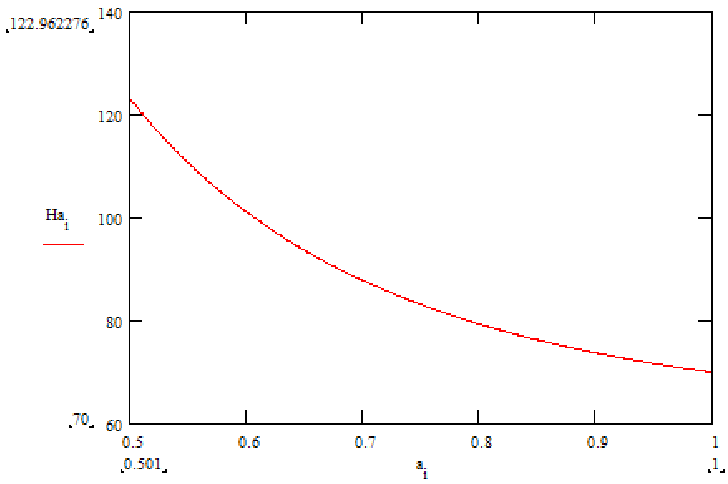
Calculating the expansion of the universe After the Dark Ages to the Present

taking into account constant mass of matter
and constant density of dark energy
since the existence of luminous matter



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Foreword

In 1998, the American Adam Riess found that the expansion of the universe is currently accelerating, and not slowing down as Newton's and Einstein's theories of gravity would suggest. Since then, this fact has been stirring the minds of the scientific community. Dark energy has been created as a construct of the mind to provide the necessary energy. Calculations show, however, that this energy must be much greater than previously assumed if it is to explain the acceleration. Again, creativity is called for in science, and the construct discussed here is another exhibit of this genre, of which there is no shortage of diversity in the many, many publications on the subject worldwide.

The idea

in this essay is hauntingly simple:
Physical research in recent years has shown that there is exactly as much energy in the universe as is necessary to generate a flat universe by means of Einstein's theory of general relativity (ART).
In addition to the fact that the author assumes that the universe is not only flat in the present, but that it is flat as far as the eye can see, i.e. up to the dark age of the history of the origin of the universe, this also means that the ART was already valid before it was discovered by Albert Einstein in 1915. It has therefore endured through all time, which means that the calculation of the critical density according to the ART, which depicts the sum of all energies in the universe, according to which it is flat, is always valid.
So if the universe has always been, is and will remain flat, the sum of all energies is always equivalent to the critical density.

Since energy and critical density are equivalent to each other, this also means that the energy of the components of the total energy change, after all, the size of the universe changes with the expansion, so that other conditions apply, i.e. a different energy content is required in order to continue to assume the flatness of the universe. This is precisely what is to be achieved by means of the conditions already stated in the title of this essay:

Matter

In the universe, there is gravity, the attractive property of matter. In addition to luminous matter, this also includes non-luminous matter, black holes and a special form of matter, dark matter. This makes up the majority of gravitationally effective matter. It is invisible, and research is being conducted into it. But it is necessary, for example, to explain the rotation characteristics of galaxies. All this matter was created during the genesis of the big bang and the phase of inflation, possibly by means of quantum fluctuation. After this time, no more gravitationally effective matter was created, i.e. the total mass of matter remains constant over the period of the expansion of the universe, i.e. its density decreases. This can be calculated (later) under some assumptions.

The infinitely large sultana bread

With the help of the cosmological constant, the ART allows for different geometries of the universe: the spherical, the hyperbolic, and the flat one, i.e. space is not curved, as it is around celestial bodies. However, since very large distances are taken into account when considering the universe, it cannot be curved, i.e. flat, over these distances, which it is.

The model of the infinitely large sultana bread is now born out of the fact that the universe was calculated to be flat by means of ART. Apart from the fact that we perceive the position of supernovae and other celestial bodies at a point in time in the past, so they could be somewhere else entirely at present, the supernova is exactly on the line where we see it with our telescopes. So space, apart from gravitational lensing, is not curved, flat.

If you put a yeast dough with sultanas into a preheated oven, it expands as it bakes, keeping all its proportions between the sultanas, because only the dough expands. On the model, the sultanas are the heavenly bodies and the dough stands for space. So while the sultanas (heavenly bodies) remain unchanged, the dough (space) becomes more. This increase in space is attributed to dark energy.

The bread of sultanas is infinitely large, and we do not know where we are. We only know that if the sultana bread were three-dimensional, it would not take into account the fact that light has a finite speed, i.e. that the light of the celestial bodies takes a time to reach us. This, however, is taken into account by ART, and so it is possible for us, although our view cannot go beyond the cosmic horizon, i.e. the distance at which, with increasing expansion speed, light can no longer reach us. We thus have access to the time of the end of the dark age, when the sultana bread was still small, even though it is further away if we assume a three-dimensional sultana bread.

