION

At the core of our thoughts on the nature of the cosmos is the postulate that, alongside dark energy, there is only baryonic matter. Matter is not the sum of dark matter and baryonic matter; rather, it is the relativistic mass of baryonic matter according to Albert Einstein's theories of relativity.

However, the expansion of the universe is determined by the expansion of space. Space carries the celestial bodies along, leaving them with no velocity relative to it. In contrast, drawing upon Richard Feynman's Lectures on Physics [2], we postulate space and gravitation as a field-dynamic phenomenon, which clears the way for us.

In our view, the expansion of the universe is not the result of a chaotic Big Bang explosion of all matter, but rather the result of negative gravitation fueled by potential and dark energy. The expansion velocity is therefore the outward velocity of free fall.

Section II and III thus address the derivation of the potential energy of this system. Consequently, the fundamental master equation can already be established here. In Section IV, the five unknown functions within the master equation are initially addressed by taking only present-day values into account. Based on this, the trajectory of the master equation toward the Big Bang is determined on the basis of the internal relativistic relationship. Section V then presents the numerical results. The subject of Section VI is the curvature of space, which has emerged as a new aspect of the universe and serves as the foundation for proposed explanations of current problems in cosmology.

II. FOUNDATIONS

Since the ΛCDM standard model concerns this theory only insofar as its final statements must be communicable — and even derivations from fundamental physics are being reinterpreted here — this article presents a considerable challenge to the reader.

A. Free Fall

The approach to deriving the velocity of free fall from infinity is not gravity per se, but rather kinetic (SR) and gravitational time dilation (GR):

$$\sqrt{1 - \frac{v^2}{c^2}} = 1 + \frac{\phi}{c^2} \tag{1}$$

Under this condition, the velocity v is:

$$v = \sqrt{2\frac{MG}{R} - \left(\frac{MG}{Rc}\right)^2} \tag{2}$$

Proof is provided by general relativity (GR). Here the gravitational time dilation reads $\sqrt{1 - 2\frac{MG}{Rc^2}}$, so that under the condition of equivalent time dilations one obtains the well-known expression for the second cosmic velocity, the escape velocity $v_e = \sqrt{2\frac{MG}{R}}$, which corresponds to the free-fall velocity v when start and target heights are exchanged.

The gravitational time dilation $1 - \frac{MG}{Rc^2}$ is based on an article by Richard Feynman [3], written in 1964. There is no contradiction to GR herein.

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B. Gravitation

The core of the derivation of gravitational acceleration from v, using the example of free fall, is the gravitational potential:

$$v^2 = 2\int_R^\infty g(r)\,dr \tag{3}$$

$$g = \frac{d}{dR}\left(-\frac{MG}{R} + \frac{1}{2}\frac{M^2G^2}{R^2c^2}\right) \tag{4}$$

$$g = \frac{MG}{R^2} - \frac{M^2G^2}{R^3c^2} \tag{5}$$

The term $-\frac{M^2G^2}{R^3c^2}$ appears in GR, where it is called the perturbation parameter [4], because EINSTEIN ignored it due to its obvious negligibility. We shall later learn of its elementary significance for this theory. The effect of the perturbation parameter with respect to gravitational time dilation is also described by FEYNMAN in the form:

$$1 - \frac{GM}{rc^2} \;\rightarrow\; \dots \;\rightarrow\; \sqrt{1 - \frac{2GM}{rc^2}} \tag{6}$$

C. Energy of Free Fall

The rule when computing the difference of gravitational potentials is to subtract the initial state from the final state, staying with NEWTON. Reversing this rule, however, yields exactly the released energy that is converted into kinetic energy:

$$E_g = m\left(\phi_R - \phi_r\right) \tag{7}$$

The other way around, it would be the escape velocity — the vertical launch velocity to reach height R — which would then take on complex values.

D. Force from the Speed of Light in a Gravitational Field

Due to time dilation, the speed of light is also affected by the gravitational field:

$$c' = c\left(1 - \frac{MG}{Rc^2}\right) \tag{8}$$

We are not aware of whether there is a targeted derivation showing that the difference in the variance of the speed of light has a relation to gravity:

$$\Delta E_0 = m\left((c')^2 - c^2\right) \tag{9}$$

This ΔE_0 agrees with the energy of free fall in the following way: according to Newton, the approach is $E_{kin} + E_{pot} = \text{const}$. From the previous section we know that $E_g = E_{kin}$. Now, however, $E_g + E_{kin} = \Delta E_0$. Thus:

$$E_{kin} = E_g = \frac{1}{2}\Delta E_0 \tag{10}$$

The quotient $\frac{\Delta E_0}{2m}$ is then the gravitational potential, which leads to the gravitational acceleration g:

$$g = \frac{d}{dR}\frac{1}{2}\left(c^2\left(1 - \frac{MG}{Rc^2}\right)^2 - c^2\right) = \frac{MG}{R^2} - \frac{M^2G^2}{R^3c^2} \tag{11}$$

Together with the perturbation parameter, this g is already known from the considerations on gravitation. But it is hardly to imagine, how this equation shall return EINSTEIN's Perihelion:

For my understanding EINSTEIN confused Sun and Mercury [5]. He calculated the Perihelion as the Sun rounds Mercury. Doing right, the calculation returns 50", and by using the $-\frac{M^2G^2}{R^3c^2}$-term additional it returns the sensational 43".

