Potential Reality I: Relative Scale Spacetime

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Abstract

Ensuing from first principles, a new theory of spacetime has been suggested, called ‘relative scale spacetime’. It denounces the absolute size of objects at different length scales, thanks to which the phenomena known as quantum state (‘just in the middle between possibility and reality’, Heisenberg) and Einstein’s “total field of as yet unknown structure” are unified as potential reality of quantum-gravitational origin (dubbed causal field), endowed with relative-scale metric. At macroscopic scale, it produces what is known as gravitation, without any dark matter nor dark energy.

1. Introduction

This is the first from three papers¹, presenting a theory of spacetime, based on the ideas of Plato, Heraclitus, and Aristotle. It is called relative scale spacetime (Fig. 15)*, and is applicable to quantum, gravitational, and biological systems. The theory reflects my personal views (Sec. 5) on the foundations of Mathematics (Fig. 9 and Fig. 13) and adopts the philosophical doctrine about the design of the Universe, according to which it is both the only possible and the optimal one — Nature is coherent, therefore if we uncover the physics of life and solve² the mind-body problem, one could expect that such solution may outline the only possible theory of quantum gravity (Paper II¹) as well. To reconcile life science with quantum gravity, I model the physical presentation of the Universe as ‘Brain of the Universe’, suggesting an universal flow of events defined with a new form of retarded relativistic causality applicable to quantum, gravitational, and biological systems, dubbed ‘biocausality’² (Paper II), for which the so-called hyperimaginary numbers have been introduced (details in Paper III¹). The proposition about mental “reflection”²¹ or qualia from the Brain of the Universe (Universal Mind and The Holy Trinity) is considered ‘absolutely undecidable’ and will not be discussed. God as ‘the Universe as ONE’ is considered purely mathematical object, which is beyond our cognition and cannot be proved nor disproved.

This paper, dedicated to the centenary of Einstein’s General Relativity⁹ announced on 25 November 1915, suggests a new quantum-gravitational spacetime, in which the size of objects is not considered absolute, but ‘relative to their length scale’, hence the concept of relative scale spacetime (Eq. 2). In a nutshell, I suggest to abolish the presumption of absolute length scale and replace it with relative length scale: the “size” of an objects, say, a table with length 1m, is dual. On the one hand, it is indeed smaller with respect to the size of a galaxy and larger with respect to the size of a proton, but on the other, its (quadratic) invariant spacetime interval 1m is not only “flexible”¹³ due to coordinate-free presentation of gravity (there is no background spacetime supplied by an ether, due to background independence), but is also indistinguishable from the size of a galaxy and the size of a proton — the metric in

* The latest version of the paper, with live links, can be downloaded from http://chakalov.net.
relative scale spacetime changes along the length scale (Eq. 2), in such way that a
galaxy and a proton will have, within their respective length scale domains, the same
**indistinguishable** relative-scale “size” of “1m” **as well**. Hence the quantum-
gravitational spacetime begins from the macroscopic length scale of tables and chairs
in two opposite “directions”, toward the Large and the Small, and all physical objects
always keep their relative and dual “size”. This unique feature of relative scale
spacetime might (i) facilitate the bootstrapping of the entire Universe by a topological
“bridge” of all systems along the length scale (Table 1), produced by sharing a
common quantum-gravitational **potential** reality (dubbed ‘spacetime entanglement’ in
Paper II\(^1\)), and (ii) open the possibility for spacetime engineering\(^6\), provided the
human brain can access such topological “bridge” (Paper III\(^1\)).

With **relative scale spacetime**, the phenomenon known as ‘gravity’ is reduced to
**variable relative metric** (not to “curvature”\(^4\)), and the choice of **tensors** for
mathematical presentation of gravity is considered **wrong**: the gravitational “field” is
not classical objective reality ‘out there’. If it were, it will be a force field, like the
electromagnetic field, in which case the gravitational energy\(^{11,12}\) will be localizable at
a point\(^4\) and the inertial mass of an accelerating particle will be a simple “back-
reaction to its own gravitational field”\(^5\), which in turn will render the **geometrization**
of gravity impossible. The alternative viewpoint would be that gravity “does not
exchange energy-momentum with both particles and electromagnetic field. So, it is
not a force field, it does not carry energy-momentum” (private communication from
Zhaoyan Wu), which makes the energy-momentum contributions of gravity pure magic.
Either way, the unwarranted presumption in present-day General Relativity\(^32,60\) that
the gravitational “field” were objective reality subject to **classical** physics (cf. Sec. 3)
will force us to choose from two options, both of which inevitably lead to dead end\(^6\).

In my opinion, the only way to resolve the puzzle of how matter couples to its
geometry\(^6\) is to elaborate on the proposal by Plato and suggest a new kind of reality,
called after Aristotle ‘potential reality’, which becomes **physicalized** by exerting
energy-momentum and angular momentum in the physical stuff placed in right-hand
side of Einstein’s field equations, yet does not exist as objective reality ‘out there’.
Surely the potential reality is not ‘mind’ nor anything related to **res cogitans**, but a
new kind of **physicalizable** reality “just in the middle between possibility and reality”\(^7\).

In Quantum Theory, we encounter **quantum** potential realities in terms of quantum
state and ultimately quantum vacuum, which are neither objective reality ‘out there’
nor plain mathematical abstraction. As Erwin Schrödinger stressed in 1935\(^8\),

> In general, a variable *has* no definite value before I measure it;
then measuring it does *not* mean ascertaining the value that it *has*.

In brief, I suggest gravitational potential reality, which casts its **physicalized**
explications à la Plato in terms of invariant spacetime intervals with **variable** relative
metric, resulting in **relative scale spacetime** (Fig. 15). The two main issues are (i)
the relative scale “size” of objects (recall the example with one-meter table above) and
(ii) the emergence of gravity due to alteration of the **variable** relative metric,
producing force-free gravitational attraction and, at extragalactic scale, force-free
gravitational “inflation” (Hubble flow). Hence (i) offers a global relational theory of
‘space’ with topological properties ‘large’ vs. ‘small’\(^69\), but without absolute **length
scale**, while (ii) suggests the *origin* of gravity by reducing it to **local** effects of variable
relative metric. (Recall that the current version of Einstein’s theory of gravity\(^60\) does
not even try to explain how the aggregation of matter could evoke the appearance\textsuperscript{44} of gravitational “field”.\textsuperscript{,} The scope of ‘relative scale spacetime’ is full geometrization of gravity by recovering Einstein’s “total field of as yet unknown structure”\textsuperscript{9}:

The right side is a formal condensation of all things whose comprehension in the sense of a field-theory is still problematic. Not for a moment, of course, did I doubt that this formulation was merely a makeshift in order to give the general principle of relativity a preliminary closed expression. For it was essentially not anything more than a theory of the gravitational field, which was somewhat artificially isolated from a total field of as yet unknown structure.

Briefly about the Ansatz of relative scale spacetime. After an overview of the theory, offered in this section, I will examine the proposal by Plato and the arguments for gravitational potential reality (Sec. 2). In the next two sections, I will suggest the origin of gravity as local alteration of the spacetime metric (full geometrization of gravity), and then offer conceptual solution to “the worst theoretical prediction in the history of physics!”\textsuperscript{10}, removing all “dark”\textsuperscript{53} manifestations of gravity – there is no need for any physical stuff acting as “cold dark matter” nor as “dark energy”, because the “shrinking” and “inflating” of the metric (producing in case (i) a “small” proton and a “large” galaxy, relative to a macroscopic table) are presented as force-free effects of the variable metric of relative scale spacetime. The force-free gravitational rotation will be examined in Sec. 4, as the phenomenon of torsion is considered an essential property of gravitational potential reality. In Sec. 5, I will offer a discussion of relative scale spacetime and will finish with an outline of the next Paper II\textsuperscript{1}.