With the help of ART, it is thus possible to assume the expansion characeristics of the universe based on a three-dimensional sphere without knowing its true size, simply by taking the distance of the cosmic horizon as a basis. After all, we know the true age, namely the time it takes for light to reach us from the cosmic horizon. But where the horizon sphere, which is on a three-dimensional basis, is located in the infinitely large sultana bread, the true universe, remains a mystery.

The dark energy

It has been said that the space between the celestial bodies is becoming more. This is simply taken into account in this essay:

It is certain how great the density, which is equivalent to its energy, must be, if one takes the enlargement of the space between the galaxies as a basis. For the present, their density parameter $\Omega\Lambda_{,0}$ has been quantified as about 0.7, which corresponds to a certain density $\rho_{\Lambda,0}=\Omega_{\Lambda,0}\rho_{c,0}$ corresponds.

If all energies in the universe arose from quantum fluctuation during the inflationary phase, it should be the case that the fluctuation of the quanta that create space continues after this phase, albeit on a much smaller scale. So while the genesis of matter was complete with the end of the dark age, it is not for dark energy. However, as we know, space cannot be compressed, i.e. the density of the quanta of space, i.e. dark energy, is constant over the time after the dark age. Since we know the density of dark energy, we only need a statement about its increase. The acceleration should correspond to the force of gravity, but with the opposite sign to the force of mass attraction: $a_\Lambda(R)=\frac{M_\Lambda(R)G}{R^2}$. The radius R corresponds to the distance from the cosmic horizon in the Einstein universe and MΛ is the mass of the dark energy within this distance: $M_\Lambda(R)=\frac{4}{3}\pi\rho_\Lambda R^3$.

Gravity

Based on the knowledge of the age of the universe, it is now possible to determine the total content of matter in the universe, because the radius to the present is $R_0=\frac{c}{H_0}$. Based on the fact that a flat Einstein universe, and also according to the logic of observation, which states that the universe looks the same everywhere and has no particularly distinguished location, it has the shape of a three-dimensional sphere. The total mass of matter is therefore $M_M = \frac{4}{3}\pi\rho_M R_0^3$. The present density ρM,0 results from $\rho_{M,0} = \rho_{c,0}\,\Omega_{M,0}$. In this equation the critical density $\rho_{c,0} = \frac{3H_0^2}{8\pi G}$ is included.

The density ρ_M is now no longer constant, considering that the total mass of matter remains constant over the expansion of the universe: $\rho_M(R) = \rho_{M,0}\frac{R_0^3}{R^3}$.

The acceleration that has a braking effect on the universe from the total mass of matter is the gravitational acceleration according to Newton or Enstein, here Newton: $g(R) = -\frac{M_M G}{R^2}$.

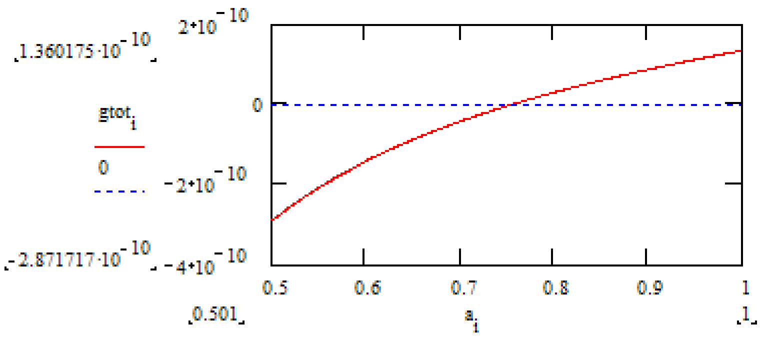
Resulting acceleration gtot

The accelerations from dark energy and matter must be combined. They conflict with each other: $g_{tot}(R) = a_\Lambda(R) + g(R)$. Written out it reads $g_{tot}(R) = \frac{4}{3}\pi\rho_\Lambda G R - \frac{4}{3}\frac{\pi\rho_{M,0} G R_0^3}{R^2}$.

The age a

To achieve a representation via age, the radius of the universe must be represented via time. The age is $t_0 = \frac{1}{H_0}$, c is the speed of light, so the radius of the universe is $R(t) = c\,t$ is . $R_0 = c\,t_0$. The age in the present is denoted by a=1, so that the entire past is $a = \frac{t}{t_0}$ is .

Thus the acceleration of the size of the universe $g_{tot}(a)$, the expansion, looks like this:



Only the last half of the expansion is shown to congruence with the confirmation from research that follows later. You can see well how in the last quarter of the age the acceleration changes to positive. This is the accelerated expansion. Before that, the braking effect of the gravitation of matter dominates.