III. TRANSITION TO COSMOLOGY

While in the Foundations section there was still a distinction between the mass center M and the mass of the considered object m, cosmological considerations show no such distinction. The gravity of the universe is self-induced, i.e., the sum of the celestial bodies causes its own gravity and moves within it. In this respect, $m = M$.

A. Dark Matter

Conventionally, dark matter is distinguished from baryonic matter. Nevertheless, it is described by a factor relative to it: $\frac{\Omega_m - \Omega_b}{\Omega_b} \approx 5$. We, however, assume that dark matter is directly related to baryonic matter: $q = \frac{\Omega_m}{\Omega_b}$. The idea is to obtain the mass factor q from the relativistic mass (SR):

$$q = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{12}$$

Since assuming a velocity of celestial bodies requires a stationary aether, a purely kinetic consideration is ruled out here. But RICHARD FEYNMAN [2] has advice here too: he assumes a scalar field and considers the universe field-dynamically. With this artifice, one can speak of a velocity v in the universe. It is no coincidence that the parameter for velocity is called "v" in accordance with the conventions of this article — later we shall see that the celestial bodies are in free fall, even though they are not falling toward a common center.

1. Mass Factor and Potential Energy

To equip the expression for the energy from the speed of light in the gravitational field E with the mass factor q, a mnemonic is needed: one clarifies what belongs to the initial state (Big Bang) and what belongs to the considered final state. Since the initial state is at rest, q cannot apply. q is part of the motion v:

$$E_{pot} = M\frac{1}{2}\left(qc^2\left(1-\frac{MqG}{Rc^2}\right)^2 - c^2\right) \tag{13}$$

2. Gravitational Acceleration and Force

The potential energy E_{pot} supplemented by the mass factor q yields a questionable gravitational acceleration g:

$$g_q = \frac{d}{dR}\frac{1}{2}\left(qc^2\left(1-\frac{MqG}{Rc^2}\right)^2 - c^2\right) = q^2\frac{MG}{R^2} - q^3\frac{M^2G^2}{R^3c^2} \tag{14}$$

In terms of the force F in the self-induced universe, the skepticism is put in perspective:

$$F = Mg = M\left(q^2\frac{MG}{R^2} - q^3\frac{M^2G^2}{R^3c^2}\right) = q^2\frac{M^2G}{R^2} - q^3\frac{M^3G^2}{R^3c^2} \tag{15}$$

The powers of M and q are identical, so that the principle of relativistic mass is satisfied.

B. Energy Balance of Free Fall

The weightlessness during free fall suggests that the sum of energies of an object cannot differ from zero. In addition to the energies already mentioned (kinetic energy, energy of relativistic mass, potential energy E), dark energy also carries considerable weight for the universe. A factor x relative to baryonic matter is assigned to it, analogously to the mass factor q:

$$x = \frac{\Omega_\Lambda}{\Omega_b} = \frac{1}{\Omega_b} - q \tag{16}$$

The proven flatness of the universe gives the freedom to replace x in this way, where $\frac{1}{\Omega_b} \triangleq \rho_c$. Against this background, the main equation can be established:

$$0 = Mc^2(q-1) + Mc^2q + \frac{Mc^2}{2}\left(q\left(1-\frac{MqG}{Rc^2}\right)^2 - 1\right) - Mc^2x \tag{17}$$

Dark energy $(\Omega_b \cdot x)$ counts toward the total mass, but acts repulsively contrary to the other components, and therefore receives a negative contribution. The negativity of the potential energy is left to the internal processes of the derived expression (more on this later). This opens up the possibility of negative gravity, which thus remains not only a component of dark energy.

The bracket in the first term is recognizable when one recalls q (Eq. (12)) and the kinetic energy of SR, and compares it with the relativistic energy: $E_{kin} = Mc^2\left(\frac{1}{\sqrt{1-\frac{v^2}{c^2}}} - 1\right)$ and $M = M_0\frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$.

IV. COSMOLOGICAL ALGORITHM

The main equation is a function with many unknowns and variables:

$$f(q,x,R,M,v) = 0 = Mc^2(2q-1) + \frac{Mc^2}{2}\left(q\left(1-\frac{MqG}{Rc^2}\right)^2 - 1\right) - Mc^2\left(\frac{1}{\Omega_b} - q\right) \tag{18}$$

Some of these can be replaced: In a flat universe, $x = \frac{1}{\Omega_b} - q$. Under substitution with $Y = \frac{4}{3}\pi\rho_b$, the total baryonic mass is $M = YR_0^3$. This arrangement has the advantage that the total baryonic mass M can vary during iteration. The free-fall velocity v, however, is evidently obtainable from $q = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$: $v = c\sqrt{1-\frac{1}{q^2}}$, although its original form was already established in the Foundations section with Eq. (2). More on this later.

