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Article

# Cosmological Expansion Rate—Various Measurements and Interpretation III

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## Abstract

Differently measured values of the Hubble constants for extragalactic objects are not considered here. We give a number of examples for the extreme agreement of expansion rates of different fields of knowledge with the cosmological expansion rate. The correspondence of the expansion rates means that a common cause is almost inevitable. All these examples are gravitationally bound and in this case are subject to cosmological expansion. According to standard theory, this should not occur. We therefore question the common boundary of gravity and expansion on both theoretical and observational grounds and conclude that all gravitationally dominated objects participate in cosmological expansion or scale drift in contradiction to the general doctrine. Space expands with its contents while numerically maintaining distance, radius, rotation time and density. What is generally interpreted as expansion is obviously a scale drift with a drift rate that corresponds to the size of the Hubble constant. The Earth is subject to expansion and scale drift. This results in numerically constant measurements. This drift also seems to apply to distant galaxies and other objects. The cosmological redshift is not interpreted here as a Doppler effect and numerical increase in distances, but rather as an expansion or drift of the space-time scale, in accordance with standard theory. The expansion of the radii of galaxies makes the assumption of dark matter superfluous. The continents and our everyday environment are not subject to expansion or scale drift.

**Keywords:** Cosmological expansion; Earth expansion; Joint expansion rates; Recession velocity/relative velocity; Examples

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## 1. introduction

A number of coincidences have been found with the Hubble relation or expansion rate of the universe ( $72 \text{ km} \times \text{s}^{-1} \times \text{Mpc}^{-1} \cong 2.4 \times 10^{-18} \text{ s}^{-1}$ ) in areas that are connected by gravity. A causal connection was already ruled out by Einstein and Straus in 1945 [1]. This was certainly a reason to ignore the counter-arguments, some of which lay in areas of knowledge other than astrophysics. However, there is much to be said in favour of not doing so. Some relevant terms should therefore be explained in particular. These terms are described in more detail in sections 2 - 4. Section 5 briefly describes the origin and nature of counter-arguments and section 6 contains some of the resulting conclusions. Basic conclusions on which others are based are :

Cosmological expansion is also present in areas that are dominated or defined by gravity. Cosmological expansion is not a relative velocity according to the special theory of relativity (STR). It is a scale drift which corresponds to a recession speed. The size of this drift is exclusively defined by the distance of an object from the respective centre of gravity. We therefore assume that cosmological expansion does not lead to a relative velocity and thus to no change in the number of distance units (!). However, there is an expansion of these units, i.e., a scale drift. These expanding units include both spatial and temporal units. Today's SI second was smaller in the past and can be

roughly equated with the UT second. This scale drift affects all distances that are defined by gravity and are measured on **today's scale** (SI system) although some of the events are very old.

## 2. Expansion of Space and the Relative Velocity

In the spectra of extragalactic objects, redshift values occur which correspond to a recession velocity greater than the speed of light ( $c$ ). The cosmological recession velocity can therefore not be a relative velocity in the sense of the special theory of relativity (STR) [2]. Numerical changes in distances (relative velocities) are therefore different from cosmological recession velocities. The numerical distance only changes if a relative velocity is present. Relative velocities between the light source and the observer according to the STR can therefore be ruled out as the cause of the cosmological redshift, provided that peculiar velocities are neglected.

The expansion of the universe or space is therefore *not a numerical* increase in the growing distances in space. The distances and radii expand with space, so they do not expand into or in space. This leads to the unusual situation that the distances grow but not the number of distance units. The distance units are subject to the same rate of expansion as the distances. *We therefore assume that not the number of distance units, but their scaling value expands or drifts.* Space expands with its objects while numerically maintaining distance, radius, rotation time, mass and density. There is therefore no numerical increase in distance or relative speed corresponding to STR as a result of cosmological expansion! With the expansion of space, the numerical distance does not change, but space with its dimensions expands ( Mpc, light year, AU, kilometre, second etc.). The expansion of space with the Hubble parameter means that 1 Mpc has grown approx. 72 km after one second [3]. An object at a distance of 1 Mpc does not move away at a relative speed of 72 km/s, but at this recession speed.

The numerical distance of the object remains constant over time at 1 Mpc, and the expansion corresponds to an expansion (drift) of the unit of measurement used.

## 3. The Lower Limit of Cosmological Expansion or Scale Drift

The lower limit of cosmological expansion postulated by Einstein and Straus [1] is found today by comparing (difference-formation) the respective potential of a gravitating mass with the potential of cosmological expansion. In doing so, an essential incorrectness is committed: The potential of a gravitational mass leads to a change in the relative velocities of objects in the area of influence. In contrast, cosmological expansion does not result in a relative velocity according to STR but something else, namely scale drift. So two different phenomena are being compared. Such a comparison is inadmissible! This inadmissible comparison leads to the assumption that gravitationally bound objects are not subject to cosmological expansion. We consider this assumption to be incorrect. Apart from a few exceptions (e.g., [24, 26, 27, 28]), there is broad agreement that gravitationally bound objects do not expand cosmologically. On the other hand, despite the redshift of the Virgo cluster, i.e., cosmological recession, the so-called Virgo infall exists [4]. In addition to this obvious contradiction, expansion effects of the size of the Hubble constant are repeatedly found in much smaller areas. As a result of different assumptions about the lower limit of cosmological expansion, we have our own view:

The lower limit is not formed by the Einstein/Straus relationship, nor by comparing the gravitational and expansion potentials. We assume that the lower limit of the cosmological expansion is found by comparing the effects of the gravitational potential with the effects of the electromagnetic potential. If one compares the shape of the planets with the shape of small planetoids or even smaller objects, it becomes apparent that the shapes are differently characterised or dominated. Low-mass objects, such as small asteroids, are obviously not influenced in their expansion behaviour by their gravity. The inner bond is not primarily due to their own gravity, as is the case with the Earth, Moon, planets (and galaxies), but to other forces ( electromagnetism ). We conclude that the lower expansion limit is in the transition region. With increasing mass, the shapes become rounder and more characterised by gravity. Smaller, lower mass objects show crystalline and molecular shapes. The

shape-forming properties are less or not dominated by gravity. For example, overhanging parts of a structure (bridges, jibs on a crane) do not obey gravity. A 1 metre rock slab does not become a sphere in free space due to its own gravity. The internal electromagnetic forces are stronger than the gravitational forces. Although gravity determines the spatial structure, this plays a subordinate role in this case. Molecular / crystalline forces dominate the shape of the rock slab. As a result, monolithic, rigid blocks expand less or not at all unless they exceed a limit size/mass ratio. However, rubble piles of the same size can expand. The internal spatial properties determined by gravity are subordinate to the internal electromagnetic properties when the mass is small. Cosmological expansion or scale drift is a property of gravitationally dominated space. This property is not relevant at low mass. Due to this subordination, objects in our daily environment and smaller objects (e.g., small asteroids, second pendulums and caesium atoms) do not participate in the cosmological expansion or scale drift. The relation (1) used below loses its meaning. Although the Earth as a whole is subject to cosmological scale drift (expansion) according to [7], this does not apply to continents with a thickness of a few kilometres (according to [5] and Table 1, line 8). Small asteroids obviously do not expand either. The acceleration of the rotation of small asteroids can therefore occur not only through a change in mass or the YORP effect, but also through shrinkage at a numerically constant radius and angular momentum. Because small objects are not dominated by gravity, they shrink compared to gravitationally dominated objects with constant angular momentum. The measurement system with the SI second shrinks compared to the UT second [20]. The distance between the Earth and the Moon is determined by gravity and is subject to expansion. As with the Earth's radius, the expansion affects the size of the units of measurement, not their number!

Objects or phenomena bound by their own gravity are listed in Table 1. According to standard theory, these should show no cosmological expansion.

If one assumes that all gravitationally dominated distances expand or are subject to scale drift, as is to be expected according to Table 1, then a scale for these phenomena can be introduced in which no drift occurs. In this scale there is no cosmological expansion, but a shrinkage of small objects and distances that are not dominated by gravity. According to T Van Flandern [32], dynamic time is displayed in this scale. This dynamic time is defined by gravity in contrast to SI time, which is defined by atomic processes.

**Table 1.**

<b>Row</b>	<b>Example</b>	<b>Rate</b>	<b>Possible Other Causes</b>	<b>References*</b>
1	Expansion-rate of the universe	$2.33 \pm 0.26 \cdot 10^{-18} \text{ s}^{-1}$	Scale drift ?	[3]
2	Expansion of galaxies	$2.37 \cdot 10^{-18} \text{ s}^{-1}$	Scale drift ?	[6,12]
3	Pioneer anomaly	$2.91 \pm 0.44 \cdot 10^{-18} \text{ s}^{-1}$	Thermal radiation pressure	[15]
4	Expansion of moon's orbit (LLR-Technology)	$3.15 \pm 0.06 \cdot 10^{-18} \text{ s}^{-1}$	Tidal friction	[9]
5	Expansion of moon's orbit (Eclipse)	$2.32 \cdot 10^{-18} \text{ s}^{-1}$	Tidal friction	[8,10]
6	Delay of the Earth's rotation	$2.93 \cdot 10^{-18} \text{ s}^{-1}$	Tidal friction	[11]
7	Distribution of rotational delay of pulsars	$2.7 \pm 0.4 \cdot 10^{-18} \text{ s}^{-1}$	?	[18]
8	Surface relation oceans/continents	$3.0 \cdot 10^{-18} \text{ s}^{-1}$	?	[5]
9	5-dimensional field theory	$3.6 \cdot 10^{-18} \text{ s}^{-1}$	Scale effect	[19]
10	Polar diameter of Earth	$2.5 \pm 0.95 \cdot 10^{-18} \text{ s}^{-1}$	Post glacial uplift	[17]

11	Inner Earth's core	$3.0 \cdot 10^{-18} \text{ s}^{-1}$	Growth by phase-conversion	[16]
12	Expansion of the orbit of Saturn's moon Titan	$2.93 \pm 0,52 \cdot 10^{-18} \text{ s}^{-1}$	Tidal friction on Saturn	[25]
13	Origin drift CM ITRF2008+GRACE+OMCT	$2.5 \pm 1.0 \cdot 10^{-18} \text{ s}^{-1}$	Networksparseness	[7]
14	Expansion of galaxies	$2.33 \pm 0.26 \cdot 10^{-18} \text{ s}^{-1}$	DM in Bose-Einstein condensate	[13]
15	Deimos orbit	$2.16 \cdot 10^{-18} \text{ s}^{-1}$	Tidal friction	[30]
<u>16</u>	<u>Change in the gravitational constant</u>	<u><math>2,19 \pm 0,76 \cdot 10^{-18} \text{ s}^{-1}</math></u>	<u>?</u>	<u>[32]</u>

\* Werte in Spalte 3 wurden vom Autor berechnet. Berechnungsgrundlage sind die Angaben aus Spalte 5.