The alternative, and strictly materialistic, view on the origin of spacetime bluntly ignores the proposal by Plato viz. the presence of physicalizable potential reality, and leads to “nontensorial”\textsuperscript{12} (explanation below) nature of gravitational energy (physical energy-momentum tensor for the gravitational field does not exist\textsuperscript{11,12}) and inherent energy non-conservation\textsuperscript{13}. In my view, the current formulation of GR\textsuperscript{9} cannot be applied to a spacetime point\textsuperscript{4} nor to the observable universe, and is also based on mathematical jabberwockies\textsuperscript{14}, which I hope can be fixed by solving particular problems of the continuum of spacetime points, namely, by introducing ‘potential reality’ to point set topology, set theory, and number theory (Paper III\textsuperscript{1}). To explain why we need to “insert” potential reality in the continuum of spacetime points, imagine a train moving along its railroad: we can suggest all sorts of alterations of the railroad (spacetime) to geometrize gravity, but these alterations cannot in principle encode the engine of the train – the railroad alone cannot drive the train. The train’s engine is not present in the railroad, being the Aristotelian Unmoved Mover endowed with self-action\textsuperscript{6} (dubbed Aristotelian Connection in Paper II\textsuperscript{1}). Thus at every instant ‘here and now’ (Fig. 3), we’ve been passing through ‘the Universe as ONE’ (Luke 17:21) possessing indetermined numerical values, being both the smallest object called ‘the atom of geometry’ or simply ‘point’ and the largest object in “asymptotically” flat spacetime, located exactly at null-and-spacelike infinity (absolute infinity). Notice that the entire physical universe, equipped with metric\textsuperscript{69}, is “wrapped” by two presentations of “the Universe as ONE”, obtained by reaching the limit of the physical world at absolute infinity, yet these presentations cannot have metric and are indistinguishable, being “that which has no part” (Euclid). Stated differently, from the perspective of the length scale of the physical world equipped with metric, ‘the Universe as ONE’ looks extremely small or extremely large, while it is in fact one and the same dimensionless potential reality. There can be no metric\textsuperscript{69} (P. Chrusciel\textsuperscript{19}).
in such luxonic realm\textsuperscript{20}, just as there is no size of the Platonic ideas placed “behind” the chained observers (Fig. 1), to claim that the idea of a tree is smaller than the idea of a mountain.

Let me begin with an explanation of the object referred to as ‘potential reality’. Later I will introduce ‘necessary and sufficient conditions for spacetime’, arguing that one cannot derive the topological dimensions of spacetime exclusively from the physical stuff in the universe; hence the need for potential reality and ‘causal field’ as sufficient conditions for spacetime. Following Niels Bohr, I wish to stress that every sentence of mine should be understood not as an affirmation but as a question.

2. Potential reality: Causal field

The ancient idea that the physical world emerges from a different form of reality, for which I chose the term ‘potential reality’, can be presented with the famous ‘allegory of the cave’ by Plato, modified by adding an axis $W$ (Fig. 1) from Fig. 4. The explicated world of physical “shadows” is cast on a continuum depicted with a film reel (Fig. 2) comprised from infinitely many (uncountably infinite) snapshots possessing indetermined “size”, called spacetime points (Fig. 3), such that every spacetime domain of finite size (invariant spacetime interval with relative scale metric) is a set of such spacetime points, whereby the cardinality of such uncountable set is undecidable\textsuperscript{15}. Every individual snapshot or frame (Fig. 2) is a re-created “shadow” (Fig. 1) obeying Einstein’s equivalence principle (‘no evidence of gravity’\textsuperscript{16}), while the ‘engine of the train’ (see above) is the light source in Fig. 1. Only a sequence of such re-created frames (Fig. 2) can assemble the topological dimensions of the spacetime of physicalized “shadows”, and within such sequence the law of energy non-conservation is mandatory\textsuperscript{13} and we encounter gravitational radiation\textsuperscript{17}. As Hermann Bondi remarked, the gravitational waves are real, “one can boil water with them!”\textsuperscript{18} Yet at every individual frame (Fig. 2), gravity is being completely re-eliminated and “conserved”\textsuperscript{16} – once-at-a-frame, as read with a physical clock. Again, the topological dimensions of spacetime are obtained only by assembling the individual “shadows” to obtain a sequence of frames (Fig. 2), while the duration of the light along $W$ (Fig. 1) is indetermined. If we picture the light source as a movie projector and the physical world as an assembled 4-D movie, we cannot notice whether the movie operator (not shown) have decided to, say, take a break and “temporarily” halt the movie, because her “time” pertains to the dark strips “between” the frames (Fig. 2). Such unphysical “time” pertains to light-like intervals\textsuperscript{19} and to the atemporal\textsuperscript{2} (with respect to a physical clock) potential reality living on the light cone\textsuperscript{20} and “attached” (Paper III\textsuperscript{1}) to quantum, gravitational, and biological systems\textsuperscript{21}, such as the human brain.

In the second paper (Paper II\textsuperscript{1}), I will suggest perfectly continual trajectories of quantum-gravitational objects in relative scale spacetime, offering a different interpretation of the ideas of Kevin Brown\textsuperscript{22}. Suffice it to say that the metaphor of a film reel (Fig. 2) is wrong: the dark strip, separating consecutive “frames”, does not exist in Nature. Although we cannot imagine individual “frames” without something that would separate them, like the dark strips “between” the consecutive instances ‘here and now’, such cognitive “discreteness” is very misleading, because it makes the “frames” countable (Fig. 9) and suggests Hausdorff space, which are illusions (Fig. 13). To produce a perfect continuum of ‘points and nothing but points’, we have to ignore the convenient, but deadly wrong, idea of ‘dark strips’ and introduce brand new structure of the spacetime continuum by dual topology of every point ‘here and now’
(Fig. 3), such that every (uncountably infinite) set of such points will yield a spacetime of physicalized points, wrapped by a boundary of potential reality (highlighted in red, Fig. 5), which will be called ‘causal field’. Stated differently, I replace the expression ‘asymptotic flatness at infinity’ and all related jabberwockies with ‘causal field’, stressing that the latter encodes the topological structure of spacetime points, known as ‘time orientability’ (P. Chrusciel, p. 247). Notice that the so-called causal field must not be physical reality, which would make it a physical Lorentzian ether at absolute rest or a physical ‘reference fluid’ fixing the points in space and their instants of time, but an atemporal luxonic potential reality endowed with the self-action of the Unmoved Mover. Needless to say, the causal field is not res cogitans either, but the Platonic, not-yet-physicalized reality “just in the middle between possibility and reality”, residing in the potential future of biocausality. Every spacetime event ‘here and now’ is the very interface (Fig. 3) “between” its past and potential future, possessing dual topology: it is both fixed in its irreversible past and indefinable in its potential future (causal field) spanned along the axis W in Fig. 4. At every physicalized event in the right-hand side of Einstein’s field equations, the axis W (Fig. 4) is being completely re-nullified (resembling the Phoenix Universe of Abbé Georges Lemaître), to meet the requirements for perfect spacetime continuum (no “dark strip”, Fig. 2) along the entire length scale.

Also, our physical experience is comprised of already completed interactions, like one single event of emission-and-absorption of a photon (resembling clapping hands), and in this sense the physical “footprint” of the interface ‘now’ (Fig. 3), pertaining to the right-hand side of Einstein’s field equations, is always already-fixed in its irreversible past, while the potential “part” of the same interface ‘now’ (Fig. 3) always remains an indefinable ‘causal field’: not-yet-physicalized potential reality placed in the potential future of biocausality, and endowed with an extended atemporal instant ‘now’ (but not with qualia) along the atemporal W axis (Fig. 4). Were the wegtransformierbar gravitational field a physical reality (recall the statements by Heisenberg and Schrödinger above), it will have to be “dark”,

Fig. 1, adopted from Plato

Fig. 2
which will inevitably lead to “the worst theoretical prediction in the history of physics!”