It thus becomes clear that the mass factor q and the cosmic radius R_0 are entangled and cannot replace each other. To find a way out of this dilemma, there are various possibilities: one can approach the cosmic radius via $R = vt$, but then one also estimates the age of the universe as an additional unknown. One can also make a statement using the Hubble constant $R_0 = \frac{c}{H_0}$.

The accuracy of the measurement of H_0 using the Planck satellite ($H_0 = 67.4 \pm 0.5\frac{km}{s \cdot Mpc}$) introduced the concept of precision cosmology. Just a few years later, a measurement using the cosmic distance ladder was to dampen this enthusiasm: the measured value deviated by more than one order of magnitude of Planck's measurement uncertainty. This unfortunate circumstance today carries its own name: the Hubble tension. More on this later.

We were unable to agree on any variant of estimating R_0. Only determining the present-day mass factor q_0 from the measured value of $\Omega_{m,0}$ seems to be a still-viable path: $q_0 = \frac{\Omega_{m,0}}{\Omega_b}$, where $\Omega_{m,0} = 0.315$. Substituting the total baryonic mass (computable from present-day values) $M_0 = YR^3$ into the main equation enables a solution for the present cosmic radius R_0. The equation[1] is found in App. VII A.

Unfortunately, the result for R_0 with this q_0 deviates more strongly than what a determination of $R_0 = \frac{c}{H_0}$ permits, despite the uncertainty of the Hubble constant including the Hubble tension.

However, the expression for R_0 reacts extremely sensitively to changes in $\Omega_{m,0}$. This led us to the idea of examining the free-fall velocity more closely. After all, it is crucially involved in determining q_0 and later also $q(t)$:

$$q = \frac{1}{\sqrt{1 - \frac{2\frac{MG}{R} - \frac{M^2G^2}{R^2c^2}}{c^2}}} \tag{19}$$

This calculation produces entirely unacceptable values for the mass factor q_0. Now, the main equation crucially depends on the mass factors q and x. It therefore stands to reason that the mass in the free-fall velocity v falls into this category as well. A mathematical phenomenon emerges whose physical proof is still pending: through experimentation it emerged that the required mass factor — which is called Q according to its dimension — corresponds exactly to its counterpart in the main equation (18) for relativistic and kinetic energies. This, however, includes the addition of the mass factor for dark energy. With reference to a flat universe, this yields an elegant result:

$$Q = 2(q + x) - 1 = \frac{2}{\Omega_b} - 1 \tag{20}$$

The calculation of the entanglement of q_0 and R_0 can now be resolved using Newton's iteration method. The iterated function, by Newton's method, always yields zero in the result of the iterated value. Thus a second function is needed. The iteration via the expansion velocity v suggests itself here. On the one hand, this is the known free-fall velocity; on the other hand, its equivalent from the inner equation q:

$$0 = \sqrt{2\frac{M\left(\frac{2}{\Omega_b} - 1\right)G}{R} - \frac{M^2\left(\frac{2}{\Omega_b} - 1\right)^2 G^2}{R^2c^2}} - c\sqrt{1 - \frac{1}{q(R)^2}} \tag{21}$$

The mass factor $q(R)$ in the second term, or the alternative expansion velocity v_{aus}, is taken from the main equation. The expression is found in App. VII B.

The iteration is accordingly carried out with respect to R, so the result is R_0. This is very satisfactory. q_0 is obtained via the just-derived expression for $q(R)$ with $R = R_0$. The density parameter of matter thereby obtained, $\Omega_{m,0} = q_0\Omega_b$, increases by approximately 1 percent relative to the measured value. The total baryonic mass of the universe M now follows as $M = YR^3$. Furthermore, the mass factor x_0 is obtained via $x_0 = \frac{1}{\Omega_b} - q_0$ for a flat universe.

A. Equivalence to Free Fall

According to the mass factor Q, the expansion velocity of the universe — or that of free fall — will be close to the speed of light c. Numerical values become useful here only when they permit a comparison of the two different expressions for v just used. Although these are already numerically equivalent in the present via q_0, a comparative calculation over the expansion history of the universe is still outstanding.

For a flat universe with constant density parameters, science has developed the scale factor a for the relationship between time and the respective cosmic radius. It moves in time from the Big Bang to the present with values $0 \ldots 1$, establishing a proportionality. Only the conversion to the temporal progression reveals the nonlinearity.

We postulate, for lack of better knowledge and regardless of the anticipated variance of the density parameters Ω_m and Ω_Λ, linearity for $a(t)$. Thus, two expressions for the cosmic radius are again sought, but this time over time.