#### 4. Coincidences

Coincidental numerical equality of two different phenomena in  $10^{\pm 18}$  powers of ten and of the same dimension are very rare coincidences. The occurrence of such a rare coincidence becomes even rarer if another phenomenon of the same size and dimension is added. The probability, or rather improbability, must then be exponentiated. The coinciding rates of terrestrial tidal friction (rotational deceleration) and cosmological expansion rate are a coincidence of two different phenomena. A coincidence of this with the delay rate of the Pioneer anomaly is an almost impossible coincidence. As further phenomena (see Table 1) are added, we exclude random concordance and assume causal concordance. The phenomena mentioned have a common rate because they have a common cause! This cannot be tidal friction. Causal correspondence cannot be based on the Earth because, for example, even the most distant galaxies are obviously subject to this expansion rate (Table 1, [6,12]). We see the still unknown cause of cosmological expansion or scale drift as the cause of this common rate. Its lower limit, however, lies in the region in which gravity is dominant over other fundamental forces, i.e., in the region of gravitationally bound objects.

#### 5. Measured Values Versus Standard Theory

The occurrence of the rate  $\sim 3 \times 10^{-18} \text{ s}^{-1}$  in all the regions listed in Table 1, from the radius of the Earth to the astronomical horizon, is remarkable. In these two extreme cases, relative velocities are excluded as the cause of the existing rate. For the Earth's radius, the exclusion is based on measurement results from X. Wu et al. [7] and for the universe because recession velocities at large distances are greater than the speed of light ( $v > c$ ). If there is a common cause, the relative velocities must also be rejected for intermediate values. This applies, among other things, to lunar orbit and solar orbit in the galaxy. If no relative velocities occur as a result of cosmological expansion, the corresponding distances are numerically constant despite this expansion. The cosmological expansion manifests itself as recession velocity or scale drift. For the distance of the Earth's radius it is approx.  $0.05 \text{ cm/a}$  [5]. Depending on the type of measurement, this results in approx.  $2.9 - 3.9 \text{ cm/a}$  for the lunar orbit [8,9,10]. The distance of the solar orbit from the core of the Milky Way gives a recession velocity of about  $4 \times 10^{15} \text{ km/orbit}$  ( $\sim 420 \text{ Ly/orbit}$ ) or  $18 \times 10^6 \text{ km/a}$ . The distance of the Andromeda nebula gives a speed of  $50 \text{ km/s}$ . However, the recession velocity of the Andromeda nebula is superimposed by a larger, opposite relative velocity. The values given are obtained by using the rate  $\alpha = 2.5 \times 10^{-18} \text{ s}^{-1}$  and the relation (1). The resulting values agree with the measured values (where measurable).

$$\alpha = \Delta r / (t \times r) \quad (1)$$

( $\alpha$  = expansion rate  $\equiv$  recession rate,  $\Delta r$  = distance difference or recession value,  $t$  = time period,  $r$  = distance)

It is also noteworthy that the expansion and drift rates obtained in the solar system, at approx.  $2.9 \times 10^{-18} \text{ s}^{-1}$ , are significantly higher than the value resulting from extragalactic investigations (see

Table 1). According to investigations by W. Freedman et al. [3], for example, this value is  $\alpha \cong 2.33 \pm 0.26 \times 10^{-18} \text{s}^{-1}$ . The difference in the values can have different causes. The deviatingly high expansion rate of the lunar orbit of  $3.15 \times 10^{-18} \text{s}^{-1}$  obtained by LLR may be caused by the addition of cosmological expansion (scale drift) and relative velocity (due to tidal friction).

Below are some examples of the occurrence of the cosmological expansion rate in gravitationally bound objects. Further examples are partly contained in Table 1.

### 5.1. Earth's Inner Core

In 1962, S.K. Runcorn stated a growth rate of 243 km /  $10^9$  years for the Earth's inner core [16]. That is 0.0125 cm per year and radius of the Earth's inner core. With relation (1), this results in an expansion rate or drift rate of  $\cong 3 \times 10^{-18} \text{s}^{-1}$  and thus approximately the cosmological expansion rate or Hubble constant. The 'surface' of the inner core of the Earth moves away proportionally to the surface of the Earth, the distance to the Moon and the extragalactic objects because the same rate is present for all of them. More recent publications usually also assume an expanding inner Earth core of the same order of magnitude. Although there is an almost the same rate for the phenomena listed in Table 1, a different cause is given for the expanding inner core of the Earth than is likely for all other phenomena. This raises serious doubts.