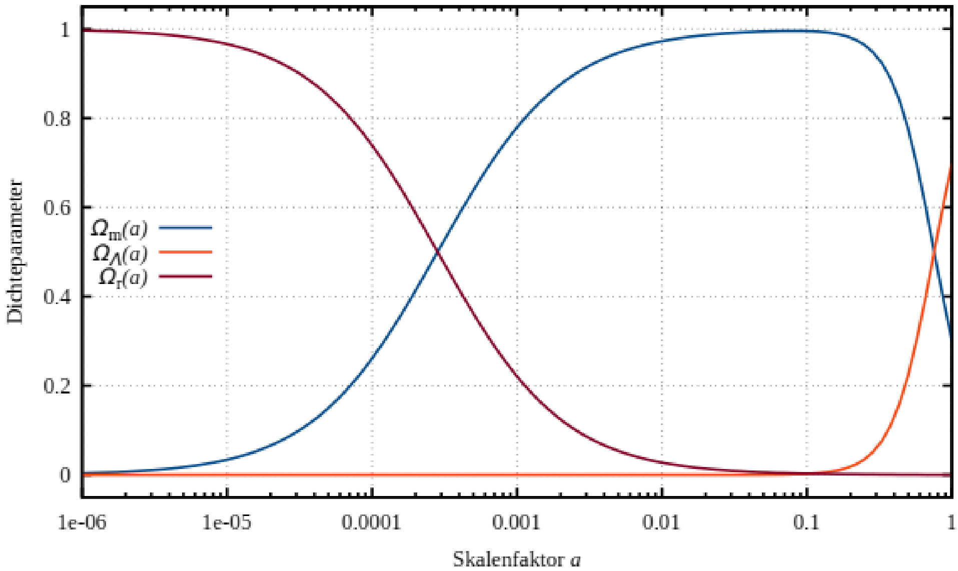
Density parameter

In a flat Einstein universe, for the sum of all (equivalent) energies $\rho_\Lambda(a)+\rho_M(a)=\rho_c(a)$is the critical density. This means $\Omega_{tot}=1=\Omega_\Lambda(a)+\Omega_M(a)$. With these two relations, statements can be made for the partial density parameters. Since ρ_Λ is constant over the age a, holds:

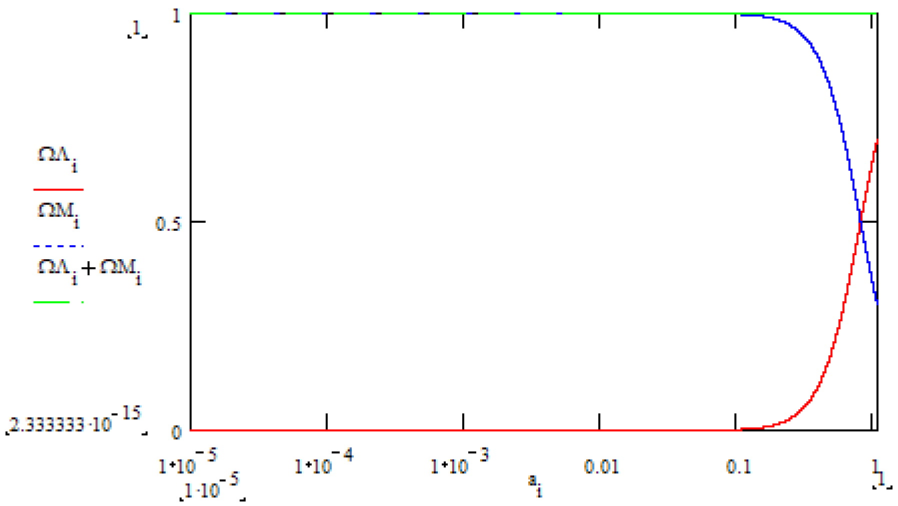
From $\rho_\Lambda=\rho_c(a)\Omega_\Lambda(a)$ becomes $\Omega_\Lambda(a)=\frac{\rho_\Lambda}{\rho_c(a)}$ which $\Omega_\Lambda(a)=\frac{\rho_\Lambda}{\rho_\Lambda+\rho_M(a)}$ means, and from

$\rho_M(a)=\rho_c(a)\Omega_M(a)$ becomes $\Omega_M(a)=\frac{\rho_M(a)}{\rho_c(a)}$ which $\Omega_M(a)=\frac{\rho_M(a)}{\rho_\Lambda+\rho_M(a)}$ means.