Going back to the interface ‘here and now’ (Fig. 3 and point P in Fig. 4), which presents the notion of spacetime point or ‘event’, notice that the left-hand side of Einstein’s field equations is replaced with potential reality as ‘causal field’ (Einstein called it ‘marble’) residing in the potential future (highlighted in red, Fig. 3) and endowed with self-action (Aristotle), and also with completed or actual infinity, explained by David Hilbert (4 June 1925) as “a totality of things which exists all at once.” The same interface ‘here and now’ (Fig. 3 and point P in Fig. 4) represents also the physicalized content of spacetime (Einstein called it ‘timber’), placed in the irreversible past (highlighted in blue, Fig. 3) and endowed with never-ending potential infinity. The latter is crucial for making the physical manifold perfectly smooth (all sets and intervals are open) by infinitely differentiable (C^∞) “glue” — no physical object could run out of points due to some mythical “geodesic incompleteness.” The existence of “discrete” or quantized objects is beyond doubt, but, to use the analogy in the previous section about the idea of a tree and the idea of a mountain, keep in mind that such not-yet-physicalized, intact objects are stored in the “memory” of the causal field (resembling aether and akasha), so their apparent “discreteness” does not lead to any “jumps” (verdammten Quantenspringerei, Erwin Schrödinger) in the quantum world without (Sic!) observers. Dead matter makes quantum jumps; the living-and-quantum matter is smarter.

To make the dual topology of the interface ‘here and now’ (Fig. 3) easier to explain, I will call the causal field (marble), placed in the potential future, ‘global mode of spacetime’, and the physicalized — once-at-a-time mode of spacetime, placed in the irreversible past, ‘local mode of spacetime’ (timber). The axis orthogonal to the “inflated” local mode of spacetime, passing at P, is denoted with W (Fig. 4), from the German wunderbar, as a humble tribute to Theodor Kaluza. The ark APB (Fig. 4) shows the scale-dependent proper time and proper distance in relative scale (RS) spacetime.

Physically, the inflation time, matching the radius (Fig. 9 and Fig. 6) of the “inflating balloon” (Fig. 4), is tending asymptotically toward The Beginning (John 1:1) and The End by never-ending potential infinity (highlighted with blue, Fig. 5), so the physical time can never actually reach it. In this sense, the local (physical) mode of spacetime
is “infinitely old because infinitely many things have happened since its beginning”\textsuperscript{27}. On the other hand, the same cosmological time has \textit{finite} duration as well (Fig. 10), as at every interface ‘here and now’ (Fig. 3) it is presented with a \textit{closed interval} defined by the causal field and fixed with \textit{actual infinity} (David Hilbert), in such way that every interface \( P \) ‘here and now’ (Fig. 5) is just as “real” as is The Beginning. In physical theology (see Case IV below), The Beginning (John 1:1) was (notice the temporal ordering of events) the union \( M = N = 0 \cup AB = \{\text{absolute infinity}\} \), after which God as the \textit{Unmoved Mover} created the spacetime (Luke 17:21). I believe this proposition is undecidable, as it cannot be falsified and presented with a theorem.

To sum up, I suggest ‘dual cosmological time’ and \textit{Finite Infinity}\textsuperscript{28} (Fig. 5; see Sec. 5), and the so-called ‘eye of the Universe’ (Fig. 8). Again, let me stress that there is a fundamental difference between ‘time as change within spacetime’ (the ark \( APB \) in Fig. 4), called ‘proper time’ and denoted with the Greek letter \( \tau \) (tau), and its orthogonal complement ‘time as change of the spacetime itself’ along the axis \( W \) in Fig. 4. The genuine dynamics of General Relativity\textsuperscript{9} is based on both cases of ‘time as change’. The first case pertains to physical, non-inertial observers endowed with \textit{unending} potential infinity, while the second case corresponds to an orthogonal, ideal inertial “meta” observer endowed with unphysical \textit{actual} infinity (Fig. 10), who can capture the evolving physical universe \textit{en bloc} (Hubblesite), including the \textit{red} ideal endpoints in Fig. 5, hence claim that the universe is always ‘finite’. Yet a physical, non-inertial observer will always claim that the same universe is ‘infinite’. Who is right? Wrong question. Both observers are “right”, thanks to Finite Infinity.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{Finite_Infinity.png}
\caption{Finite Infinity}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{4-D_surface.png}
\caption{4-D "surface" of inflating balloon}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{Fig_5.png}
\caption{P does not belong to [AM] U [NB]\textsuperscript{69}}
\end{figure}

With respect to the physical world equipped with metric\textsuperscript{69}, depicted with \textcolor{blue}{blue} in Fig. 5 and in Fig. 3, the Universe as ONE (depicted with \textcolor{red}{red}) is both extremely “small” and extremely “large” Platonic object (like a “small” idea of a tree and a “large” idea of a mountain; see above), which does not belong to the local (physical) mode of spacetime. It (not “He”) is called ‘causal field’ (global mode of spacetime). It also acts as \textit{unphysical} boundary “wrapping” each and every interface ‘here and now’ (Fig. 3) viz. the \textit{entire} local (\textcolor{blue}{blue}) mode of spacetime \textit{en bloc}, presented in the current, and essentially incomplete\textsuperscript{9}, formulation of GR in the right-hand side of Einstein’s field equations\textsuperscript{22}. Thus, the topological boundary, made by the causal field (depicted with \textcolor{red}{red}, Fig. 5), is not some \textit{subset} of the topological space of the \textit{physical} world, as suggested in the statements regarding \textit{topological boundary} and \textit{topological interior}:
the causal field is not some “subset” of the topological space pertaining to the physical world depicted with blue in Fig. 5.

Again, the causal field harbors the potential, not-yet-physicalized states of the physical world (see Heisenberg and Schrödinger above), which do not exist as an objective, non-contextual physical reality3,29. It is like the grin of the Cheshire cat45 without the cat (Fig. 16): the grin is not a “subset” of cat’s topological space.

Recall the existential definition of ‘set’ by Georg Cantor (7 November 1895)30: any gathering-together (Zusammenfassung) of determined and well-distinguished objects into a whole (zu einem Ganzen). Replace ‘a whole (zu einem Ganzen)’ with ‘causal field’ and keep in mind that both objects are purely mathematical. In the quantum-gravitational realm, the causal field casts a physicalized world (depicted with blue, Fig. 5), once-at-a-time16, yet the causal field itself is not ‘physical reality’4 and does not “collapse”29. It can be ignored only in the macroscopic world of inanimate objects, described in classical physics, where its influence is vanishing small, yet not zero. The causal field is potential reality “just in the middle between possibility and reality”7, and may have qualia21, but this is relevant to its practical implications, such as spacetime engineering63 (e.g., REIM), which will be examined later (Paper III1). To be a bit more precise, in relative scale spacetime all quantum, gravitational, and biological systems6 constituting ‘the Brain of the Universe’ are endowed with an extended atemporal instant ‘here and now’21, depicted with the axis W in Fig. 4, while the physical footmark of W on the local (physical) mode of spacetime (blue line in Fig. 5) is infinitesimal, matching the “thickness” of the interface ‘here and now’ in Fig. 3. Even in the macroscopic world of tables and chairs, the atemporal “duration” of W (Fig. 4) is vanishing small but not zero, which marks the beginning of the causal field. Its effects increase along W and 0W (Fig. 6), leading to what I dubbed previously ‘entanglement of spacetime’ (Sec. 1), but these effects are always perfectly localized on the local mode of spacetime (blue line in Fig. 5), once-at-a-time16,29. If we denote the so-called entanglement of spacetime (leading to topological “bridge”, Sec. 1) with w, the effects of the causal field can be “spanned” along 0W (Fig. 6) as follows:

| Case I: | w → 0 , classical physics |
| Case II: | 0 < w < ∞ , quantum gravity and life sciences |
| Case III: | w → ∞ , hyper physics (?) |
| Case IV: | w ≡ 0 ≡ ∞ , physical theology, At the interface ‘here and now’ (Fig. 3), we pass through the Noumenon (Luke 17:21) at absolute infinity. |