### 5.2. Earth's Radius and Rotation Time

X.Wu et al. investigate the expansion behaviour of the Earth in [7]. Among other things, the relative velocity between the centre of mass and the earth's surface was measured. They came to the conclusion that there are serious indications of expansion of the Earth's radius. However, the measurements using ITRF 2008 + Grace + OMCT + ECCO showed values  $\sim 0.1 \pm 0.2$  mm/a or smaller, i.e., currently insignificant or non-existent. The scale drift or drift of origin found is of interest here. Its size is not particularly certain due to the insufficient amount of data and, depending on the parameters used, amounts to approx. 0.5 mm / year for the Earth's radius; if the Earth's radius is numerically constant and the units of measurement drift in an expanding manner, the Earth's radius must expand with numerical constancy. We equate the corresponding values and obtain:  $0.05 \text{ cm} / (31.56 \times 10^6 \text{ s} \times 6370 \times 10^5 \text{ cm}) = 2.5 \times 10^{-18} \text{s}^{-1}$ . The cosmological expansion rate with W.L.Freedman et al. [3]  $2.33 \times 0.26 \times 10^{-18} \text{s}^{-1}$  has almost the same value as the scale drift rate given here for the Earth's radius. If the Earth's radius is numerically constant and the scale of the units of measurement drifts, this means that the Earth's radius grows with the scale value. The deceleration rate of the Earth's rotation is also of approximately the same magnitude at  $\cong 2.93 \times 10^{-18} \text{s}^{-1}$ . Some authors ([23, 27]) and we assume tidal friction to be only part of the cause of the rotational deceleration according to section 6 point 3. The rotational deceleration should lead to the pirouette effect if the Earth's mass is approximately constant and the moment of inertia is valid. The earth's radius should expand according to the rotational deceleration. The difference in radius ( $\Delta r$ ) is calculated as in (2).

$$\Delta r = r [ (1 + \Delta t / t)^{0.5} - 1 ] \quad (2)$$

( $\Delta r$  = radius difference,  $r$  = earth radius (cm),  $t$  = rotation time (s),  $\Delta t$  = Length of day (LoD) change (/100 a),  $\Delta r = 6371 \times 10^5 [ (1 + 0.0016 / 86400)^{0.5} - 1 ] = 5.9 \text{ cm} / \text{cy} = \underline{0.059 \text{ cm} / \text{a}}$ , The value 0.0016 / 86400 refers to the lengthening of the day in 100 years.

This value corresponds to the expansion of the Earth's radius per year assumed by L.Egyed and HG Owen. Since the value of the radius difference according to (1) corresponds to the cosmological expansion rate, there is no expansion of the numerical earth radius according to section 2. The increase in the value by  $0.059 \text{ cm} / (a \times r)$  results from the scale drift published in [7] at a numerically constant earth radius. The scale drift value of approx. 0.5 mm / year and earth radius given in [7] is therefore acceptable. If the drift is continuous, smaller drift values are obtained for smaller distances and periods and larger drift values for larger distances and periods. The expansion of the lunar orbit and other distances can also be explained by scale drift.

As an earth expansion is assumed here, albeit with a constant numerical radius, the pirouette effect should also be assumed. For the near past, a rotational delay of the Earth is therefore noticeable, e.g., during historical solar eclipses. In 1959, P. Ahnert gave the delay as  $\Delta t \sim 29.95 \times T^2$  and N. Baer [11] as  $\Delta t = 29.2208 \times T^2$ . NASA favours the value  $\Delta t = 32 * T^2 - 20$  seconds from Espenak and Meeus for events close in time. ( $\Delta t$  in s)

We use Baer's value here without claiming better accuracy.

$$\Delta t = 29,22 \times T^2 \quad (3)$$

( $\Delta t$  in s,  $T$  = number of Julian centuries)

Since a century has approx.  $31.56 \times 10^8$  seconds, the deceleration rate ( $\alpha$ ) of the last millennia is obtained as follows  $\alpha = 29.22 \text{ s} \times (1/31.56 \times 10^8 \text{ s})^2 = 2.94 \times 10^{-18} \text{ s}^{-1}$ .

We take this result as a clear indication that this deceleration rate results from the drift rate found by X Wu and represents the cosmological expansion rate.

Rotational delay could also be detected much further back in the past. According to studies by N. de Winter et al. [31], the year had 372 days  $70 \times 10^6$  years ago with a constant year length ( $31.56 \times 10^6$  s). The length of today's day (Lod) is  $372 / 365.25 = 1.018480$  times longer than at the beginning of this time. This is only true if today's atomically defined time scale also applies to gravitational processes, which is not self-evident. Conversely, the Lod at the beginning was only 0.98185 of the recent Lod. The sum of the past days is greater than with a constant number of days per year. At a constant 365.25 d / a, the number of days would be  $25.5675 \times 10^9$  days. However, the total is

$$\Sigma = 0,5n (x_1 + x_n) \quad (4)$$

( $\Sigma$  = Sum of past distance units,  $n$  = age in days ( $1a = 365.25$  d),  $x_1$  = scale value of the first unit (0.98185),  $x_n$  = current scale value of the distance unit ( $1\Sigma = 0.5 \times 25,5675 \times 10^9 \text{ d} \times (1 + 1,018480) = 25,80374 \times 10^9 \text{ d}$ ).

The accumulated rotation delay is  $25.8037 \times 10^9 \text{ d} - 25.5675 \times 10^9 \text{ d} = 236.240 \times 10^6 \text{ d}$  (646790 years with 365.25 days each). Using relation (3), the delay is  $\Delta t = 1.43 \times 10^{13} \text{ s} = 165\,509\,259 \text{ d} = 453140$  years. The value determined with (3) is approx. 0.7 of the value from (4) and confirms the applicability of (3) for longer periods of time, contrary to other publications.

The statement that the day used to have fewer hours (seconds) was obviously not examined in the literature, A scale drift of the (SI) second or the use of the UT.second (dynamic time scale) is not mentioned anywhere. In this case, the day in the past would not have had fewer hours or seconds than today, but shorter! It is generally accepted that the length of the day was shorter in the past. It is incomprehensible why other units of time (hours, seconds) should have had a constant length in the past.