In [1, 24] the following diagram can be found for this chapter:



It agrees between age a = 0.1 and a = 1 with the diagram below from calculations of the model of density parameters Ω_M(a) and Ω_Λ(a) discussed here:

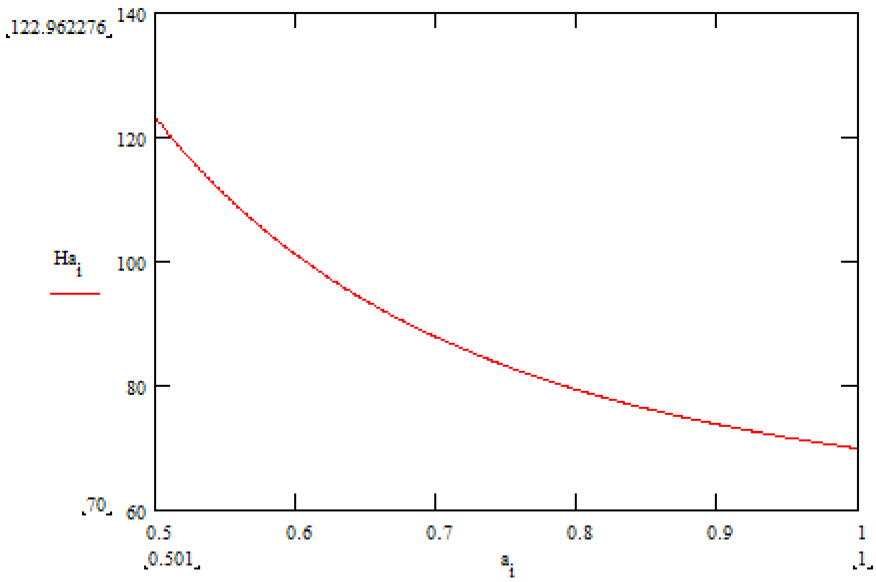


The difference is that the values from source [1, 24] of this period were determined empirically, while the values in the diagram above are based on the theory of the model discussed here. Source

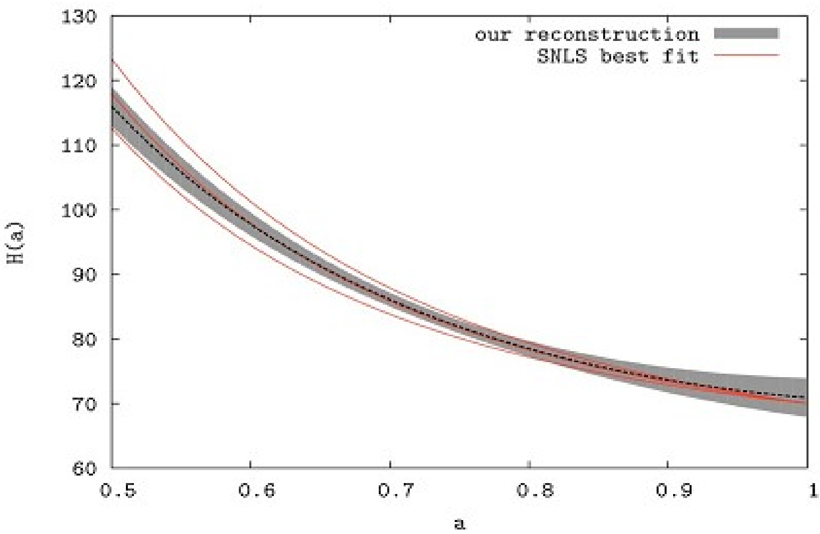
[1, 24] offers assured theoretical values for a < 0.1, since no empirical values are possible due to the lack of luminous matter. Only the microwave background could be determined from the time before the dark age with the Planck Space Telescope of the ESA, and from this a very exact value for the Hubble constant H_0, which confirms a flat universe.

Hubble parameters

With $\Omega_{tot}(a)=1=const.$ and $\rho_c(a)=\rho_\Lambda+\rho_M(a)$ it is assumed that the universe is flat, at least over the time since luminous matter has existed. Thus $\rho_c(a)=\frac{3}{8}\frac{H(a)^2}{\pi G}$. From this, however, it is also true that the Hubble parameter $H(a)=\sqrt{\frac{8}{3}\rho_c(a)\pi G}$ is . H(a) thus looks like this:



This coincides very well with the result of the observation from the SuperNova Legacy Survey:



Appendix

Underlying values

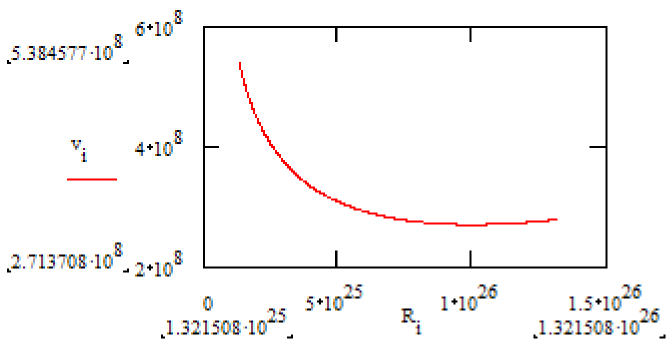
$H_0 = 70 \frac{km}{s\,Mpc}$[1, 19];

