Article

Not peer-reviewed version

Cosmic Expansion – Clues From the Earth

Volkmar Müller *

Posted Date: 18 June 2024

doi: 10.20944/preprints202406.1202.v1

Keywords: Expansion rate; Drift rate; Relative speed; Recession speed

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 18 June 2024 doi:10.20944/preprints202406.1202.v1

Article

Cosmic Expansion Clues from the Earth

Volkmar Müller

Germany, 08428 Langenbernsdorf and Trünziger Str. 20; v.mueller@sternwarte-crimmitschau.de

Abstract: It is generally assumed that the universe expands only on large scales. For some time now, there has also been a well-founded assumption in the literature that cosmic expansion also exists in gravitationally bound systems. In this article we attempt to establish whether cosmic expansion also takes place on scales such as the Earth's sphere of influence. In the examples presented, we find the expansion rate of the size required by the "constant" found by Hubble and Lemaître. This is supported by other examples that also contradict the general assumption mentioned at the beginning. However, this leads to conclusions that also call other cosmological assumptions into question.

Keywords: expansion rate; drift rate; relative speed; recession speed

---

1. Introduction

The constant named after Hubble and Lemaître states that the universe expands at approximately 72 km/s per megaparsec (1 Mpc ≅ 3.26×10^6 Ly = 3.1×10^{19} km). At a distance of 100 Mpc, this gives a proportional expansion or recession speed of 7200 km/s. At smaller distances, this proportionality is maintained up to a certain limit, and at large distances it was recognised a few years ago that the proportionality is lost and the Hubble constant (H) is smaller there. However, the author points out in [1] that the distances expand spatially and temporally without relative velocities occurring. The scales of cm, km, s and Mpc (!) drift (expand) because a relative velocity (V_{Rel}) cannot exist, as shown below. Numerically, the distances remain constant. Due to this drift, not only the Hubble constant used to be smaller, but also the Mpc. It has long been acknowledged that recession velocities at great distances (z-values) exceed the speed of light. Recession velocities resulting from cosmic expansion cannot be considered as relative velocities in the context of special relativity (STR). This also applies to smaller and smallest recession speeds, if they occur at all. In 1945, Einstein and Straus [2] assumed a lower limit for cosmic expansion corresponding to (1).

$$(6M/æ \times \mu \times c^2)^{1/3} \quad (1)$$

(2M=Schwarzschild radius of mass, m = substrate density in the universe (3 10^{-31} gr/cm^3), c = speed of light, æ=Einstein's gravitational constant (2×10^{-48} gr^{-1}cm^{-1}s^2))

According to this definition, no cosmological expansion can take place in the region of gravitationally bound objects. This premise was discarded, and now it is widely accepted that the minimum threshold for cosmological expansion can be determined by comparing the gravitational potential of a mass with the potential for cosmological expansion. However, as gravity produces a relative velocity between objects and cosmological expansion does not, these are distinct phenomena that cannot be compared. In recent years, new research has emerged and some authors have raised doubts about the definition of the lower expansion limit, presenting counter-arguments [3–6]. These counter-arguments include results from the realms of galaxies, the Milky Way, the solar system and the Earth. The following sections contain the latter arguments, albeit not in full.

For better comparability, we will use the cosmological expansion rate (α) instead of the Hubble constant (H). This value of the rate α can be calculated by substituting the distance travelled (distance difference), the time required and the object distance into equation (2).

$$\alpha = \Delta r \quad (t \times r)^{-1} \quad (2)$$

(a = expansion rate ≡ recession rate, drift rate, Δr = distance difference or recession value, t = time period, r = distance)

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 18 June 2024 doi:10.20944/preprints202406.1202.v1

For example, for a distance of 1 Mpc: $\alpha = 72\ \text{km} \times (1\ \text{s} \times 3.26 \times 10^{19}\ \text{km})^{-1} = \underline{2.3 \times 10^{-18}\ \text{s}^{-1}}$.