### 5.3. Area Ratio of Continents to Oceans

Including the continental shelves in oceanic shelf areas down to a depth of  $\sim 200$  m, the total area of the continents on Earth is approx.  $177 \times 10^6 \text{ km}^2$ . This area would completely cover a globe with a radius of 3750 km. With an earth radius of  $r = 6370$  km,  $333 \times 10^6 \text{ km}^2$  remain for the oceanic crust. The difference between the radii is  $\Delta r = 2620$  km. The age of the Earth's oceanic crust is less than  $200 \times 10^6$  years, while the age of the continents is about  $4 \times 10^9$  years ( $t = 1.26 \times 10^{17} \text{ s}$ ). If the oceanic area was newly added, this corresponds to an expansion of the Earth's radius but not an expansion of the continental surface. This assumption is made by Hilgenberg, Carey, Maxlow, Scalera and other expansionists. This expansion is possible if the Earth's radius is dominated by mass and gravity, but the continental surface is dominated by the rigidity of electromagnetic forces. The expansion should also be detectable. According to the work of X. Wu et al. [7], it is generally assumed that there is no relevant earth expansion. In contrast, we assume an imaginary expansion, or better, scale drift, as shown in sections 2. and 5.2. (Rotation time). The expansion does not mean an increase or change in the number, but an increase in the size of the units of measurement with a constant number. The

size of the drift rate or expansion rate can be determined with the relationship (1) if the above values for  $r, t$  and  $\Delta r$  are used. It results in  $\alpha = 3.265 \times 10^{-18} \text{ s}^{-1}$ .

For comparison, If the age of the continental crust is assumed to be  $4 \times 10^9$  years and the age of the universe  $13.7 \times 10^9$  years, the age of the crust is 29.2 %. Since a relatively constant expansion rate of the universe is to be expected for  $4 \times 10^9$  years, this results in a cosmological expansion of 29.2 %. If this applies to the Earth according to Section 5.2, the Earth was 29.2 % smaller than it is today when the continental crust formed. The radius of the Earth was 1860 km smaller at that time. On today's scale,  $r = 6370 - 1860 = 4510$  km. Equation (1) results in an expansion or drift rate of  $\alpha = 2,313 \times 10^{-18} \text{ s}^{-1}$ . The difference to the value of  $\alpha = 3.265 \times 10^{-18} \text{ s}^{-1}$  determined above may have been caused by an incorrect crustal age or area ratio, but also by scale drift.

The expansion rate determined with both methods is close to the cosmological expansion rate.

#### 5.4. Distance to the Moon

The distance to the Moon is about 60 times greater than the Earth's radius. If both the drift rate at the Earth's radius and the expansion rate of the Moon's orbit have the same numerical value and the same cause as assumed here, then the drift or recession value of the Moon's orbit should be 60 times greater than that of the Earth's radius. With the drift value of the Earth's radius of 0.05 cm per year and Earth radius ( section 5.2.), the recession value of the Moon is  $60 \cdot 0.05 \text{ cm} = 3.0 \text{ cm}$  per distance and year. This is in good agreement with values obtained for solar eclipses. Sediment data also indicate an expansion or drift of  $2.9 \pm 0.6 \text{ cm/year}$  for the recent geological past [8]. Some smaller recession values have been published for the distant past [10]. This is probably due to the use of today's drifted scales for original phenomena. By using the relation (1) and inserting the values for recession value, distance and period, we obtain  $3.0 \text{ cm} / (384400 \times 10^5 \text{ cm} \times 31.56 \times 10^6 \text{ s}) = 2.47 \times 10^{-18} \text{ s}^{-1}$ . This is approximately the cosmological expansion rate. Measurements with LLR result in the larger recession value of  $3.82 \pm 0.07 \text{ cm/a}$  ( $3.15 \times 10^{-18} \text{ s}^{-1}$ ) [9]. However, it is likely that a relative velocity (e.g., from tidal friction) and the recession velocity or scale drift complement each other because the Moon still exists (see also Section 6.3). This assumption is now supported by several authors [28]. In the case of the Andromeda galaxy, a (negative) relative velocity must also be added to the recession velocity.

#### 5.5. Pioneer Anomaly

The Pioneer anomaly describes an anomalous deceleration of the Pioneer X and XI space probes. The deceleration value is  $8.74 \times 10^{-8} \text{ cm} / \text{s}^2$  [15]. It results from a frequency shift of the radio signals assuming the Doppler effect. Division of the delay value by the speed of light results in a delay rate of  $2.91 \times 10^{-18} \text{ s}^{-1}$ . This value is exactly the same as the Earth's rotational delay and corresponds approximately to the Hubble parameter (!). Shortly after the discovery of the pioneer anomaly, cosmological expansion was considered a possible cause. This possibility was rejected by cosmologists [22]. The argument: cosmological expansion only leads to redshift, and only outside gravitationally bound systems. We refute these assumptions in sections 2 and 3. If, contrary to standard theory, the Universe is expanding within the Solar System, then the units of space (metres, light-years, seconds, etc.) were smaller at the time of the spacecraft launches than they are today. Due to the expansion of the units of measurement since the probes were launched, the current measured distance is numerically smaller than expected. To determine the distance at the time of measurement, the average scale value of the expanding units of measurement must be used. The measured distance must therefore be corrected using equation (4). The same procedure is used in section 6, subsection 8, where the expanding scale value at the end of a period must also be taken into account and the distance corrected. Failure to make this correction will result in an apparent delay.