Density parameters in the present: $\Omega_{M,0} = 0.3$; $\Omega_{\Lambda,0} = 0.7$

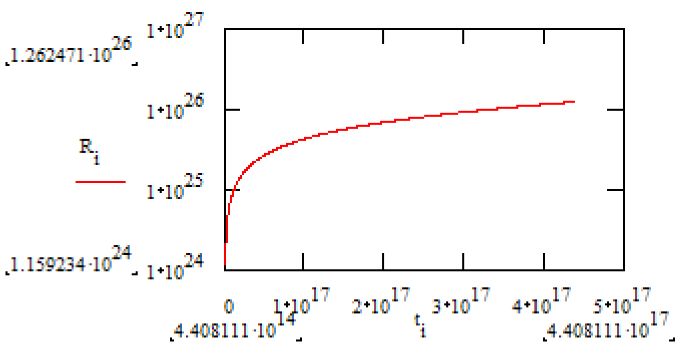
Sources

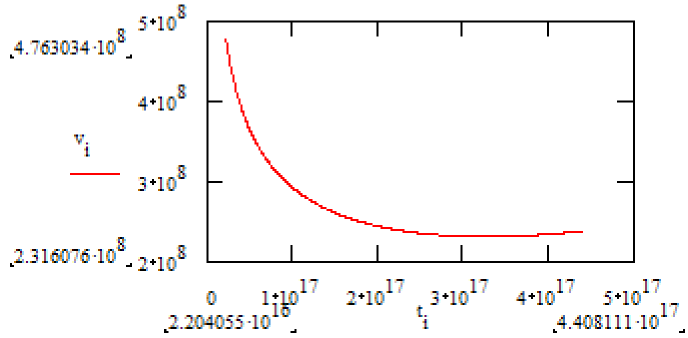
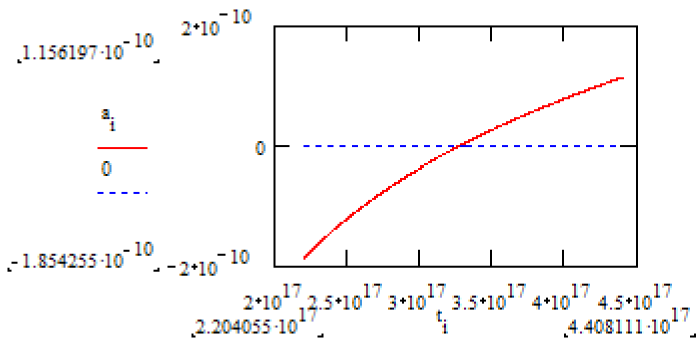
[1] The Cosmological Standard Model, M. Bartelmann, 2019, Springer

Results of the acceleration relation

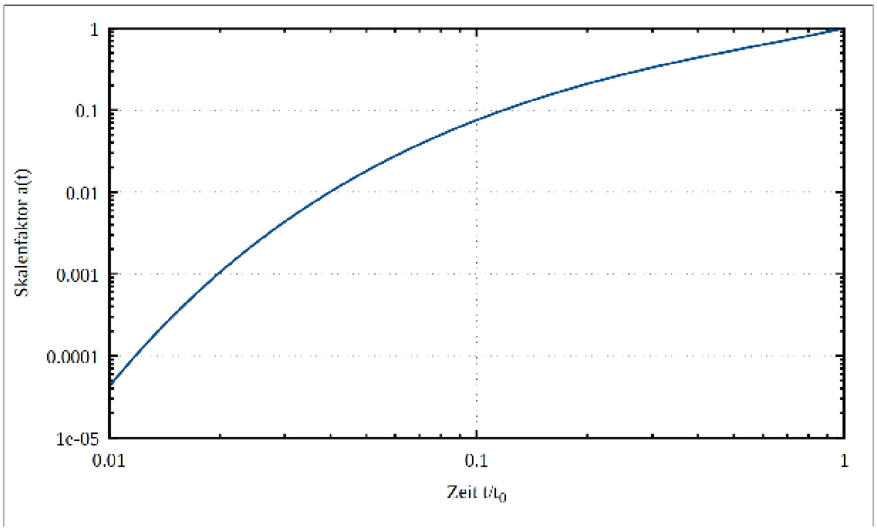
<table>
<tr><td>$a(R) = a_1 R - \frac{a_2}{R^2}$</td><td>Acceleration relation with
$a_1 = \frac{4}{3}\pi \rho_\Lambda G$ and $a_2 = \frac{4}{3}\pi \rho_{M,0} G R_0^3$</td></tr>
<tr><td>$R(t) \Rightarrow R''(t) = a(R)$</td><td>No success; result incomplete and too complicated</td></tr>
<tr><td>$v(R) \Rightarrow \frac{dv}{dR} v = a(R)$</td><td>
</td></tr>
<tr><td>$R(t) \Rightarrow R'(t) = v(R)$