Table 1

The so-called hyperimaginary numbers (Paper III1) involve w, which becomes physicalized with its unique property w² = 0, casting its “shadows” (Fig. 1) on the physical footmark of W, marked with the blue line in Fig. 5, including the real parts of imaginary numbers. The intact29 Platonic case in which w is not squared pertains to an extended atemporal presence ‘now’21 along the non-squared w viz. the effects of the causal field in Cases I - III in Table 1 above, as w lives “within” light-like intervals20, constituting the luxonic or ‘global mode of spacetime’. 
Regarding Finite Infinity, let me show the Universe as ONE (the red objects in Fig. 5) exactly at infinity: the ark APB in Fig. 4 is depicted at absolute infinity in Fig. 6 with a horizontal black line and, due to the absence of any metric there, \( AP = PB = \emptyset \). All physical points along APB will superimpose and fuse into one single point (John 1:1), together with The Beginning at 0 and the causal field along OW. Obviously, the metaphysical notions of ‘infinity’, ‘empty set’ \( \emptyset \) and ‘zero’, and ‘point at infinity’ are completely devoid of specific substance, yet need exact mathematical clarification.

To sum up, in relative scale spacetime the endless physical world\(^{56}\) passes through ‘the Universe as ONE’ at absolute infinity, once-at-a-time\(^{56}\), by non-smooth sphere-torus transitions (Fig. 7), trespassing (Sic!) the black horizontal lines at absolute infinity in Fig. 6 and Fig. 7. The murky expression ‘asymptotic flatness at infinity’ is replaced with quasi-flat spacetime being infinitesimally close to both closed spacetime (sphere, Fig. 6) with maximal size tending asymptotically toward infinity, and open spacetime (torus) with maximal size tending asymptotically toward infinity. Namely, the blue horizontal line in Fig. 5 is not “flat” but is tending asymptotically toward the horizontal lines in Fig. 6 and Fig. 7, from both “south” (sphere) and “north” (torus). These hypothetical topological waves of the causal field (global mode of spacetime) remotely resemble quantum waves, as their non-squared “amplitude” \( w \) along OW (Fig. 6) is also unphysical. Perhaps one can expect various physical effects by tweaking their hyperimaginary phase (Paper III\(^1\)). Perhaps spacetime engineering\(^{63}\) can only be performed effortlessly, much like the way we “move” our thoughts\(^{21}\), but with the Law of Reversed Effort: when the mind is still, the universe surrenders (Lau-Tzu).

The so-called ‘eye of the Universe’ (Fig. 8) shows the causal field (depicted in red), immersed into a colorless area presenting a bona fide Noumenon (Das Ding an sich), also known as ‘the true monad without windows’ (Leibniz). It is an omnipresent non-reality, which explicates its physical and mental content as colored reality. It is ‘the unknown unknown’, resembling some physical-and-cognitive vacuum, explicated along the W axis (Fig. 4) by genuine creatio ex nihilo. It (not “He”) can never be exhausted, not even during an infinite cosmological time. As John Wheeler put it, “Time is Nature’s way to keep everything from happening all at once.”\(^{31}\)

The eye of the Universe

Physical (blue) and potential (red) present two forms of reality (Fig. 5), complemented by an omnipresent colorless non-reality, the Noumenon.
The union of colored reality (red and blue) and colorless non-reality should correspond to the incomprehensible ‘Universe as ONE’, known as God (John 1:1; Luke 17:21). It cannot be grasped with human cognition: we operate with ‘sets’ but cannot produce the ultimate ‘set of all sets’, if any. No statement about God’s existence can be presented with a theorem that can be proven true or false, hence reduce God to science and Mathematics. Thank God, this is impossible.

In Sec. 3 below, I will offer specific arguments in support of the main ideas in Fig. 3, and will also ‘put my cards on the table’ by providing the conditions under which the entire theory can and will be rejected (Fig. 11). Then in Sec. 4 I will suggest the origin of gravity by reducing it to dynamic relative-scale metric, and Sec. 5 will present the current unsolved problems — nur die Fülle führt zur Klarheit, und im Abgrund wohnt die Wahrheit (Friedrich von Schiller).

3. Verification of the main ideas

In Sec. 2, I tried to explain the proposal for relative scale (hereafter RS) spacetime. Here I will do my best to verify the theory by showing where it comes from, and will begin with the most controversial, in my opinion, hypothesis in the current, and essentially incomplete, mathematical relativity, known as ‘locally Minkowskian’.

We are led to believe that, in a “sufficiently small” neighborhood around every spacetime point (see the “running guys” in Fig. 5), one can “erect a locally inertial coordinate system in which matter satisfies the laws of special relativity”. In my opinion, the slippery boundary of such “sufficiently small” neighborhood is sheer poetry, not even an operational definition. What people call “sufficiently small” neighborhood refers to a finite (Sic!) spacetime domain, yet it does not have numerical value along with acceptable error margins to determine ‘sufficiently small’. The same objection applies to ‘sufficiently large’ spacetime domain at which people suggest asymptotic flatness at “infinity”, as well as to the “small” yet finite distance between neighboring congruent geodesics: one cannot define limits with Eq. 1.

The numerical values of ‘sufficiently small/large’ can be defined only with the exact – not slippery – boundary of an open set determined with the diameter $2r$ of a ball with center $P$ (Fig. 9). If we picture a finite spacetime domain as a ball with center $P$ and radius $r$ (Fig. 9), it can be defined only with the $(\varepsilon, \delta)$-definition of limit applicable to finite objects and based on actual infinity. An explanation from a bartender runs as follows (Fig. 10):

An infinite crowd of mathematicians enters a bar. The first one orders a pint, the second one a half pint, the third one a quarter pint... “I understand”, says the bartender - and pours two pints.

But the $(\varepsilon, \delta)$-recipe for obtaining the exact size of ‘two pint beer’ (Fig. 10) cannot be used in GR to define a ‘small’ spacetime domain, not to mention ‘sufficiently small’. If we cut an apple into two pieces, we may claim that there is a “sufficiently small” neighborhood around its center, occupied by its seeds, yet such neighborhood and the exact boundaries of the finite apple (cf. the diameter $2r$ in Fig. 9 and the two pint...
beer in Fig. 10) must be defined relationally, with respect to both (i) the unphysical center at P (Fig. 5) and (ii) the unphysical boundaries called causal field (highlighted with red in Fig. 5), residing “within” P as well.

Thus, I suggest to treat P as an interface ‘here and now’ (Fig. 3), and endow P with dual topology to solve the problems of localization of gravity and the quantum state.

Let me explain. First, the “thickness” of the blue boundary in Fig. 9 above cannot be that of one single point or “frame” separated by “dark strips” (Fig. 2), because it will make such individual single point countable, as stated above. We can only imagine one single red point P in Fig. 9 and one single blue point to define the radius r, because these two points are uniquely defined with their “coordinates”, even though we cannot see the “next” red point placed to the left of P, which does not already belong to r. But all this is based on pure imagination. We claim that the “number” of points constituting r is Aleph-0, although Aleph-0 plus/minus one point is again Aleph-0, so we cannot actually define individual points, yet they are needed to define r with our imagination. Well, Nature does not work with imagination.