#### 5.6. Expansion of the Orbit of Saturn's Moon Titan

Measurements by the Cassini probe show that the orbit of Saturn's moon Titan is expanding (or drifting) by  $11.3 \pm 2.0$  cm/year. This value could be due to tidal friction. However, without additional assumptions, as described by V. Lainey et al. in [25], this value is clearly too large for normal tidal friction. However, according to F.R. Stephenson et al. [23], the orbital expansion of our Earth's moon and other Saturnian moons measured by the LLR is also too large to be caused by tidal friction. Taking into account the measured value and Titan's orbital radius of  $1.22 \times 10^{11}$  cm, this gives an expansion rate of  $\alpha = 11.3 \text{ cm} \times (31.56 \times 10^6 \text{ s} \times 1.22 \times 10^{11} \text{ cm})^{-1} = 2.93 \times 10^{-18} \text{ s}^{-1}$ . It should be noted that the proximity to the cosmological expansion rate has already led to discussions [26].

### 5.7. Size Evolution of Galaxies

The effective radius of large galaxies decreases with distance, and the internal density and dynamics increase. There are a number of studies on this topic, e.g., in [6,12,21]. P.v.Dokkum et al. [6] describe galaxies at a distance of  $z \sim 2.2$  ( $\sim 10.7 \times 10^9$  Ly). We see these galaxies as they were after 20% of today's age. The radii appear to be about 0.9 kpc, or 20% of the radius of galaxies of the same type and mass today. There are no such galaxies in the nearby Universe today. No other explanation than expansion seems possible. Let us assume that today's galaxies began at this size and density. In this case, the expansion rate results from the difference in radius per radius and expansion time (1).

$$\alpha = \frac{\Delta r}{r} = \frac{5 - 1}{5} = \frac{4}{5} = 2.37 \times 10^{-18} \text{ s}^{-1} \quad (1) \quad r \times t = 5 \times 10.7 \times 10^9 \times 31.56 \times 10^6 \text{ s} = 1.688 \times 10^{18} \text{ s}$$

$\alpha$  = expansion rate or drift rate,  $\Delta r$  = difference between present radius (=5) and emission radius (=1),  $r$  = adequate present radius (=5),  $t$  = distance in light travel time (SI-s).

This expansion rate corresponds to a Hubble constant of 73.2 (km / s) / Mpc. The objects are gravitationally bound objects. They expand according to the cosmological expansion. This contradicts standard cosmology. I.Trujillo makes a similar observation when he writes: 'Consequently, the very dense nature of our objects at high  $z$  could reflect the much denser state of the universe at the time of their formation' [21]. We see that these studied objects exhibit the same effect and expansion rate as observed today as scale drift on Earth (see above: Earth radius). The expected lower expansion rate at this large distance (early time) is not noticeable! It is obvious that a fundamental argument in favor of dark energy is invalid.

### 5.8. Deimos, the Moon of Mars

According to several authors, the Martian moon Deimos is gradually moving away from Mars. In [30] L. King gives an average expansion value of 3032 km in  $\cong 1.85 \times 10^9$  years. This is  $\Delta r \cong 0.16$  cm per year. The possibility that this orbital expansion is caused by cosmological expansion is explicitly acknowledged. With a current orbital radius of  $r = 23460$  km and equation (1), the expansion rate becomes

$$\alpha = \Delta r / (t \times r) \quad (1)$$

$\alpha \cong 0,16 \text{ cm} / (31,56 \times 10^6 \text{ s} \times 23460 \times 10^5 \text{ cm}) \cong 2,2 \times 10^{-18} \text{ s}^{-1}$ . If cosmological expansion is present, i.e., a rate of  $\cong 2.3 \times 10^{-18} \text{ s}^{-1}$ , then a  $\Delta r$  of 0.17 cm/a is required. Since a slightly different rate also appears for other, different phenomena (see Table 1), it can be assumed that the same cause is present for this correspondence and that L King's consideration in [30] is correct.

### 5.9. Speculations

If galaxies expand at the cosmological expansion rate, contrary to the doctrine, or their spatial units drift, then Van Dokkum's galaxies, as *apparently* observed, had 1/5 of their present size after 1/5 of the age of the universe. Assuming the same cause due to the same drift rate, the Earth's radius during the formation of the continental plates approx.  $4.2 \times 10^9$  years ago or after approx. 2/3 of the universe age is *apparently* also 2/3 (0.66) of its current size. 'Apparent' because this drift is not a relative velocity between the centre and the Earth's surface (periphery). The Earth's volume (and density) remained numerically constant according to X.Wu [7]. We conclude: The mentioned galaxies

were only apparently 5 times smaller and  $\sim 5^3 = 125$  times denser than our (today's) neighbouring galaxies of the same type. Using this approach, galaxies that can be observed at a distance of  $13 \times 10^9$  light years (i.e., approximately 6% of the age of the universe) are apparently 17 times smaller than our neighbouring galaxies. This makes them approximately  $17^3$  ( $\sim 4900$ ) times denser.