2. Expansion of the Earth

In 2011, X. Wu et al. investigated in [7] how much the distance between the Earth's centre and the Earth's surface changes in a given period of time. In other words, a possible expansion of the Earth has been measured. It was concluded that there are well-founded arguments in favour of an expansion of the Earth. However, the analysis revealed an expansion of the earth's radius of 0.1±0.2 mm/a. An earth expansion assumed by several authors thus appears to have been refuted. A relative speed between the centre of the earth and the earth's surface obviously does not exist. In [1], however, the author states that with relation (2) and the scale drift of ~0.05 cm per year and Earth radius found in [7], there is a drift rate of size α.

$\alpha = 0.05\ \text{cm} / (31.56 \times 10^{6}\ \text{s} \times 6371 \times 10^{5}\ \text{cm}) = \underline{2.48 \times 10^{-18}\ \text{s}^{-1}}$.

This rate is of the same size as the cosmological expansion rate and therefore corresponds to the Hubble constant. Here too, as with very distant galaxies (z > 2), the recession is not caused by a relative velocity but by scale drift. Since this rate also occurs at other distances, a relative velocity between centre and periphery must also be rejected for these distances (e.g. for the inner core of the earth, lunar orbit, radii of galaxies, and other gravitationally orbiting objects). More on this in the following sections. If **no** relative velocity occurs and the number of distance units is constant, the measured scale drift means an expansion of the earth's radius corresponding to 0.05 cm/a.

The values found in [7] indicate not only a temporally constant number of units of the Earth's radius (approx. 6371×10^{5} cm), but also their expansion due to scale drift. If the units of measurement cm and km are expanding, this is also true for Mpc (!) and, if the speed of light is numerically constant, also for the second and other units of time. It can therefore be assumed that the second was smaller in the past. The emission wavelengths of light from distant galaxies were therefore smaller than when they were received (redshift).

3. Rotation of the Earth

From the beginning of development until 1967, the day had 24 hours, i.e. 86400 seconds. Then the definition of the second was revised, and from that moment onwards, the second was no longer defined by gravitational (dynamic) processes but by atomic processes. This change had significant implications. It turned out that these two time scales are not synchronised. Using much more accurate clocks, it was found that the sun advanced by about 1.2 arc seconds in 100 years and that the "earth clock" needed about 29.22 seconds [20] to reach the expected position. Solar and lunar eclipses have confirmed this delay in the Earth's rotation over the past 3 millennia. This means that small changes and changes of short duration can be neglected. For significantly longer periods of time, around 0.5×10^{9} years, an approximately equal deceleration rate of the Earth's rotation could be determined using fossils. For example, corals with an age of approx. 380×10^{6} a were found (= $380 \times 10^{6} \times 31.56 \times 10^{6} \approx \underline{1.20 \times 10^{16}\text{s}}$). The samples displayed distinct growth rings, wherein an annual ring contains approximately 396 daily growth rings. With a constant numerical year length of 31.56×10^{6} s, 79700 s remained per day. The length of the second was 79700/86400 = 0.92 of today's value. In 380×10^{6} years, 1.20×10^{16} (UT) seconds have elapsed.

This sum of the elapsed UT seconds forms a time span in SI seconds, which results from (3).

$$\Sigma = n/2(x_1 + x_n) = 1.20 \times 10^{16} / 2 \times (1 + 0.92) = \underline{1{,}152 \times 10^{16}}. \quad (3)$$

(Σ = Sum of SI seconds (today's measure), n= number of UT1 seconds, x_1= length of the SI second, x_n = length of the first second.)

The cumulative deceleration of the Earth's rotation during this period is

$\Delta t = 1.20 \times 10^{16}\text{s} - 1{,}152 \times 10^{16}\text{s} = \underline{4{,}8 \times 10^{14}\ \text{s}}$ (=$15{,}2 \times 10^{6}$ years= 3,9 % of 380×10^{6} a).