Necessarily, Q can no longer be $\frac{2}{\Omega_b} - 1$ but must account for $Q = 2(q + x) - 1$ in order to compute with the inner equation for q:

$$q = \frac{1}{\sqrt{1 - \frac{2\frac{M(2(q+x)-1)G}{R} - \frac{M^2(2(q+x)-1)^2G^2}{R^2c^2}}{c^2}}} \tag{22}$$

The expression for R_{in} is found in App. VII C. The main equation holds and now has the following form:

[1] The result contains seven solutions. To identify the correct one, it is necessary to examine them with suitable parameters. During research, transformations of equations frequently yielded multiple solutions. We ensured that the sought solution is real, positive, nonzero, and plausible.

$$0 = Mc^2(2q-1) + Mc^2\left[\frac{1}{2}\left[q\left(1-\frac{MqG}{aR_0c^2}\right)^2 - 1\right]\right] - Mc^2\left(\frac{1}{\Omega_b} - q\right) \tag{23}$$

The missing mass factor of dark energy x is preceded by the following thought: to account for curvature, $x = \frac{1-\Omega_k}{\Omega_b} - q$. The value of the main equation, however, can only remain zero if the energy of spatial curvature is also subtracted: $-Mc^2\left(\frac{1-\Omega_k}{\Omega_b} - q\right) - Mc^2\frac{\Omega_k}{\Omega_b} = -Mc^2\left(\frac{1}{\Omega_b} - q\right)$. Thus the main equation is independent of spatial curvature. The decisive background is the basic equation $\Omega_m + \Omega_\Lambda + \Omega_k = 1$.

From the main equation, a time-dependent mass factor $q(a)$ can now be determined (a representation analogous to App. VII B is inappropriate). Since R_0 and a are known, this yields the desired time-dependent values.

As already noted, R_{aus} as a result of the main equation reacts very sensitively to changes in Ω_m or $q(a)$. R_{aus} is obtained from the above main equation (17), but without a, since this was consumed for $q(a)$. The expression is found in App. VII D.

The iteration of $x(a)$ is carried out via the function $R_{in}(a) - R_{\text{aus}}(a) = 0$. With this, the curvature factor $k(a) = \frac{\Omega_k(a)}{\Omega_b}$ can also be determined via the mentioned but transformed basic equation $\frac{1}{\Omega_b} = q(a) + x(a) + k(a)$.

Since the main equation does not permit a statement on curvature, but the flatness problem appears solved to science, a numerical comparison suffices to confirm the equivalence of the free-fall velocity v to the test velocity $v_{\text{aus}} = c\sqrt{1 - \frac{1}{q(a)^2}}$ by their difference (Fig. 1):

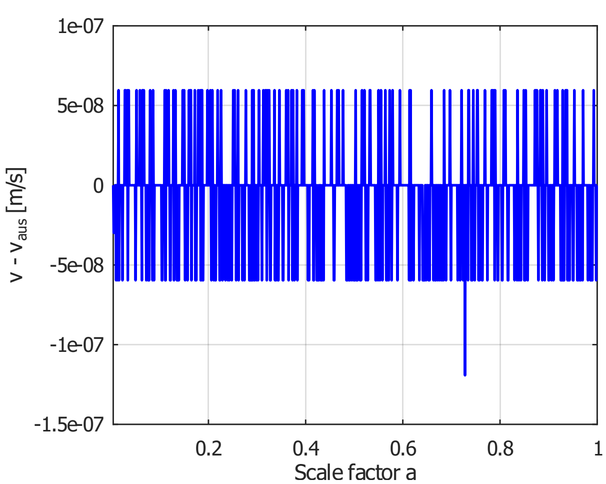

Figure 1. Difference between the velocity of free fall (expansion velocity of the universe) v and test velocity v_{aus} over $a = 0 \ldots 1$

V. RESULTS

Enumeration of values in the order of their appearance in the text:

$R_0 = 1.277 \cdot 10^{26}$ m; $q_0 = 6.425$; $M = 3.693 \cdot 10^{51}$ kg; $\Omega_{m,0} = 0.31867$; $x_0 = 13.722$; $v_0 = 2.961 \cdot 10^8 \frac{m}{s}$; $t_0 = 13.752 \cdot 10^9$ yr, as well as Figs. 2, 3, 5 of the trajectory.