This is consistent with the density of matter in the early universe according to doctrine. In consideration of the scale drift with the original units of space and time being smaller, the light travel time (distance)  $\Sigma$  of these objects of  $13 \times 10^9$  Ly is to be corrected using relation (4) (see analogue section 6.8).

$$\Sigma = 0,5n (x_1 + x_n) \quad (4)$$

$$= 0,5 \times 13 \times 10^9 (1 + 17) = 117 \times 10^9$$

In consideration of the preceding scale values for the light travel time, the resultant value is  $117 \times 10^9$  years.

For the microwave background (CMB), the apparent age of which is approximately 380000 years less than the age of the universe, this results in a light travel time (distance) of approximately  $2.36 \times 10^{14}$  Ly. Whether the age of the universe is now  $13.8 \times 10^9$  years or  $\infty$  then depends on whether the atomically defined SI time scale or the (dynamic) scale defined by gravitation is used, in other words: The question of whether the correction according to (4) is carried out must be considered. The doctrine operates under the assumption that the SI time scale is not subject to scale drift. This contradicts Einstein's requirement of a constant speed of light. This is only the case if the smaller spatial scale values in the past are also assigned smaller temporal scale values. By applying relation (4) it is assumed that the SI second drifts with a drift rate equal to the cosmological drift or expansion rate. This application for calculating distances also has the advantage that it puts cosmological problems in a completely different context. This means that very large and very old structures in an infinitely large and infinitely old universe are not a violation of the cosmological principle. Recent measurement results indicate this problem.

## 6. Conclusions

The recession rates of  $2 - 3 \times 10^{-18} \text{ s}^{-1}$  listed in Table 1 suggest that there is a common cause for the phenomena listed and that the scale drift determined for the Earth is identical to the cosmological expansion. The multiple occurrence of the recession rate also occurs in gravitationally bound systems. Section 2 shows that expansion or recession is not a relative velocity in the sense of STR. There is therefore no numerical change in distances due to the occurrence of this rate. The work of X. Wu [7] and NASA confirms, in the case of the Earth, that this rate is caused by scale drift and not by a relative speed, albeit very small, between the centre of the Earth and the surface. It can be assumed that relative velocities between orbiting and central objects are generally very small or non-existent. The very small expansion value of  $15 \pm 4 \text{ m/cy}$  was given by GA Krasinsky & VA Brumberg [29] for the relative velocity between the Sun and the Earth. The cosmological expansion is approx. 2 orders of magnitude greater for this distance (if present). However, it is not noticeable numerically as there is scale drift. If one assumes that the cosmic recession is not based on a relative velocity corresponding to the STR and that this occurs in gravitationally bound objects, further subsequent phenomena must occur or be present, for example:

1. According to paragraph 2, there is no relative velocity due to cosmological recession. Orbiting objects therefore retain their numerical distance from the centre of gravity despite this recession. The orbital velocity and orbital radius of the Earth remain numerically constant despite the recession of about  $11 \text{ 'a}^{-1} \text{ AU}^{-1}$ , as does the length of the year. With the numerically constant orbital radius, the orbital velocity also remains numerically constant despite the recession. This applies to the orbits of the Moon and planets, as well as stars in galaxies. When the orbital velocities are plotted against the orbital radii in a diagram, the orbital velocities are approximately flat outwards [14]. The flat curve is necessary because stars further out have not moved numerically away from the centre of the galaxy. These objects have numerically retained

- their orbital velocity from previous orbits. The flat course of orbital velocities in galaxies does not require dark matter. Modified Newtonian dynamics (MOND) is also not required.
2. Gravitationally bound objects (e.g., Earth) and their orbits expand according to the scale drift rate. We can see an example of this in the expanding galaxies in Section 5.7. but also in the Earth's radius and the Moon's orbit. The speed of light remains numerically constant, but can be perceived here as increasing due to our expanded scales. The numerical radii also remain constant as relative velocities according to section 2 are not present [7].
  3. The length of day (LoD) is increasing at about the same rate as the cosmos, and therefore probably has the same cause. An increase in LoD due to tidal friction is assumed here in addition to scale drift. However, tidal friction theory requires a much faster increase in LoD (2.3 - 2.4 ms/cy) than observations allow (1.6-1.8 ms/cy) [23]. This indicates shortcomings. Some of the Earth's angular momentum is transferred to the Moon by tidal friction. This causes the Moon to move away from the Earth as the LoD increases. The LLR measurements of the lunar orbit give a recession of  $3.82 \pm 0.07$  cm/a. This gives a recession rate of a  $3.15 \pm 0.06 \cdot 10^{-18} \text{s}^{-1}$ , the highest similar value for scale drift or recession near the Earth. We therefore assume that the difference to the cosmological expansion rate, or Hubble constant, is caused by tidal friction. The rate is still very close to the cosmological expansion rate. We conclude that the measured recession of about 3.82 cm/a is not primarily a relative velocity. 2.9 cm/a of it is obviously caused by the cosmological expansion or the scale drift of the units of measurement. A relative velocity of 2.9 cm/a, i.e., a change in the numerical distance, therefore does not exist (analogous to the Earth's radius in [7] and galaxy expansion in [6]). Only the difference of  $3.82 - 2.9 = 0.9$  cm/a can be a relative velocity. This value corresponds to the expected tidal friction better than the other two values. It would be wrong to claim that the Moon would be destroyed by the Earth's Roche limit in early times.
  4. According to section 5.7. it can be assumed that radii and distances of spiral galaxies used to be smaller during cosmic expansion, but were numerically constant according to section 2. Outer orbital paths and regions of galaxies move away from their respective gravitational centre faster than the regions near the centre. We observe an analogous situation in the expansion of the Earth and the Moon's orbit: At smaller distances in the past, the scale drift ( expansion) was less than  $3.82 \pm 0.07 \text{ cm/a}$  ( [10] G.E. Williams (2000). ' Our respective' centre of gravity can be the centre of the Earth, the Sun or the galactic centre. The Hubble constant or cosmic expansion rate can therefore have exact scattering widths due to orbital velocities (this is observed).
  5. The continents and our everyday environment do not participate in the expansion or scale drift. These objects as well as e.g., small moons and planetoids are obviously dominated and shaped by electromagnetic forces and not bound by their own gravity (Section 3 ).
  6. The lower limit of cosmic expansion is not cancelled. However, this limit is at a smaller distance than in the standard theory. The size of this distance is interesting for space travel (pioneer anomaly), geophysics (LoD), time determination (leap seconds) and other areas.
  7. Using the brightness of supernovae, it was found that the Hubble constant was smaller at great distances (in space or time) than it is today. The cosmological recession velocity or scale drift has increased less per Mpc at great distances than in the nearby universe (there  $H < 70 \text{ km's-1/Mpc-1}$ ). According to Section 2, gravitationally defined dimensions (radii, distances, time periods) are subject to expansion or scale drift. The Hubble constant relates a recession velocity ( $\text{km's-1}$ ) to a distance (Mpc). The smaller Hubble constant (H), which is determined for large distances, refers to a smaller Mpc. If this is taken into account, the expansion rate remains constant there ( @  $2.4 \cdot 10^{-18} \text{ s}^{-1}$ ). This contradicts the increase in the Hubble constant due to dark energy. We see an indication of the constancy of the numerical Hubble constant in the statement made in point 5.7. that the galaxies investigated in [6] have an expansion rate which is equal to the rate in our neighbourhood.
  8. The deceleration rate of the Earth's rotation is close to the expansion rate of the universe. The deceleration corresponds to a drift of the (SI) time scale. The galaxies mentioned in section 5.7.