The above-mentioned delay of 29.22 s/100 a comes from observations of the last 3 millennia. For the period of 380×10^{6} years, a delay is obtained in this way with relation (4)

$\Delta t = 29{,}22 \times T^2$ (4)

$= 29{,}22 \times (3{,}8 \times 10^6)^2 = \underline{4{,}2 \times 10^{14}\ s}$

(T = number of Julian centuries)

The period 380×10^6 years also allows long-term periodic changes, such as the precession period, to be neglected. The approximate agreement of the Δt values found with both methods confirms the applicability of the delay value of 29.22 s / 100 a to both time periods. Since the deceleration rate is related to 1 second, i.e. $1/ 31.56 \times 10^8$ of a century, the deceleration rate α can be determined using relation (4)**:**

$\alpha = 29{,}22\ s \times (1/31{,}56 \times 10^8\ s)^2 = \underline{2{,}94 \times 10^{-18}\ s^{-1}}$.

This value is very close to the cosmic expansion rate or Hubble constant. It would be very surprising if tidal friction led to the same value, especially as the same rate occurs on Saturn's moon Titan and other objects. The deceleration rate of the Earth's rotation results from the change from the previously used gravitationally (dynamically) defined second to the atomically defined second.

Since the spatial expansion of the universe also implies a temporal expansion or drift at a numerically constant speed of light, an expansive drift of the time scale is expected. This drift disappears if the UT1 scale is used. For very large distances, this leads to completely different values than generally specified. Even at a distance of 380×10^6 years there is a difference of $15{,}2 \times 10^6$ years (see above). D.McCarthy et al [17] state a difference of the UT1 / SI scales with reference to Jeffreys (1976) already for the entire earth age and V.Müller separates the UT scale from the existence of the Earth [1]. He refers to the occurrence of almost the same rate in the orbit of Saturn's moon Titan and also to the fact that this difference between the UT1 and SI scales with the same rate already exists at a distance of 10.7×10^9 light years (z~ 2.186). Investigations by P.Oesch et al [18] at a distance z ~ 6.5 show a similar drift rate and new JWST measurements at z~14 do not contradict this either [21]. Maintaining this drift rate results in a limit value for $\Delta t = \infty$ for a distance of 13.7×10^9 light years, which is confirmed by $z = \infty$. The Big Bang occurred at an infinitely distant point in time on the UT scale. We are not talking about a specific, distant past as in the standard theory!

The Big Bang occurred at an infinite point in time on the UT scale. It is not a specific, distant past **!**

In [12], T.C. Van Flandern assumes the existence of dynamically and atomically defined time scales, which correspond to the UT and SI scales. We assume here that the delayed dynamically (gravitationally) defined time scale due to tidal friction on Earth only increases the delay from 1.7 ms/cy to 2.4 ms/cy.The rotational delay of 1.7 ms/cy results from the cosmic expansion or scale drift as described in [16].

The distance of 4.5×10^9 years (1.42×10^{17} s) with relation (2) already results in a difference of the time scales which amounts to approx. 1/3 of the temporal distance (section 8). The difference in time scales becomes even greater at a distance of approximately. 10.7×10^9 light years. Then this difference is not 15×10^6.years, i.e. not 3.9% and not 1/3 of the distance but, as described in [1], 32.1×10^9 Ly, i.e. 3 times the distance. It should be noted, however, that the difference times (Δt) in light travel time are given in secularly growing (expanding) UT seconds. The insertion/removal of leap seconds can be omitted due to this and the size of the time span. We see the justification for this in the fact that all historical rotation times of the Earth and precisely known orbital distances can be assigned to the same drift rate (α) and thus to the same cause. The drift rate corresponds to the scale difference UT1 - TAI (SI).

4. The Inner Core of the Earth

According to S.K. Runcorn, the Earth's inner core grows at an average speed of 243 km / Ga [8]. The radius of the Earth's inner core would therefore grow at a speed of 121.5 km / Ga, i.e. 0.01215 cm/a. The "surface" of the Earth's inner core is apparently "moving away" from the centre of the Earth at a recession speed of 0.01215 cm/a. The expansion rate α of the inner core radius (~1270 km) results from the relationship (2)

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 18 June 2024 doi:10.20944/preprints202406.1202.v1

$\alpha = \Delta r (r \times t)^{-1}$ (2)

$\alpha = 0{,}01215$ cm $\times$ (1270 $\times 10^5$ cm $\times$ 31,56$10^6$ s $)^{-1}$ = $3{,}0\times10^{-18}$ s^{-1}.