The genuine perfect continuum of ‘points and nothing but points’ (Fig. 3) contains uncountably infinite points, which form a set with undecidable cardinality. Thanks to Thomson’s lamp paradox (see below), none of the colored points in Fig. 9 can be individuated viz. counted, which is why there is no difference whatsoever between countably infinite sets with the alleged cardinal “number” aleph-0 and uncountably infinite sets with undecidable cardinality: aleph-0 is undecidable as well, and no ‘number’ can designate the infinite points assembling the number line in Fig. 10.
What we call ‘spacetime point’ is the very interface ‘here and now’ endowed with dual topology (Fig. 3), thanks to which its ‘potential reality’, with footprint on the physical reality (Fig. 17) marked with blue in Fig. 3, is spanned along the unphysical axis $W$ in Fig. 4 and $W_0$ in Fig. 6 as well, leading to the so-called hyperimaginary numbers (Paper III) and to physical theology, as explained in Table 1 above. The presentation of blue points forming a “boundary set” in Fig. 9 is false, because it requires a “dark strip” (Fig. 2) inserted somehow between the “boundary set” and the “open set” in Fig. 9.

Such “dark strip” does not exist in Nature. It is a grave misconception, which makes the continuum problem insoluble and leads to mathematical jabberwockies. NB: The localization of gravity is only and exclusively only on the physical footprint of $W$ (Fig. 4), which is placed in the irreversible past depicted with blue in Fig. 3. The potential gravitational state (Fig. 16), residing in the potential future of the same interface ‘here and now’ (Fig. 3), does not exist in the physicalized state in the past (see Fig. 17 and the analogy with the Cheshire cat above), which is why one can “eliminate” it by hand. The same applies to the intact quantum world.

Without such distinction between the two “components” of gravity, physical (Fig. 17) and potential (Fig. 16), we cannot understand Einstein’s equivalence principle (‘no evidence of gravity’) and the localization of gravity is impossible in principle. The same conceptual solution applies to the potential quantum state and its localization; the problem is widely known since 1911, thanks to Charles Wilson, which is why I consider it the most widely known public secret in theoretical physics.

The explanation of the so-called “sufficiently small”32 neighborhood, in which the spacetime were ‘locally Minkowskian’, is straightforward: it is not “small”, but pertains only and exclusively only to the physicalized gravity placed in the irreversible past, depicted with blue in Fig. 3. Hence we can ‘catch two birds with one stroke’: the localization of gravity and Einstein’s equivalence principle are two facets of the same gravitational phenomenon, while the second ‘bird’ is the localization of the quantum state — check out Heisenberg7 and Schrödinger8 above.

The joint solution to these two problems, presented as localization of the quantum-gravitational causal field (see NB above), also explains the puzzle of the energy density of the vacuum and resolves what has been called “the worst theoretical prediction in the history of physics!”10: if we treat the causal field as ‘nothing but physical reality’, the energy density of the quantum vacuum, with cutoff at Planck scale, will correspond to “a mass density of about $10^{56}$ kilograms per cubic meter!”34, and there will be an enormous “dark”53 manifestation of gravity in terms of “cold dark matter” and “dark energy”.

Moreover, the current theoretical physics will need some Biblical “miracle” to raise a robust Lorentzian metric within $10^{-30}$ seconds “after” the “big bang”, starting much earlier at $10^{-35}$ seconds “after” it (the spacetime metric is already postulated), when the spacetime were just about 1 cm across and a causally connected region would have been only $10^{-24}$ cm across (the horizon problem), in such way that one could “inflate” the spacetime by a factor of $10^{78}$ and then safely keep the Lorentzian metric for at
least \(13.798 \pm 0.037\) billion years rooted on the Planck scale\(^{35}\) at which the spacetime points have become totally fuzzy and locality has lost any meaning\(^{36}\).

I will assume that no “miracles”, included those performed for profit\(^{37}\), are acceptable in science, and will proceed further by declaring the conditions under which the whole theory can and will be rejected.

Consider the dynamics of General Relativity\(^{60}\) exhibited in the transport of energy by gravitational waves (GWs); the phenomenon is genuinely non-linear\(^{18, 68}\) and no linearized approximation\(^{17}\) can be applied for detecting the physicalized energy of GWs. I will also presume that the theory suggested in NB above is either true or false. So if it is proven false, I will immediately trash it.

The condition for proving the theory false is to demonstrate that the textbook presentation of GR as classical theory\(^{38}\) is indeed correct. If so, we have only two alternatives for explaining the transport of energy by GWs: either they are (i) physical waves capable of transporting energy, momentum, and angular momentum along a continual path, or (ii) GWs are not physical waves and therefore they cannot transport any physical stuff, much like the quantum waves. Again, notice that such alternative framework, either GWs are physical or not, is mandatory for a classical theory\(^{69}\).

As an example for continual path of energy transport by GWs, consider PSR J1603-7202\(^{39}\), with dimensionless amplitude \(2.3 \times 10^{-26}\): case (i) requires that their intangible energy (Sir Hermann Bondi\(^{13}\)) is being converted into some physical (tangible) energy at each and every point\(^4\) along the path from PSR J1603-7202 to Earth\(^{39}\). To prove case (i) possible, at least in principle, the proponents of GW “astronomy”\(^{39}\) must use the only available theory of gravitational radiation, suggested by Sir Hermann Bondi in 1961 (private communication from Josh Goldberg) and published one year later\(^{18}\), and of course abandon the linearized approximation\(^{17}\). Here’s a simple example of case (i), depicted in Fig. 11:

Imagine an empty plastic bottle on your desk, trespassed by GWs from PSR J1603-7202\(^{39}\), with dimensionless amplitude \(2.3 \times 10^{-26}\), and explain the coupling of their wave strain to the plastic material of the bottle, leading to stresses\(^{40}\). How could gravitational radiation\(^{18}\) produce work to induce stresses\(^{40}\) and squeeze the bottle? Perhaps at \(2.3 \times 10^{-26}\) m?

\[t_1: \text{No gravity waves} \quad t_2: \text{Gravity waves present} \quad t_3: \text{No gravity waves}\]

Fig. 11
Even if this formidable task is achieved and case (i) proven correct, at least in principle, the dynamics of GR will be reduced to describing some physical gravitational field, which in turn requires that its localization and energy conservation will be possible with such classical theory — reductio ad absurdum. The alternative case (ii) requires that GWs are fictitious objects that cannot transport any physical stuff — reductio ad absurdum, again.

Thus, the initial presumption that General Relativity were bona fide classical theory is proven wrong, and the only possible theory, by means of logical choice, is the one presented in this paper. Yes, GWs transport energy, momentum, and angular momentum, but only and exclusively only by their localization explained in NB above. Hence we can ‘have our cake and eat it’.

Needless to say, if case (i) or case (ii) is proven correct, the entire theory will be trashed and I will switch to other activities, say, to raising tomatoes in my garden.

Meanwhile let me outline the new form of causality, dubbed biocausality, and suggest ‘necessary and sufficient conditions for spacetime’.

In the outline of the theory presented above, the quantum-gravitational potential reality, called causal field, complements the physical reality placed in the past and marked with blue in Fig. 3. The latter forms the necessary condition for spacetime, while the former is considered sufficient condition for spacetime. Their causality is called biocausality, covering Cases I – III in Table 1 above. It is relativistic causality, conforming to the metaphysical principle of locality, and retarded causality, because the “dark strip” (Fig. 2), which would allow for advanced causality viz. tachyons, does not exist in the perfect continuum of instances ‘here and now’ (Fig. 3). If the Planck scale were nothing but physical reality, resembling an individual (hence countable) pixel in a digital image, the spacetime would be fundamentally discrete and one could recover the size of every finite object exactly, say, a table with length 1m would be recovered by multiplying the Planck length by its reciprocal value, 1.616199(97)×10^{-35}. If this was the case chosen by Nature, the set of such extended points, constituting ‘one meter’, will have countable cardinality of extended points plus extended “dark strips” between them (Fig. 2), the “dark strip” will be the ultimate cutoff at Planck scale, and Cantor will be wrong, because the spacetime will possess Archimedean topology and 1m will contain less countable points than one cube with rib 1m.