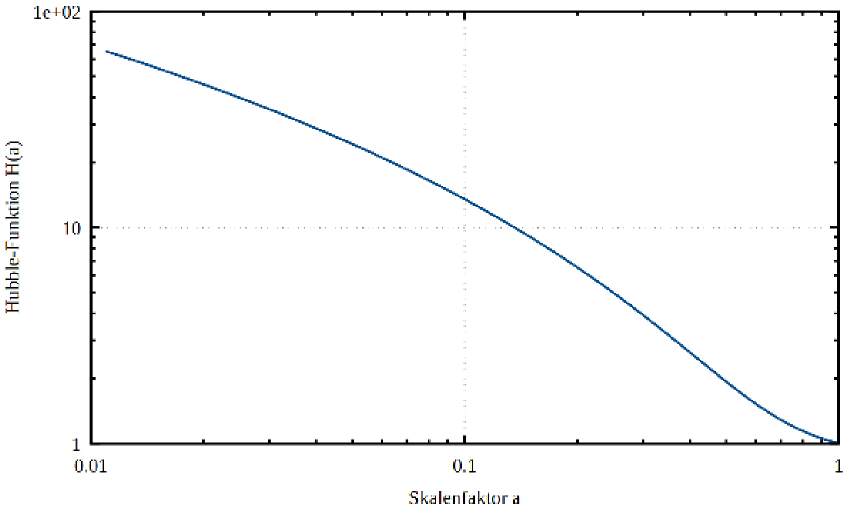
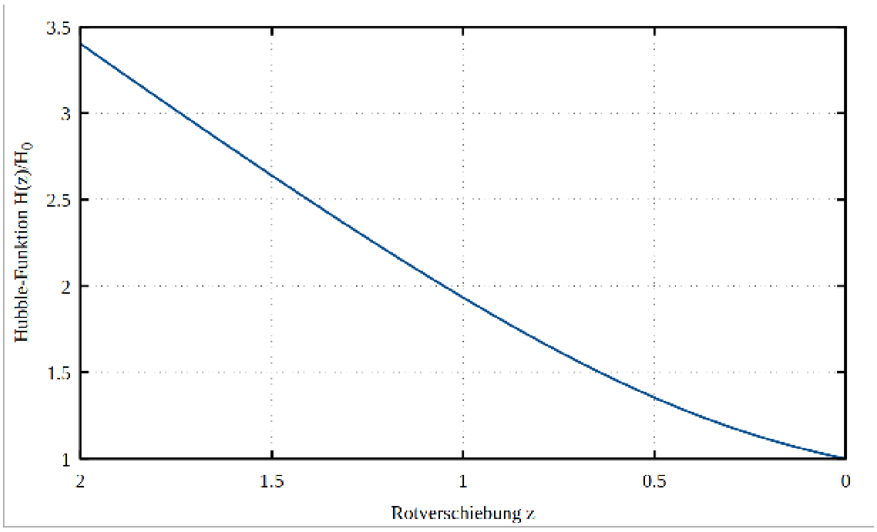
$c_1 = 0$

$c_2(R(t=0) = 0)$</td><td>
</td></tr>
</table>

$v(t)=R'(t)$	
$a(t)=v'(t)$ $t_0-t(a=0)=3.604\ Mrd.a$	
$v(t;c_1)\Rightarrow R'(t)=a(R)$	No success
$R(t)\Rightarrow R'(t)=v(t;c_1)$	No success

Scientific results of the presumption

from ρ_Λ, $\rho_M(a)$	

from ρ_Λ, $\rho_M(a)$	
from ρ_Λ, $\rho_M(a)$	

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$Mpc := 3.0856775\cdot 10^{22}$ $\quad \Omega M := 0.3$ $\quad \Omega tot := 1$ $\quad \Omega\Lambda := \Omega tot - \Omega M$ $\quad G := 6.674\cdot 10^{-11}$ $\quad H0 := 70\cdot\frac{1000}{Mpc}$

$c := 2.9979\cdot 10^{8}$ $\quad R0 := \frac{c}{H0}$ $\quad R0 = 1.322\cdot 10^{26}$ $\quad \rho c0 := \frac{3\cdot H0^2}{8\cdot\pi\cdot G}$ $\quad \rho c0 = \rho c0\cdot\Omega tot$ $\quad \rho\Lambda := \rho c0\cdot\Omega\Lambda$ $\quad \rho M := \rho c0\cdot\Omega M$