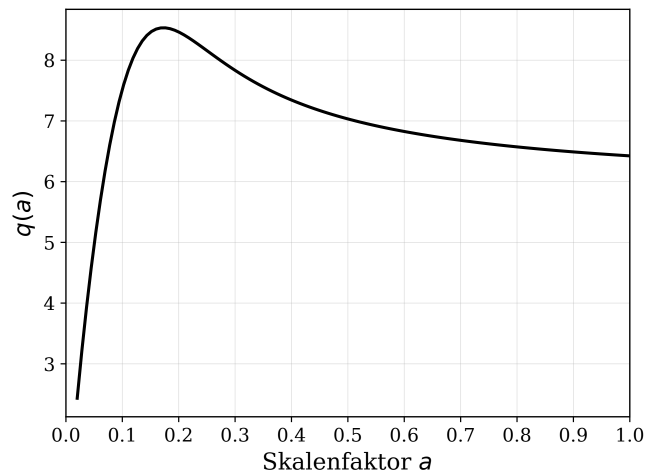

Figure 2. Progression of $q(t)$ over $a = 0 \ldots 1$

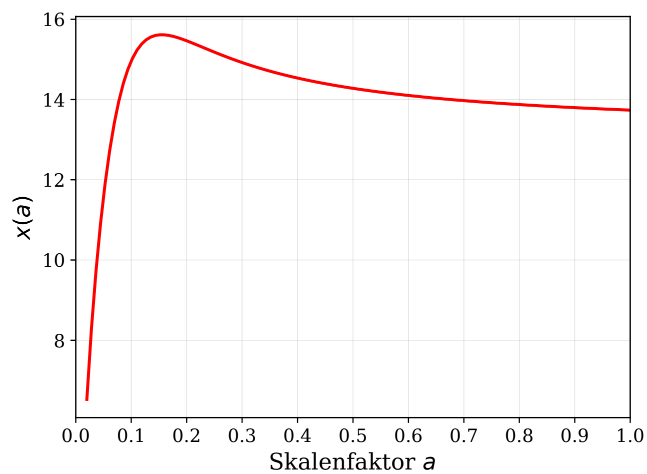

Figure 3. Progression of $x(t)$ [1] from the main equation (23) over $a = 0 \ldots 1$ to compare with fig. 4

A. Hubble Parameter

1. Observed Hubble Parameter

The observed Hubble parameter is easy to determine. Its definition is $H_{DL}(t) = \frac{c}{R(t)}$. The key values can be taken from Fig. 6:

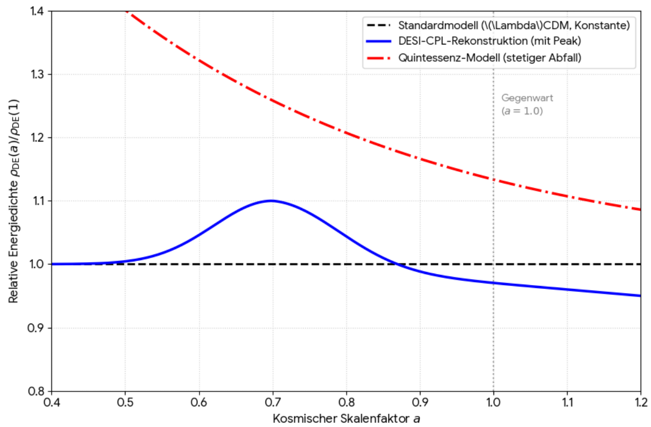

Figure 4. Progression of Quintessence [6–8] comparing qualitatively with fig. 3

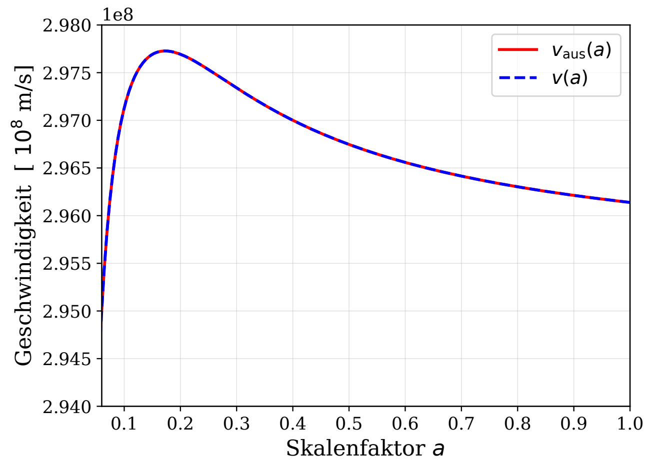

Figure 5. Free-fall velocity v and test velocity v_{aus} over $a = 0.06\ldots1$

$$H_{DL}(1) = 72.4\,\frac{km}{s\cdot Mpc} \text{ and } H_{DL}(0.5) = 144.9\,\frac{km}{s\cdot Mpc}$$

2. *Geometric Hubble Parameter*

The geometric Hubble parameter H_{CMB} refers to the Cosmic Microwave Background, the context of its investigation. Its definition is $H_{CMB}(a) = \frac{\dot{a}}{a}$.

The circumstance that the mass factors of matter $q(a)$ and dark energy $x(a)$ are no longer constant creates problems in developing the Hubble parameter. There is no scale factor $a(t)$ for dynamic parameters, and so one cleverly improvises:

We decide to accept the flatness of the universe so that the scale factor a can be used. It reads:

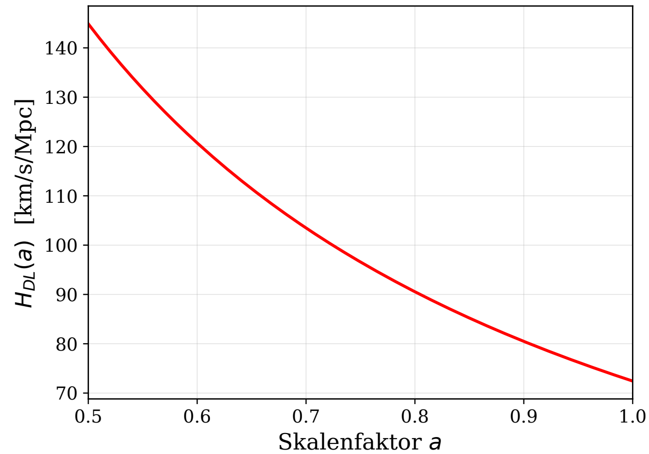

Figure 6. Observed Hubble parameter $H_{DL}(a)$ over $a = 0.5\ldots1$

$$a(t) = \left(\sqrt{\frac{q(t)\Omega_b}{1-q(t)\Omega_b}}\sinh\left(\frac{3H_0 t\sqrt{1-q(t)\Omega_b}}{2}\right)\right)^{\frac{2}{3}} \tag{24}$$

Since the matter density parameter here is a function of t, $q(t)$ must be developed from the main equation:

$$0 = Mc^2(2q-1) + Mc^2\frac{1}{2}\left[q\left(1-\frac{MqG}{\frac{t}{t_0}R_0c^2}\right)^2 - 1\right] - Mc^2\left(\frac{1}{\Omega_b} - q\right) \tag{25}$$

Here the time t is assumed to advance linearly. The current age of the universe t_0 was obtained from the transformation of the scale factor $a(t)$:

$$t_0 = \frac{2}{3}\frac{\operatorname{asinh}\left[\frac{1}{\sqrt{\frac{q_0\Omega_b}{1-q_0\Omega_b}}}\right]}{H_0\sqrt{1-q_0\Omega_b}} \tag{26}$$

From the Super Nova Legacy Survey, we have a diagram of the measured Hubble parameter (Fig. 7):

To establish a comparison with this measurement, we need t_1 from $a(t_1) = 0.5$. The iterative determination of t_1 is carried out via the function $0 = a(t) - 0.5$ using Newton's iteration method.

We decide on two different approaches:

3. *Ω_m smoothed*

To determine the average value of $\Omega_m(t)$, the values of the mass factor $q(t)$ are summed:

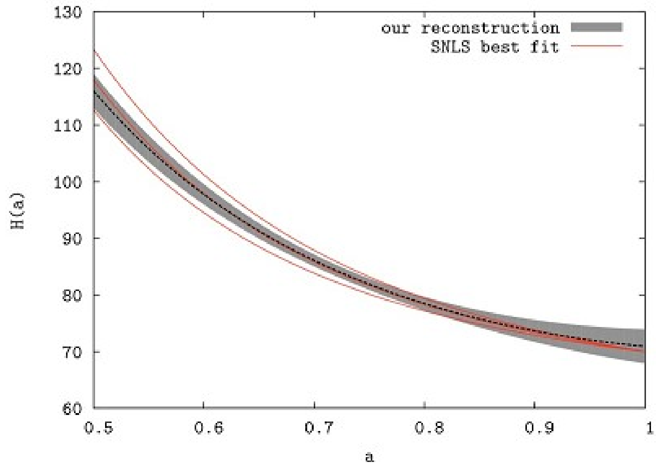

Figure 7. Measurement of the Hubble parameter $H(a)$ over $a = 0.5 \ldots 1$

$$\bar{q} = \frac{1}{t_0} \int_0^{t_0} q(t)\, dt \tag{27}$$

Here the values t_0 and t_1 for the considered age of the universe do not need to be iterated, since the scale factor provides analytical solutions. With $HI_{CMB} = \frac{\dot{a}}{a}$, the following representation results (Fig. 8):

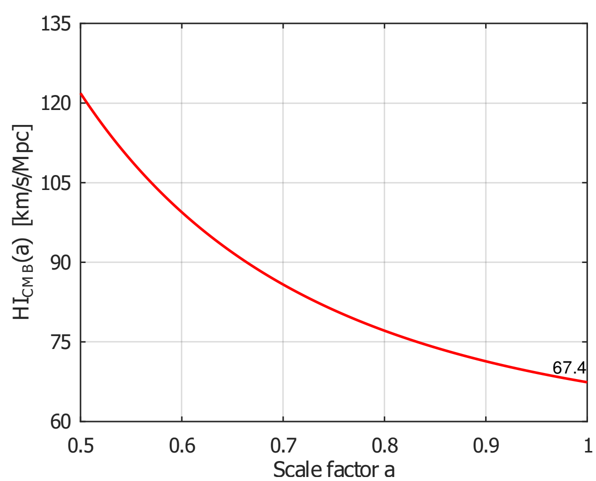

Figure 8. Smoothed Hubble parameter $HI_{CMB}(a)$ over $a = 0.5 \ldots 1$

As expected, $H_0 = 67.4 \, \frac{km}{s \cdot Mpc}$ appears in the present.