Let me show how the interface ‘here and now’ (Fig. 3) can be derived from the limit of a sequence. First, see Thomson’s lamp paradox, which will be explained here with the limit 1 minute:

Consider a lamp with a toggle switch. If flicking the switch once turns the lamp on, another flick will turn the lamp off. Now suppose that there is a being endowed with infinite time, and able to perform the following task: starting at time zero, she turns the lamp on. At the end of half minute, she turns it off. At the end of another quarter of a minute, she turns it on. At the next eighth of a minute, she turns it off again, and she continues thus, flicking the switch each time after waiting exactly one-half the time she waited before flicking it previously. The sum of this infinite series of time intervals is exactly one
The alleged paradox is based on mixing apples (MN in Fig. 5) with oranges (P): the lamp is always a finite physical stuff possessing unending potential infinity, depicted with the finite interval MN in Fig. 5, while the endpoint or limit at exactly 1m is reached only with actual infinity (Fig. 10), which must end at the endpoint P in Fig. 5. To explain the paradox, imagine that you are about to enter a tunnel by foot, and the tunnel has a diameter of, say, 2m. As you walk in the tunnel, you measure its diameter every 10m, and also notice that both you and the tunnel are shrinking by 10cm at every 10m. So at some remote point of your journey, you have to stop, because you just can’t move further: you (not the tunnel) have become the smallest physical object MN and cannot “disappear” (Eq. 1) in order to reach the calculated (with actual infinity) limit at which the diameter of the tunnel might supposedly shrink to zero, hitting the endpoint P. You may imagine that your state at MN, at which you can’t move further, might be ‘exactly the same’ as at the calculated limit at P performed with actual infinity, but you can never be certain, because the actual endpoint at P (Fig. 5) is unreachable to you: you are physical object of finite size. Surely at the smallest yet finite MN (Fig. 5) the state of your lamp is definitive, but you wrongly imagine that if you could (only you can’t) use actual infinity to reach the endpoint P of ‘zero diameter’ of the tunnel ‘in front of you’, the state of your lamp would be definitive as well, and then you ask the tantalizing question, ‘what is the definite state of my lamp at both MN and P?’, which is mixing apples with oranges. Your “reasoning” is nothing but counterfactual supposition, and secondly – your finite extension of MN can accommodate any state of your lamp: the “number” of such allowed states within MN is uncountably infinite (Sic!), but since your lamp has only two alternative states, you claim that the state of your lamp at MN will be either on or off. Fine, but there is no definite lamp at P, simply because there is no ‘lamp’ there (Fig. 16). Only a superposition (Paul Dirac) of states |on> and |off>, like Schrödinger’s cat. You will always obtain some definite value of your lamp at MN, either on or off, but only after you perform the “measurement” at MN, which “does not mean ascertaining the value that it has” (cf. Schrödinger) at P (Fig. 5). In GR this leads to various pseudotensors suggested to calculate the gravitational analog of lamp’s states |on> and |off>, despite that (i) the “linear” connection (the Christoffel symbols) is atemporally non-linear (Fig. 18), and (ii) the energy-momentum of gravity is not ‘physical reality’ like the Moon, but wegtransformierbar potential reality (Fig. 16). Physically, it may be eliminated by hand or by “collapse”. Its localization is only on the physical (blue) footprint of the causal field: see NB above.

Again, the fundamental difference between MN and P is that the former is physical stuff operating with unending potential infinity, while the latter is obtained only by actual/completed infinity, just like the limit ‘two pint beer’ in Fig. 10. And since P in Fig. 5 has dual topology, being the interface P ‘here and now’ in Fig. 3, we can think of the infinitesimal MN as having an exact limit, MN → P = 1, but only to the extent to which P has a physical footprint or “component” placed in the irreversible past, marked with blue in Fig. 3. There are no numbers in Nature; only infinitesimal physical footprints in the past, thanks to which we can imagine some “fixed” number there.

We can imagine in Fig. 5 that MN = ∅ (notice R∞ = ∅ in Fig. 12 below), but only to the extent to which its limit P (Fig. 3) has a physical “component” in the past. Yet the
interface P in Fig. 3 has a potential “component” as well, which is placed in the potential future and is considered ‘potential reality’ (Fig. 16). Hence no physical stuff, depicted in Fig. 5 with MN, can “collapse” on the entire interface P endowed with dual topology (Fig. 5 and Fig. 3). This is the reason for augmenting the current number theory with hyperimaginary numbers (details in Paper III).

Now compare the endpoint 1 in Thomson’s lamp paradox with the endpoint in Fig. 12 below (adopted from Lakoff and Núñez42), labeled also with 1.

![Fig. 12, adopted from Lakoff and Núñez42](image)

Here the process of approaching the limit 1 pertains again to the unending potential infinity, and Rn in Fig. 12 matches MN in Fig. 5, while the endpoint 1 is reached only with actual/completed infinity26 (see the largest beer in Fig. 10).

Every finite region of spacetime, denoted with MN and AB in Fig. 5, can be viewed with both potential and actual infinities (see Finite Infinity in Sec. 5), but what could possibly define the obvious difference between MN and AB in Fig. 5? There is no number, denoted with k69, to obtain AB from the smaller MN by k.MN = AB, as in the definition of international second, because the interface P in Fig. 3 is not a number. If we use actual infinity to imagine (not calculate) the limits of MN and AB in Fig. 5, we will end up with a nonsense:
0 \times \infty = 1 \text{ (Eq. 1).}

But if we use actual infinity, pertaining to ‘potential reality’, to calculate the invariant size of $MN$ and $AB$, we can obtain clear fixed results (Fig. 10). If $MN$ denotes the size of a proton$^{64}$ and $AB$ the size of a galaxy (e.g., Milky Way), obviously $MN \ll AB$. Fine, but we cannot use some number $k$ nor Eq. 1 to derive $AB$ from $MN$ (Fig. 5), since $MN$ and $AB$ are built by “the same” undecidable and nonenumerable object $P$ (Fig. 3), which “has no part” (Euclid).

4. Relative scale spacetime

Before moving further, let me present in Fig. 13 some of the misleading ideas in the current set theory$^{33}$ (Fig. 9) and in mathematical relativity$^{14}$, originating from Fig. 2.

![Fig. 13](image)

The union of (i) the bag of apples and (ii) the air between apples (Fig. 13) does not belong to the apples themselves (Fig. 17). It is a “colorless” (Fig. 8) object, which exists in every set$^{30}$ by its colorized presentation as ‘potential reality’ (Fig. 16).

Again, it is not res cogitans$^6$. It does not belong to the members of any set either. It is Platonic reality (Fig. 1), “just in the middle between possibility and reality”$^7$. In this sense, every set$^{30}$ is quantum set, although in Case I in Table 1 above the presence of potential quantum-and-gravitational reality can be safely ignored.

The misleading ideas in Fig. 13 originate from Fig. 2, because many people interested in mathematical relativity$^{14}$ tacitly presume that the notion of an isolated, identifiable macroscopic apple (see $MN$ above), which is denumerable and can be associated with a number$^{69}$, can be applied to the very boundary in Fig. 9, with radial extension of one single point. But in fact, the boundary is “that which has no part” (Euclid): the
interface ‘here and now’ shown in Fig. 3 and Fig. 5. Hence the spacetime continuum is perfect, because all members of quantum sets are wrapped by their potential reality shown in Fig. 3 as potential “component” of the interface P. Physically, we see only physicalized apples placed in the past (highlighted with blue in Fig. 3). In the physical world depicted with MN and AB in Fig. 5, there is no physical boundary whatsoever. The unphysical “boundary” is made by nondenumerable potential reality (highlighted in red in Fig. 3 and Fig. 5). Unlike in Plato’s proposal (Fig. 1), it cannot emit nor reflect light, and many people consider it “dark” (more on this issue later).