The expansion rates of the inner core and the universe are approximately the same. Similar results were obtained by C. Denis, K. R. Rybicki and P. Varga [9] in 2006.

Should be noted: If the drift rate of the Earth's radius mentioned in section 2 is of approximately the same magnitude and the Earth's radius is numerically constant, the cause of the expansion should be the same. This means that the radius of the Earth's inner core is also numerically constant and the expansion value 0.01215 cm/a results from the drift of the units of measurement and does not represent a relative velocity.

5. The Orbit of the Moon

Since 1969, when the first humans set foot on the moon, reflectors have been left on the moon with which very precise measurements of the distance to the moon have been possible using Lunar Laser Ranging (LLR). It was found that the distance increased by 3.82 ± 0.07 cm per year [10]. However, this value contradicts the value of only 2.82 ± 0.08 cm/a determined by historical eclipses. Sediment data indicate a recession speed of 2.9 ± 0.6 cm/a [11]. Equation (2) can be used to determine the expansion rates. One obtains with

Δt= 3,82 cm/a, r= 384400$\times10^5$cm, t= 31,56$\times10^6$ s an expansion rate α = $3{,}15\times10^{-18}$ s^{-1}

Δt= 2,82 cm/a, r= 384400$\times10^5$cm, t= 31,56$\times10^6$ s an expansion rate α = $2{,}33\times10^{-18}$ s^{-1} .

The recession values have tolerances which, however, are not sufficient to eliminate the contradiction. However, it is possible to eliminate the contradiction on the assumption that different phenomena were measured.

- The value 2.82 ± 0.08 cm/a corresponds to the expansion of the universe and thus, according to section 2, to a scale drift. This was found to be 60 times smaller than 2.82 cm/a by X.Wu et al in [7] at a 60 times smaller earth radius and cannot be a relative velocity even at large cosmological distances due to $V_{Rel} > c$.
- The LLR measurement result, on the other hand, obviously results from scale drift and a supplementary factor. This is approx. 1cm/a and can be caused by tidal friction and other factors, whereby relative velocity is obvious.

The assumption of a tidal friction value ~ 1cm/a offers a further advantage and the solution to another problem:

The advantage is that this value can be better explained by tidal friction than the LLR value, as F.R.Stephenson et al. wrote in [13] in 2016, as well as other authors. The observed value of the earth's rotation delayed by tidal friction of 1.72 or 1.78 ms/day in 100 a is also not exceeded. If the recession value of 3.82 cm/a corresponded to a relative velocity, then the moon would have been too close to the Earth's Roche limit at early times to ensure the moon's existence. With a relative velocity of 1.0 cm/a, this danger does not exist.

6. Area Ratio Continents/Oceans

If the continental shelves in oceanic shelf areas up to a depth of ~ 200 m are counted as continental areas, the Earth has a total continental area of approx. 177 $\times 10^6$ km^2. This corresponds to the area of a globe with a radius of 3750 kilometres. This fictitious radius and the radius of the Earth of 6370 km form a difference of Δr = 2620 km. The age of the continental crust is approx. 4 $\times 10^9$ years (t = 1.26 $\times 10^{17}$s). The oceanic crust is only less than 200 $\times 10^6$ years old. Using relation (2) and these values for r, t, Δr and equating the units, we obtain the expansion rate α.

$\alpha = \Delta r \times (t \times r)^{-1}$ (2)

$= 2620\times10^5 \times(4\times10^9\times31{,}56\times10^6\times6370\times10^5)^{-1}$ = $3{,}26\times10^{-18}$ s^{-1}.