4. Dynamic Ω_m

With regard to the present scale factor $a(t)$ and the main equation representing a flat universe, with $\Omega_m(t) = q(t)\Omega_b$ the dark energy density parameter is $\Omega_\Lambda = 1 - \Omega_m(t)$, so that $HII_{CMB}(a) = \frac{\dot{a}}{a}$ with $a(t) = \left(\sqrt{\frac{q(t)\Omega_b}{1-q(t)\Omega_b}} \sinh\left(\frac{3H_0 t \sqrt{1-q(t)\Omega_b}}{2} \right) \right)^{\frac{2}{3}}$, (Fig. 9):

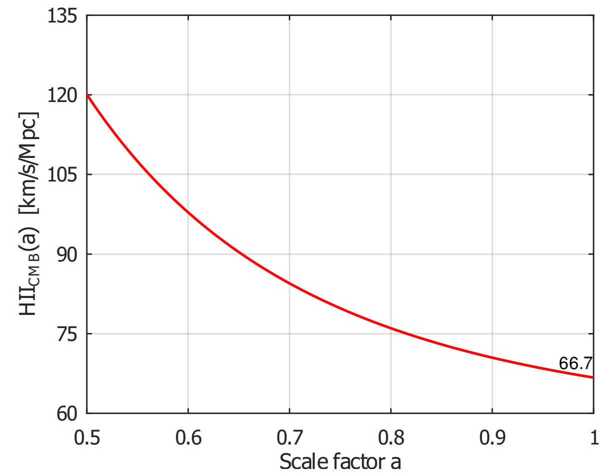

Figure 9. Hubble parameter with variable matter density parameter $HII_{CMB}(a)$ over $a = 0.5 \ldots 1$

Corresponding to the difference between $\bar{q}$ and $q(t_0)$, $HII_{CMB}(a_0)$ lies somewhat lower than $HI_{CMB}(a_0)$. However, H_{DL} is also lower than in the literature, so that $HII_{CMB}(a_0)$ remains within the measurement tolerance of H_0 (here: $H_{CMB}(a_0)$), while H_{DL} approaches the measured value ($73.05 \, \frac{km}{s \cdot Mpc}$ [9]).

VI. CONCLUSIONS

The idea of a spatially curved universe did not come to us only with the proof that the expansion proceeds at the free-fall velocity v. The measured value of $\Omega_k = 0.0007 \pm 0.0019$ [10] had already attracted our attention. Recovering this value after dealing with quantities such as the total mass M and the cosmic radius $R(a)$ in the cosmological algorithm strengthened our confidence in our software MathCad 7 Professional, which is already 30 years old.

Furthermore, the progression of the mass factor of matter $q(a)$ has shown that it was zero at the time of the Big Bang, while that of dark energy is also zero. The universe therefore begins with zero energy.

It is thus hardly conceivable that the universe is and has always been spatially flat. Looking at the curvature factor $k(a)$, (cf. Fig. 10), it is much more natural to understand the early universe in terms of spatial curvature. A bursting from extremely hyperbolical spacetime into spherical spacetime is easier to comprehend than a compression of all matter into a point — a singularity. Also in light of fully formed galaxies at the edge of the visible universe at $z = 12.5$ [11] and $z = 12.34$ [12], the early temporal progression of the cosmic radius $R(a)$, shown in

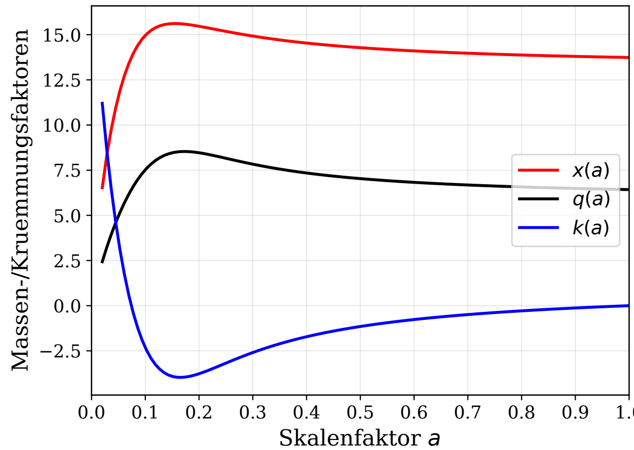

Figure 10. Mass factors $q(a)$ and $x(a)$, and curvature factor $k(a)$ from the inner equation (22) over $a = 0.02 \ldots 1$

Fig. 11, provides an anchor for explaining its formation. Finally, the question of the cosmic fog wall — which appears, though deep in the universe, amid fully developed galaxies — remains unresolved.

By testing (cf. main equation 17) it results zero over the whole Expansion history and testing with $q(a) + x(a) + k(a) = 1$ as it is obviously.

The circumstance, however, that we live at a time when we must debate the flatness of the universe because empirical science returns values that permit both possibilities — is at least thought-provoking.