$a = a1\cdot R - \frac{a2}{R^2}$ $\quad a1 := \frac{4}{3}\cdot\pi\cdot\rho\Lambda\cdot G$ $\quad a2 := \frac{4}{3}\cdot\pi\cdot\rho M\cdot G\cdot R0^3$ $\quad n := 1000$ $\quad i := 0 .. n$ $\quad t_i := \frac{1}{H0}\cdot\frac{i}{n}$

$v = -\frac{\sqrt{a1\cdot R^3 + 2\cdot a2}}{\sqrt{R}}$ $\quad \frac{dR}{dt} = -\frac{\sqrt{a1\cdot R^3 + 2\cdot a2}}{\sqrt{R}}$ $\quad c2 := \frac{1}{3}\cdot\frac{(\ln(2) + \ln(a1) + \ln(a2))}{\sqrt{a1}}$ $\quad c2 = 3.89308\cdot 10^{18}$

v(R) aus a(R):

$\frac{dv}{dR}\cdot v = a1\cdot R - \frac{a2}{R^2}$

$v = -\frac{\sqrt{a1\cdot R^3 + 2\cdot a2 + c1\cdot R}}{\sqrt{R}}$

$c1 = 0$

aus R(t):

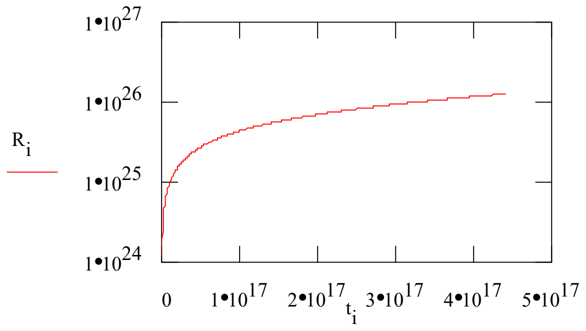
$0 = \frac{e^{-\sqrt{a1}\cdot(-c2)}\cdot\left[\left[2\cdot a1\cdot a2\cdot e^{3\cdot\sqrt{a1}\cdot(-c2)}\right] - 1\right]^{\frac{2}{3}}}{2^{\frac{2}{3}}\cdot a1^{\frac{2}{3}}}$

$c2 = \frac{1}{3}\cdot\frac{(\ln(2) + \ln(a1) + \ln(a2))}{\sqrt{a1}}$

R(t) m. c1=0 <= R'(t)=v(R) m. c1=0 $\qquad$ v(t)=R'(t) $\qquad$ a(t)=v'(t)

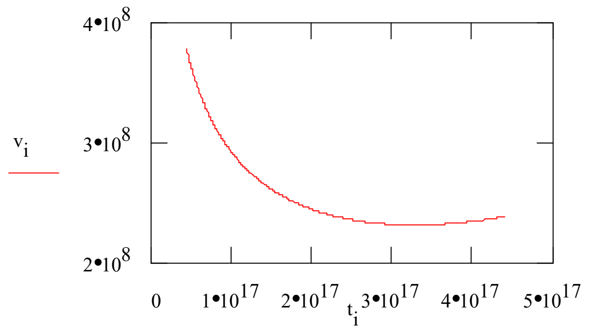
$i := 0 .. n$

$R_i := \frac{e^{-\sqrt{a1}\cdot(t_i - c2)}\cdot\left[\left[2\cdot a1\cdot a2\cdot e^{3\cdot\sqrt{a1}\cdot(t_i - c2)}\right] - 1\right]^{\frac{2}{3}}}{2^{\frac{2}{3}}\cdot a1^{\frac{2}{3}}}$



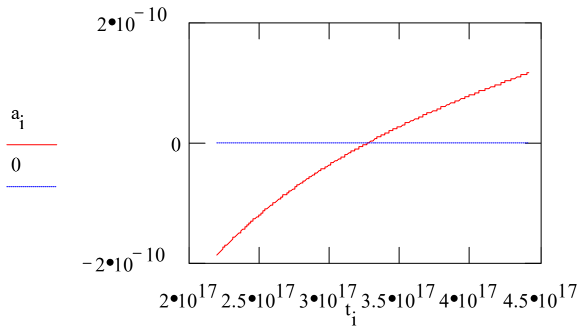
$$v_i := \frac{-1}{\left[2\cdot\left[a1^{\left(\frac{1}{6}\right)}\cdot\exp\left(\sqrt{a1}\cdot t_i\right)\right]\right]}\cdot\exp\left(\sqrt{a1}\cdot c2\right)\cdot\left[2\cdot a1\cdot a2\cdot\frac{\exp\left(\sqrt{a1}\cdot t_i\right)^3}{\exp\left(\sqrt{a1}\cdot c2\right)^3} - 1\right]^{\left(\frac{2}{3}\right)}\cdot 2^{\left(\frac{1}{3}\right)} + 2\cdot\frac{\exp\left(\sqrt{a1}\cdot t_i\right)^2}{\left[\exp\left(\sqrt{a1}\cdot c2\right)^2\cdot\left[2\cdot a1\cdot a2\cdot\frac{\exp\left(\sqrt{a1}\cdot t_i\right)^3}{\exp\left(\sqrt{a1}\cdot c2\right)^3} - 1\right]^{\left(\frac{1}{3}\right)}\right]}\cdot 2^{\left(\frac{1}{3}\right)}\cdot a1^{\left(\frac{5}{6}\right)}\cdot a2$$