The procedure is confirmed as follows:

If we assume the age of the continental crust to be 4×10^9 years and the age of the universe to be $13{,}8\times10^9$ years, this amounts to ≈ 29 %. Since a relatively constant rate of expansion of the universe

 doi:10.20944/preprints202406.1202.v1

can be expected for 4×10^9 years, a cosmological expansion of ≈ 29 % has taken place during this period. If this is true for the Earth according to section 2, the Earth was 29 % smaller than it is today when continental crust formed. The earth's radius at that time was 6370×0.29=1850 km smaller. According to today's scale, r = 6370-1850 = 4520 km. Relation (2) results in an expansion rate or drift rate of $\alpha = 1850\times10^5 \times(4\times10^9\times31{,}56\times10^6\times4520\times10^5)^{-1} = \underline{3{,}24 \times 10^{-18}s^{-1}}$.

The conformity of the values confirms the procedure, but not the accuracy of the results due to the simplification. These thoughts have little influence on the result that the expansion rate for both methods is close to the cosmological expansion rate.

7. The Earth's Orbital Radius

The length of the day as well as the distance of the Moon and other phenomena show the same rate of temporal and spatial development. It is also obvious to check the radius of the Earth's orbit for this development. If the Moon is moving away from the Earth at the cosmic expansion rate of approx. 2.5×10^{-18} s^{-1} according to relation (2), then this should also be assumed for the distance Earth - Sun. It should be noted, however, that according to sections 1 and 2 cosmological expansion cannot be a relative velocity. For example, when measuring a possible expansion of the earth, it was found that there is no relevant relative speed between the centre of the earth and the surface.

However, the scale drift found in [7] confirms an expansion at a numerically constant earth radius. The drift rate is of the same magnitude as the rate of expansion of the lunar orbit and the drift value of the Earth's radius is 0.05 cm per year. The moon's orbit is approx. 60 times larger than the earth's radius and at the same rate this means that the moon is moving 60 x 0.05 cm/a ≈ 3.0 cm/a away. This does not correspond to modern LLR measurements, but to the recession value determined during historical eclipses and elsewhere. An explanation is given in section 5. The Earth's orbit is about 390 times larger than the Moon's orbit. The scale drift or expansion of the Earth's orbit then corresponds to 390 × 3.0 cm ≈ 1100 cm /a. With (2) a similar expansion value of the earth's orbit is obtained in a different way. Since the drift rate is of the same magnitude as the cosmological expansion rate, we assume that for this reason there is no relative velocity of the Earth with respect to the Sun, but rather a scale drift. Numerically, therefore, the distance Earth - Sun (AU) remains approximately constant, as does the Earth's radius. However, a low relative velocity due to other causes is not excluded (tidal friction, change in the masses involved). Krasinski & Brumberg, for example, give a relative velocity of 15±4 m/cy. However, the much greater cosmological expansion of the Earth's orbit does not occur through an increase in the number of distance units but through expansion of the individual units at a constant number. M Standish apparently does not rule out an expansion value of the AU of 0.0 m/a as well as ≈ 15 m/a [19]. Since in our opinion there is no relevant relative velocity between the Sun and the Earth, the radius of the Earth's orbit is numerically approximately constant. Consequently, the Earth's orbital period (length of year) is also numerically constant. However, the length of the unit of measurement 'day' expanded at a rate of $\sim2.5\times10^{-18}$ s^{-1}. This makes it possible to accommodate more days in the past if the length of the year remains constant (section 3).

The different definitions of AU and Earth's orbital radius can be ignored here.

8. Discussion

In the above explanations, some examples have been given that demand the conclusion: The cosmological expansion rate also applies in the size range of the Earth. This also applies to the Hubble constant. This conclusion is supported by measurements outside the Earth's dominance range. Examples are the Pioneer anomaly, the orbital expansion of Saturn's moon Titan or the expansion of galaxies as described in [1].