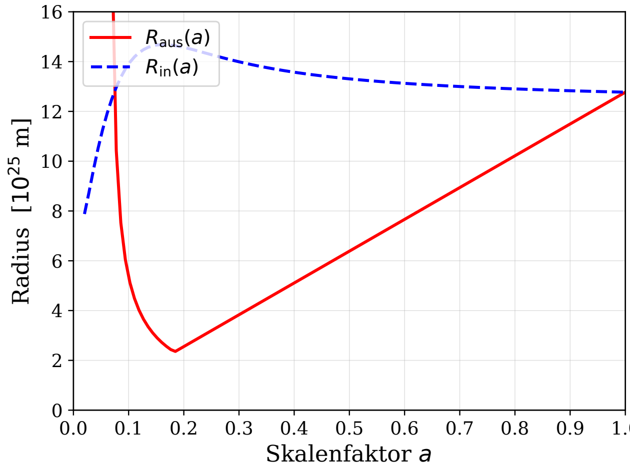

Figure 11. Cosmic radius $R(a)$ and R_{in} over $a = 0.02 \ldots 1$

In the Appendix Tab. I is comparing this model with the ΛCDM standard model.

VII. APPENDIX

A. Appendix A

Generation of the expression for the present cosmic radius:

$$R_0 = \frac{1}{[Y(q_0 G)]}\sqrt{\frac{\left(Y q_0^2 G c^2 \Omega_b - \sqrt{-6Y^2 q_0^4 G^2 c^4 \Omega_b^2 + 3Y^2 q_0^3 G^2 \Omega_b^2 c^4 + 2Y^2 q_0^3 G^2 \Omega_b c^4}\right)}{(q_0 \Omega_b)}} \tag{28}$$

B. Appendix B

Generation of $q_0(R_0)$ from the main equation:

$$0 = Mc^2(q_0 - 1) + Mc^2 q_0 + Mc^2\left[\frac{1}{2}\left[q_0\left(1 - \frac{M q_0 G}{R_0 c^2}\right)^2 - 1\right]\right] - Mc^2\left(\frac{1}{\Omega_b} - q_0\right) \tag{29}$$

A representation of q_0 is inappropriate, as it is a very large and unwieldy expression that must be generated electronically.

C. Appendix C

Generation of the expression for R_{in} as the result of the inner equation:

$$R_{in} = \frac{1}{\left[2\left(c^4 - \frac{1}{q^2}c^4\right)\right]}\left(4MGqc^2 + 4MGxc^2 + 2MGc^2 - 2Gc^2\frac{M}{q} + 4Gc^2\frac{M}{q}x\right) \tag{30}$$

D. Appendix D

Cosmic radius from the main equation:

$$R_{aus} := \frac{1}{\left[2\left(5qc^4 - 3c^4 - 2c^4x\right)\right]}\left(2c^2q^2MG + 2\sqrt{-4c^4q^4M^2G^2 + 3q^3M^2G^2c^4 + 2q^3M^2G^2c^4x}\right) \tag{31}$$

E. Physical Constants and Parameters Used

Megaparsec: $1\,\mathrm{Mpc} = 3.085677581 \cdot 10^{22}\,\mathrm{m}$
Gravitational constant: $G = 6.67430 \cdot 10^{-11}\,\frac{m^3}{kg\cdot s^2}$
Speed of light: $c = 299\,792\,458\,\frac{m}{s}$
Hubble constant: $H_0 = 67.4 \pm 0.5\,\frac{km}{s\cdot Mpc}$
Baryonic matter density parameter: $\Omega_b = 0.04960$
Present spatial curvature parameter of the universe: $\Omega_k = 0.0007 \pm 0.0019$
Baryonic matter density: $\rho_b = \rho_c \Omega_b = \frac{3H_0^2}{8\pi G}\Omega_b = 4.232 \cdot 10^{-28}\,\frac{kg}{m^3}$

F. Comparison Table

Table I. Comparison between the ΛCDM standard model and the presented cosmological model (Zero-Energy / Free-Fall Expansion).

Property / Parameter	**ΛCDM Standard Model**	**Presented Model**
Fundamental principle	Friedmann equations	Free fall / zero-G acceleration
Energy balance of the universe	Not necessarily zero	Exactly zero (self-induced)
Hubble tension	Unresolved (67.4 vs. $\sim$ 73 km/s/Mpc)	Resolved ($H_{CMB} = 67.4$, $H_{DL} = 72.4$)
Matter density parameter (Ω_m)	Constant (standardly scaled)	Time-dependent / variable ($q(t)\Omega_b$)
Dark energy (Ω_Λ)	Cosmological constant (Λ)	Dynamic mass factor $x(t)$
Spatial curvature (Ω_k)	Exactly 0 (postulated for flat universe)	Dynamically determined ($\Omega_k = 0.0007 \pm 0.0019$)
Scale factor $a(t)$	Standard vacuum energy solution	Analytical modification (Eq. (24))
Big Bang singularity	Mathematical point of infinite density	Bursting from spherical spacetime

DATA AVAILABILITY STATEMENT

The primary data from the Dark Energy Spectroscopic Instrument (DESI) used in this study are openly available from the official DESI repositories. The reconstructed datasets and trajectories generated during the current study are available from the corresponding author upon reasonable request.

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