Notice that the bag of apples in Fig. 13 and the two pint beer in Fig. 10 have referential background, while in the drawing of “expanding” universe (Hubblesite) the role of referential background is played by unphysical inertial “meta” observer, who can capture the entire physical spacetime en bloc, including its boundary. Following the discussion of the infinitesimal MN after Thomson’s lamp above, such boundary belongs to the physical world only to the extent to which its limit P (Fig. 3 and Fig. 5) has physical “component” located in the irreversible past. Hence the spacetime boundary has dual topology, because it also has potential “component”, which does not have Archimedean topology and is located in the potential future (red) of the same interface P (Fig. 3 and Fig. 5).

Now, before explaining the Ansatz of relative scale spacetime (Fig. 15), let me stress “the lack of cosmological models with realistic, gravitationally bound objects” : we still do not understand the gravitational radiation, do not know how to detect it, and certainly cannot “install” mirrors (Sic!) for gravitational waves exactly at the joint “border” of the spacetime at null-and-spacelike infinity, to obtain gravitationally closed system and prove that the mass of the physical “shadows” (Fig. 1) is indeed positive (positive mass conjecture). People try to suggest an unrealistic “vacuum spacetime” which supposedly admits a “smooth conformal completion” à la Penrose and even offer Penrose diagrams with “compactified coordinates”, totally ignoring the unsolved mathematical problems of kinematical spacelike infinity (spi) and the underlying mathematical jabberwockies.

To introduce the prerequisites to relative scale spacetime (see Fig. 15 below), notice that the inflating ark APB in Fig. 4 is not at all “curved”, as many people wrongly imagine. The dimensionless scale factor, pertaining to the inflating APB and to ‘time as measured with a clock’, has an unphysical “orthogonal” component along the axis W in Fig. 4 (marked with red in the interface ‘here and now’ in Fig. 3), which will be totally ignored if we only work “intrinsically” with Gauss-Bonnet theorem. It does not exist as ‘physical reality’ (marked with blue in Fig. 3), yet is capable of altering the spacetime metric, and many people consider it “dark”.

I suggest that the axis W in Fig. 4 is related to atemporal potential reality pertaining to the “intermediate time” of a “free” photon “during” flight (see above). It is luxonic reality, and is anything but “dark”. Also, it should be capable of fixing the extensions of ‘1m’ (Fig. 12) and ‘two pint beer’ (Fig. 10) by actual infinity. But how?

Good question. Let’s see what we cannot use to solve the puzzle.

Firstly, the buildup of ‘space’ cannot be based on some “intuitively clear” but totally wrong ideas of finite chunks of matter (Fig. 2), like in the definition of international second above, so that we can apply Baldy’s Law ‘some of it plus the rest of it is all of
it’ at the fundamental level of “that which has no part” (Euclid) and treat the atoms of geometry as distinguishable denumerable apples separated by air and wrapped by a bag (Fig. 13), after which we sweep the garbage under the rug by jabberwockies\textsuperscript{14}, like boundary set (Fig. 9), “many points”, paracompact manifold (Wald\textsuperscript{60}), Hausdorff space, compact space, second countable topology, and countably infinite set à la Chuck Norris.

Secondly, the alternative approach of seeking “intuitively clear” limit by actual infinity leads to treating the atom of geometry as “zero” viz. Eq. 1 above, which is also wrong.

In my opinion, the only solution is to apply the doctrine of trialism\textsuperscript{6} and interpret the two sides of Eq. 1 above, \textit{zero/infinite} (unphysical) and \textit{finite} (physical world\textsuperscript{69}) as \textit{complementary}, like an Eskimo trying to understand the elephant’s trunk\textsuperscript{29}.

Therefore I will introduce the idea of ‘hyperimaginary element’, denoted with \( L_i \), as \textit{potential} gravitational reality (Eq. 2), and will postulate that the invariant spacetime interval, examined as 1m (Fig. 12) and 1min (Thomson’s lamp), is being \textit{assembled} along the axis \( W \) in Fig. 4 and Fig. 1 with hyperimaginary element \( L_i \), leading to ‘space’ and ‘time’ in \textit{relative scale} spacetime. An observer at the length scale of tables and chairs (‘table 1m’ in Fig. 15) will see \( L \) being either “shrunk” to Plank length\textsuperscript{35} (\( MN \) in Fig. 5) or “inflated” to the maximal spacelike hypersurface (\( AB \) in Fig. 5) in which the normal vector at every point is time-like (P. Chrusciel\textsuperscript{19}, p. 247).

Yet the observers with the size of Plank length\textsuperscript{35} (seen as “the smallest” \( MN \), Fig. 15) and with the size of maximal spacelike hypersurface (seen as “the largest” \( AB \), Fig. 15) will have “the same” \textit{relative} size within their opposite domains as \textit{well}.

Who has the right ‘one meter’ and ‘one second’? Wrong question. All observers along the entire \textit{length scale} have \textit{the same albeit altered} RS meter and RS second.

Perhaps the best way to explain the meaning of ‘the same albeit altered’ is with the river metaphor by Heraclitus. I will introduce two Platonic (Fig. 1) objects: (i) rate of ‘time flow’, denoted with \( R \) and corresponding in the river metaphor to ‘water/time per second’; \( R \) obtains numerical values along \( y \)-axis in Fig. 14, and (ii) relative size denoted with \( S \), obtaining numerical values along \( x \)-axis in Fig. 14. A table with length 1m (Fig. 15) is located at \( x = y = 1 \) and at \(-x = -y = -1\) in Fig. 14 (two red dots).

Now I postulate

\[
RS = 1 \text{ (Eq. 2)}. 
\]

Relative to a table with length 1m, the size \( S \) of Plank length\textsuperscript{35} \( MN \) (Fig. 5 and Fig. 15) is indeed \textit{the smallest}, as \( S_{MN} \) (not shown in Fig. 14) tends asymptotically toward \( x = 0 \). But according to Eq. 2, \( R_{MN} \) tends asymptotically toward \( y = \infty \), which is interpreted as \( R_{MN} \)-times \textit{more} ‘water/time per second’ at Plank scale, producing maximal \textit{inflation} of RS spacetime at Planck scale. Hence all objects with Plank length\textsuperscript{35} \( MN \) (Fig. 5) will have at Planck scale ‘the same albeit altered’ size 1m. Yet relative to a table with length 1m, their size and Planck time is indeed \textit{the smallest}. Ditto to the opposite case of \textit{the largest} \( AB \) in Fig. 5 and Fig. 15: the value of \( S_{AB} \) (not shown in Fig. 14) tends asymptotically toward \( x = \infty \), which is why \( AB \) is indeed \textit{the largest} object but,
because of the reciprocal value (Eq. 2) of $R_{AB}$ tending asymptotically toward $y = 0$, the spacetime of $AB$ is maximally shrunk to ‘the same albeit altered’ size 1m. And if we claim that the rate of ‘water/time per second’ at macroscopic length scale is 1s/s, ‘the same albeit altered’ 1s/s will be valid for $MN$ and $AB$ as well. It’s all relative\textsuperscript{63}.