$i := 100 .. n$



$$a_i := \frac{1}{2}\cdot\frac{a1^{\left(\frac{1}{3}\right)}}{\exp\left(\sqrt{a1}\cdot t_i\right)}\cdot\exp\left(\sqrt{a1}\cdot c2\right)\cdot\left[2\cdot a1\cdot a2\cdot\frac{\exp\left(\sqrt{a1}\cdot t_i\right)^3}{\exp\left(\sqrt{a1}\cdot c2\right)^3} - 1\right]^{\left(\frac{2}{3}\right)}\cdot 2^{\left(\frac{1}{3}\right)} + 2\cdot a1^{\left(\frac{4}{3}\right)}\cdot\frac{\exp\left(\sqrt{a1}\cdot t_i\right)^2}{\left[\exp\left(\sqrt{a1}\cdot c2\right)^2\cdot\left[2\cdot a1\cdot a2\cdot\frac{\exp\left(\sqrt{a1}\cdot t_i\right)^3}{\exp\left(\sqrt{a1}\cdot c2\right)^3} - 1\right]^{\left(\frac{1}{3}\right)}\right]}\cdot 2^{\left(\frac{1}{3}\right)}\cdot a2 - 4\cdot\frac{\exp\left(\sqrt{a1}\cdot t_i\right)^5}{\left[\exp\left(\sqrt{a1}\cdot c2\right)^5\cdot\left[2\cdot a1\cdot a2\cdot\frac{\exp\left(\sqrt{a1}\cdot t_i\right)^3}{\exp\left(\sqrt{a1}\cdot c2\right)^3} - 1\right]^{\left(\frac{4}{3}\right)}\right]}\cdot 2^{\left(\frac{1}{3}\right)}\cdot a1^{\left(\frac{7}{3}\right)}\cdot a2^2$$

$i := 500 .. n$



$$tv := \left|\begin{array}{l} t \leftarrow \frac{0.5}{H0} \\ \text{while } \left[\frac{1}{2}\cdot\frac{a1^{\left(\frac{1}{3}\right)}}{\exp\left(\sqrt{a1}\cdot t\right)}\cdot\exp\left(\sqrt{a1}\cdot c2\right)\cdot\left(2\cdot a1\cdot a2\cdot\frac{\exp\left(\sqrt{a1}\cdot t\right)^3}{\exp\left(\sqrt{a1}\cdot c2\right)^3} - 1\right)^{\left(\frac{2}{3}\right)}\cdot 2^{\left(\frac{1}{3}\right)} + 2\cdot a1^{\left(\frac{4}{3}\right)}\cdot\frac{\exp\left(\sqrt{a1}\cdot t\right)^2}{\left[\exp\left(\sqrt{a1}\cdot c2\right)^2\cdot\left(2\cdot a1\cdot a2\cdot\frac{\exp\left(\sqrt{a1}\cdot t\right)^3}{\exp\left(\sqrt{a1}\cdot c2\right)^3} - 1\right)^{\left(\frac{1}{3}\right)}\right]}\cdot 2^{\left(\frac{1}{3}\right)}\cdot a2 - 4\cdot\frac{\exp\left(\sqrt{a1}\cdot t\right)^5}{\left[\exp\left(\sqrt{a1}\cdot c2\right)^5\cdot\left(2\cdot a1\cdot a2\cdot\frac{\exp\left(\sqrt{a1}\cdot t\right)^3}{\exp\left(\sqrt{a1}\cdot c2\right)^3} - 1\right)^{\left(\frac{4}{3}\right)}\right]}\cdot 2^{\left(\frac{1}{3}\right)}\cdot a1^{\left(\frac{7}{3}\right)}\cdot a2^2\right] \le 0 \\ \quad t \leftarrow t + 10^{12} \\ t \leftarrow t \end{array}\right.$$

$tv = 3.271\cdot 10^{17}$ $\quad \Delta t := \frac{t_n - tv}{10^9\cdot 365.24\cdot 24\cdot 3600}$ $\quad \Delta t = 3.603653$ Mrd. Jahre $\quad h0 := \frac{c}{R_n}\cdot\frac{Mpc}{1000}$ $\quad h0 = 73.273$ $\quad$ Differenz h0-H0 ist c1=0 geschuldet