If relation (2) is applied to astronomically relevant objects, then if t = 1 is set, the ratio Δr/r will have approximately the same value for α, regardless of the distance. If this is not the case, a relative velocity is present in addition to the scale drift. We can find examples of this with the Moon and the Andromeda Nebula. The use of the simple relation (2) has the advantage that after rearranging and equating the factors and retaining the value for α, it is immediately apparent that our moon, for example, only has a relative velocity of just under 1 cm/a. The remainder of ~ 2.9 cm/a relates to cosmic scale drift or expansion. In the case of Saturn's moon Titan, an expansion of the orbit of ~ 11 cm/a is obtained without prior knowledge of the measured value. This value results only from cosmic scale drift and corresponds to the Hubble constant. The tidal friction is negligible.

The value for α is the same at small and medium cosmic distances. It should be noted that a very long time ago the Hubble constant was smaller, which is initially accepted here. However, it is also considered certain that at least some types of galaxies were smaller in the past and have expanded. In [1], however, it is shown that the galaxies investigated by P.vDokkum et al in [14], despite their very large distance ($z = 2.186 = 10.7 \times 10^9$ Ly), have approximately the same expansion or drift rate as those of other objects in our immediate neighbourhood **!** The growing Hubble constant is thus called into question in [1]. This applies immediately to the existence of dark energy. We see the following explanation**:**

Gravitationally dominated objects expand, such as the inner core of the earth, the earth's radius, the distance to the moon, the orbit of Saturn's moon Titan, galaxy radii and distances. But UT seconds, days and other time scales also expand. The wavelengths arriving at us were also smaller in the past (red shift) although we assume that the emission wavelengths of the same cause are the same here and elsewhere. The same drift, expansion or deceleration rate occurs for all the causes mentioned. Einstein's requirement of a constant speed of light is fulfilled if the expanding temporal scales are assigned the same rate as the spatial scales. The speed of light is then smaller at great distances when using scale values of our environment, but it is numerically constant. Consequently, galaxies located at great distances appear to have radii that are too small when using our expanded scale values, even if they are of the same type as neighbouring galaxies. For example, the galaxies described in [14] are about 5 times smaller, but the scale value of the Mpc is also 5 times smaller there. The smaller Hubble constant at great distances refers to the smaller Mpc there. Since the Mpc was smaller to the same extent, the expansion rate remained constant, taking into account the scale values applicable there, and thus also the Hubble constant. A changing relative velocity is not present (see section 2.). Dark energy was therefore not required to change it. This fact does not speak in favour of the existence of **dark energy**.

It is remarkable for the existence of **dark matter** that, if the numerical constancy of cosmic expansion mentioned in section 2 is recognised, not only radii and distances are numerically constant, but also the orbital periods. The numerical size of radii and distances does not change because the cosmic scale drift or expansion between centre and periphery is not a relative velocity. It is not the number of distance units that changes, but their scale value. Old objects that have been in recession for a long time retain the original numerical orbital radii and orbital periods that existed at the beginning. External observers assume that objects with a larger maximum angular distance from the galactic centres also have larger numerical distances. According to section 2, this is not correct. Greater angular distance due to cosmic expansion does not also mean greater numerical metric distance. Very old objects have large angular distances due to recession which, according to Kepler, do not match the observed orbital velocities of this apparent distance. These objects can reach apparent orbital velocities which are not compatible with Kepler, unless there was a different kind of acceleration in the orbit. Similarly, such an acceleration is attributed to our Moon through tidal friction. However, according to section 5 and [13], this is too low to give the expansion of the lunar orbit measured by LLR. The apparent orbital velocities lead to observable extreme states of density and dynamics that do not correspond to reality. Such extreme states are described, for example, by P v Dokkum et al in [14].