have a distance of about  $10.7 \cdot 10^9$  Ly according to the current scale value. Since this distance is numerically constant according to section 2 and had smaller scale values at the beginning, the number of spatial and temporal distance units results in

$$\Sigma = 0,5n (x_1 + x_n) \quad (4)$$

( $S$  = Sum of distance units elapsed since emission,  $n$  = number of distance units defined today,  $x_1$ =scale value of the first unit after emission (=1),  $x_n$ =scale value of the unit in the observation(=5)). The sum of the distance units travelled is  $S= 32.1 \cdot 10^9$  years, according to (4). This equates to  $10.7 \cdot 10^9$  years using today's scale value. The speed of light has remained constant, but the scale value has drifted. It is evident that the light travel time for objects situated at a distance close to the age of the universe, characterised by a high redshift and  $z$ -value, is approaching infinity.

9. The value of the cosmological recession can be calculated using relation (1). For the distance Earth - Sun (AU), this results in a recession value of approx.  $11 \text{ m} \cdot \text{a}^{-1} \cdot \text{AU}^{-1}$ . According to Section 2, this recession velocity is not a relative velocity in the sense of the STR. Relative velocity does not exist. X.Wu et al. find in [7] that a relevant relative velocity of the distance earth centre - surface (earth radius) does not exist either. However, a scale drift corresponding to the expected recession velocity was measured for the Earth ( $\sim 0.5 \text{ mm} \cdot \text{a}^{-1} \cdot \text{r}^{-1}$ ). This drift rate corresponds to the cosmological expansion rate. The recession value of the AU of  $0.15 \text{ m} \cdot \text{a}^{-1} \cdot \text{AU}^{-1}$  determined in [29] is obviously a relative velocity with a cause other than cosmological expansion. For example, a decrease in the mass of the Sun results in a low relative velocity of the increasing distance Earth - Sun (AU).
10. It should be noted that there are other arguments in favour of cosmic expansion (scale drift) in small areas, and that the process of discovery is not yet complete. One example is the orbital expansion of Jupiter's moons [33].

Contrary to standard theory, objects that are bound by their own gravity are subject to cosmological expansion (scale drift). This does not apply to other objects. The former include objects such as fixed stars, pulsars, the Earth and galaxy clusters. Other objects include, for example, smaller, low-mass planetoids and moons ( $r < \approx 200 \text{ km}$ ), continents and objects in our environment.

This should also be considered: If all gravitationally dominated objects and distances are expanding from the Earth's core, the Earth's radius, the Moon's orbit, the Deimos orbit, to the radius of galaxies and their distance, then it stands to reason that the distance units are also expanding and not their number. According to Einstein, at a constant speed of light, not only the spatial units but also the temporal units must expand. So our current SI units were smaller in the past! The question arises whether it is correct to use a scale for gravitationally dominated objects and distances that is not defined in terms of gravity but in terms of atoms! If the gravitationally defined UT scale is used for measurements over larger distances, the scale drift is eliminated and the universe remains homogeneous and isotropic. An unbounded universe is obtained and the Hubble-Lemaître parameter remains constant for all distances, as described in Section 5.7.

Hilgenberg, Carey, Scalera and many others assume that the Earth is expanding. It seems that this assumption is partly justified. X.Wu et al. [7] and NASA confirm this assumption by finding that the measured number remains almost constant as the units of the Earth's radius expand ( drift).

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