Our Moon moves away by about 3 cm every year. The following can be easily calculated using relation (2): The moon and all gravitationally orbiting bodies have moved 1/3 away from their centre of gravity in the past 4.5×10^9 years (1.42×10^{17} sec), i.e. in ~ 1/3 of the apparent world age. Note the cosmological expansion or drift rate (approx. 2.5×10^{-18} s^{-1}) when calculating using (2). But 4.5×10^9 a × 3 cm/a is also 1/3 of the numerical lunar distance. The length of the day and the UT 0 scale values have increased by about 1/3 during this time. The resulting rotational delay is largely caused by

scale drift (expansion) (see also section 5). Despite the recession, the orbital radius has remained approximately constant numerically because there is no relative velocity due to cosmic expansion (Section 2). With a constant orbital radius, the orbital velocity also remains numerically constant.
This means that in diagrams in which the orbital velocities are plotted over the orbital radius of galaxies, the objects move outwards away from the ordinate with increasing age, which leads to an approximately flat curve at a numerically constant distance. The flat curve is confirmed by the research of V. Rubin et al [15] and other authors. This curve therefore does not require dark matter.

Much smaller areas than those of astronomical relevance do not appear to be expanding. This is the only way to explain the first part of section 6. There it is assumed that the continental crust did not expand, while the Earth as a whole expanded. A similar development is assumed by many proponents of an earth expansion. This becomes understandable under the assumption that gravitational forces dominate over other forces for Earth and more massive objects, while rigid continental crustal blocks and smaller, less massive objects (asteroids, everyday objects) are not dominated and shaped by gravity. All these low-mass objects are obviously not expanding. They shrink in relation to gravitationally dominated objects. Compared to heavy objects, light objects should rotate gradually at an increased speed. There are plenty of examples of exclusively small asteroids (r <~ 100 km) that rotate at an accelerated rate. This does not rule out much larger positive and negative accelerations of the rotation due to the YORP effect.

For further investigations it might be advantageous to look for the lower limit of cosmic expansion where the dominance alternates between gravity and other fundamental forces.

Conclusion

For the inner core of the earth, the radius of the earth, the rotation time of the earth and the orbit of the moon there is a rate which corresponds to the cosmic expansion rate in 17 powers of ten ! This rate is noticeable or measurable as the rate of expansion, the rate of recession or the rate of scale drift of the units of measurement. This rate does not change the number but the scale value of the distance units. A constant number of distance units means that there is no relative speed in the sense of STR. As explained above, the cosmic expansion rate is constant in the Earth's dominance region as well as in the near and distant universe. This contradicts other statements only in the case that for these statements here and now valid units of measurement are used in all distances of space and time. The distance to which the term '*here and now*' is tolerable determines the correctness of cosmological statements. Statements are also essentially dependent on whether atomic or gravitational/dynamic definitions of the units of measurement for space and time are used. Only now and here do these units of measurement coincide. Distances can change by $\sim 2.5\times10^{-18}\ s^{-1}$ after just 1 second, depending on whether this second was a UT or a TAI (SI) second!
For the occurrence of the rate $\sim 2.5\times10^{-18}\ s^{-1}$ in several cases of different fields of knowledge we only see the explanation which is called cosmological expansion. This obviously does not mean relative velocity but scale drift! For the earth's radius this should be considered certain.

The question of which of these two distance scales is drifting and why remains completely open.
A definition of 'cosmological expansion' should apply to both the Earth and the Universe.

Conflicts of Interest: There are no conflicts of interest.

References

1. V. Müller "Cosmological Expansion Rate–Various Measurement Results and Interpretation"[Online] https://www.preprints.org/manuscript/202110.0275/v2
2. Einstein A, Straus EG. "The influence of the expansion of space on the gravitation fields surrounding the individual stars". Rev Mod Phys. 1945;17(2-3):120-124
3. L.A.King and H.Sipila,"Cosmological expansion in the Solar System" Physics Essays, Band 35, Nr.2, Juni 2022, S.139-142(4)
4. A.M.Maeder & V.G.Gueorguiev,[Online]"On the relation of the lunar recession and the length-of-the-day", AstrophysSpace Sci 366,101 (2021). [Online] https://doi.org/10.1007/s10509-021-04004-7 (accessed 2023Dec18)

5. M.Křížek and Y.Dumin[Online]"Cosmology on Small Scales" (acc.2023 Dec)https://css2022.math.cas.cz/proceedingsCSS2022.pdf
6. Lainey V.,Gomez L.C.,Jim Fuller J.,et al. [Online] "New tidal paradigm in giant planets supported by rapid orbital expansion of Titan" [Online] https://arxiv.org/ftp/arxiv/papers/2006/2006.06854.pdf (accessed 2021 Sep 04.)
7. X.Wu, X.Collilieux, Z. Altamimi, B.L.A.Vermeersen, R.S.Gross, I.Fukumori,"Accuracy of the International Terrestrial Reference Frame origin and Earth expansion",Geophysical Research Letters,v 38,(2011) L13304.5
8. Runcorn SK. "Towards a theory of continental drift" Nature. 1962;193(4813):311-314.
9. C.Denis, K.R.Rybicki and P.Varga,"Secular changes of LOD associated with a growth of the inner core", Astron.Nachr. 327,No.4, p 309-313 (2006)
10. J.O.Dickey et al."Lunar Laser Ranging: A Continuing Legacy of the Apollo Program", https://www.researchgate.net/publication/6059837_Lunar_Laser_Ranging_A_Continuing_Legacy_of_the_Apollo_Program
11. L.Riofrio [Online] "Calculation of lunar orbit anomaly",Planetary Science 2012 1:1 https://planetaryscience.springeropen.com/articles/10.1186/2191-2521-1-1 (accessed 2023 Nov18)
12. T.C.Van Flandern (1982) " Is the Gravitational Constant Changing?" In: Calame, O. (Hrsg.) High-Precision Earth Rotation and Earth-Moon Dynamics (1982) Astrophysics and Space Science Library, Band 94.
13. Stephenson F. R.,Morrison L. V.and Hohenkerk C. Y.2016 Measurement of the Earth's rotation: 720 BC to AD 2015 *Proc.R.Soc.A.*47220160404[Online] https://royalsocietypublishing.org/doi/10.1098/rspa.2016.0404 (accessed 2023Dec18)
14. Pieter G. van Dokkum, Mariska Kriek & Marijn Franx " A high stellar velocity dispersion for a compact massive galaxy at z = 2.2" [Online] https://arxiv.org/pdf/0906.2778.pdf (accessed 2024 Apr 21)
15. V. Rubin, W.Ford Jr and N.Thonnard "ROTATIONAL PROPERTIES OF 21 Sc GALAXIES WITH A LARGE RANGE OF LUMINOSITIES AND RADII, FROM NGC 4605 (R = 4 kpc) TO UGC 2885 (R = 122 kpc)", The Astrophysical Journal, 238:471-487, 1980 June 1 [Online] https://articles.adsabs.harvard.edu/pdf/1980ApJ...238..471R
16. V.Müller " Common cause of earth expansion and cosmic expansion " 2019 ResearchGate [Online] https://www.researchgate.net/publication/333118059_Common_cause_of_earth_expansion_and_cosmic_expansion
17. D. McCarthy et al (2008)" THE PHYSICAL BASIS OF THE LEAP SECOND" [Online] https://iopscience.iop.org/article/10.1088/0004-6256/136/5/1906 (accessed 2024 Apr 21)
18. P.Oesch et al " Structure and Morphologies of z~7-8 Galaxies from ultra-deep WFC3/IR Imaging of the HUDF" (2009) [Online] https://arxiv.org/pdf/0909.5183v3.pdf (accessed 2024 Apr 21)
19. Standish M. "The Astronomical Unit now",Proceedings IAU Colloquium No. 196, 2004 and Online 2005 https://www.cambridge.org/core/services/aop-cambridge-core/content/view/2BE5DC4A39F90B58CAEA11EF70B24354/S1743921305001365a.pdf (accessed 2024Apr)
20. N.A.Bär [Online] „Die Akzeleration“,(Dated:Apr 11,2013) http://www.nabkal.de/akzel.html (accessed 2024 Apr 21)
21. S.Carniani et al [Online] " A shining cosmic dawn: spectroscopic confirmation of two luminous galaxies at z ~ 14" https://arxiv.org/pdf/2405.18485 (accessed 2024 6.10.)