Back to the hyperimaginary element $L_i$: it is neither finite (Fig. 10) nor zero (Eq. 1), but ‘something else’\textsuperscript{59}, sit venia verbo. Here we have to proceed with utmost caution, because such object may be beyond our comprehension. I will apply the doctrine of trialism\textsuperscript{6} and interpret $L_i$ as elephant’s trunk\textsuperscript{29}, which Eskimos see it as “nose” (equivalent to quantum “particle”)\textsuperscript{29}, but only to the extent to which ‘nose’ is finite\textsuperscript{69} reality possessing physical footprint placed in the irreversible past of the interface ‘here and how’ (Fig. 3). Hence we, as Eskimos endowed with Archimedean topology\textsuperscript{69}, can try to apply some sort of cognitive “discreteness” to understand what we picture as physicalized “nose” by frames-per-second (FPS) analogy — we can imagine that the invariant spacetime interval, shown as 1m (Fig. 12) and 1min (Thomson’s lamp), is being assembled by $L_i$ along the axis $W$ in Fig. 4 and Fig. 1 in three ways: (i) as 90 fps, producing the macroscopic world in which a table has RS length 1m (Fig. 15), (ii) as 270 fps, producing 3x “inflated” RS spacetime ($AB$ in Fig. 15), and (iii) as 30 fps, producing 3x “shrunk” RS spacetime ($MN$ in Fig. 15). In their RS domains, however, the Heraclitean flow of time will be always 1s/s, and their RS “1m” and RS “1s” will be indistinguishable. However, relative to a macroscopic observer\textsuperscript{69} in the middle between $AB$ and $MN$ (Fig. 15), $AB$ will be in fact 3x larger and $MN$ will be in fact 3x smaller as well: see Eq. 2 above. It’s all relative\textsuperscript{63}.

Relative to a table with RS length 1m (Fig. 15) depicted with two red dots in Fig. 14, $L_i$ is being shrunk to $MN$ and inflated to $AB$ (Fig. 15), depicted with the “running guys” in Fig. 5.
Fig. 14 shows the creation of RS spacetime (Eq. 2) by the hyperimaginary element \( L_i \) taking non-zero values; \( P \) (Fig. 5) lies only on \( x \) and \( y \). MN (Planck length\(^{35}\)) in Fig. 5 and Fig. 15 corresponds to \( x \to 0 \) and \( L_i \to P \) in Fig. 14, leading to the “smallest” region of relative scale spacetime; AB in Fig. 5 and Fig. 15 corresponds to \( x \to \infty \) and \( L_i \to P \) in Fig. 14, leading to the “largest” region of RS spacetime. The inflation of RS spacetime between \( x_1 = 1 \) and \( x_2 = 2 \) in Fig. 14 resembles Hubble’s law, but it is not linear and implies “accelerating universe”. The interpretation of the negative (mirror) case in Fig. 14 is still an open question; I suppose it could be related to the sphere-torus transitions in Fig. 7, resembling the transformation of a rubber glove ‘inside out’, yielding ‘left’ vs ‘right’ symmetry of the local mode of spacetime (parity inversion).

The Beginning (John 1:1) corresponds to \( x = y = 0 \), matching Case IV in Table 1. In this sense, God is eternally residing “inside” every event ‘here and now’ (Luke 17:21).

Notice that a macroscopic observer in the middle between MN and AB (Fig. 15) cannot observe the global inflation or shrinking of the spacetime itself, but only its physical effects. In RS spacetime, there is no absolute length scale: see Sec. 1 above.

As to the origin of gravity (see above), it is interpreted as local inflation or local shrinking of \( L_i \). The latter removes the so-called non-baryonic “dark matter” and “supermassive black holes”, while the former eliminates the mythical “dark energy”\(^{53}\).

Regarding the gravitational rotation accompanying the global and local gravitational effects of \( L_i \), I suppose it is caused by “rotation” of the hyperimaginary element \( L_i \), leading also to ‘spin’ in the quantum world (see Sec. 5).

Last but not least, we do not treat ‘the spacetime itself’ as an ether which may exist independently (like a reference fluid\(^{23}\)) from the physical stuff determining the spacetime, but as ‘the grin of the Cheshire cat without the cat’\(^{45}\), depicted in Fig. 16 below. The difference between the ether and the ‘grin’ is crucial, because it embodies the essence of General Relativity, as stressed by Albert Einstein on 29 November 1918\(^{9}\).
Fig. 18

Which “hand” goes first? Matter (Fig. 17) of potential reality (Fig. 16)?

Wrong question. One cannot determine ‘which goes first’ with ‘time as read with a clock’, as their non-linear negotiation has been already-completed with fixing a physical footprint of the interface ‘here and now’, marked with blue in Fig. 3, in line with Leibniz’ pre-established harmony. Needless to say, the potential reality in Fig. 16 springs from the colorless Noumenon (Fig. 8), which leads to Case IV in Table 1.

5. Discussion

Undoubtedly the theory of relative scale spacetime is still a work in progress, hindered firstly by the unclear hyperimaginary numbers (Paper III) needed for the so-called quantum sets (Paper II) briefly mentioned above. The process of building the theory very much resembles a jigsaw puzzle, in the sense that every piece snaps to its unique place effortlessly, but it also outlines a new blank section from the endless jigsaw puzzle: Nature is coherent (Sec. 1) and endless. Let me offer a snapshot of the current status of Relative Scale (RS) spacetime, based on the localization of matter and fields explained at NB above, leading to the Brain of the Universe (Table 1 and Fig. 8).

Imagine a 2-D section at the center of 3-D sphere in Euclidean space: all points of such flat circle (Fig. 9) belong to the 3-D sphere as well, yet the physical points belong only to the flat circle of 2-D “shadows” (Fig. 1). The physical points possess dual topology, being the very interface ‘here and now’ (Fig. 3) between the irreversible (blue) past and the potential (red) future spanned along an atemporal luxonix axis W (Fig. 4) pertaining to the 3-D sphere, including the dual points of the circle. At every physicalized (blue) “component” of the interface ‘here and now’ (Fig. 3), the axis W is being completely re-eliminated – once-at-a-time to produce a perfect (Sic!) continuum of re-created, physicalized (cf. NB above) world of matter and fields (Fig. 17) cast in the irreversible (blue) past (Fig. 3). Hence 2-D Flatlanders will live on 2+1-D spacetime obtained by assembling their 2+1-D physicalized universe, endowed with a perfect 3-D continuum. Let’s move now to 3-D Flatlanders (Fig. 1) with brains.

1. The alleged ‘point’ in point-set topology is not a denumerable “apple” (Fig. 13) but spacetime interface endowed with internal structure and dual topology (Fig. 3): its physical “footprint” is complemented by atemporal potential reality (Fig. 16)
residing in the potential future\textsuperscript{61}, of the so-called biocausality\textsuperscript{2}, spanned along the atemporal luxonic\textsuperscript{20} axis $W$ in Fig. 4. The physical world\textsuperscript{59} is physicalized world (Fig. 1), ranging from the smallest (MN) to the largest (AB) spacetime domains (Fig. 15). The latter are endowed with Finite Infinity (Fig. 5) presenting two complementary presentations of ‘size’ and ‘duration’ in RS spacetime: both finite (Fig. 10 and the ark APB in Fig. 4) and infinite (along $W$ in Fig. 4), because ‘potential reality’ (Sec. 2) is indefinable due to the absence of metric. Hence Finite Infinity is also dual topological object keeping its complementary presentations en bloc, which makes it totally incomprehensible with human cognition\textsuperscript{57}. In the next Paper II\textsuperscript{1} (in preparation), I will elaborate on the doctrine of trialism\textsuperscript{6} applicable to ontologically dual objects (every quantum-gravitational object is both “particle” and “wave”, resembling elephant’s trunk\textsuperscript{29}) by suggesting a new zero-valued logic YAIN (from Yes And neIN).

Regarding Finite Infinity (Fig. 5), notice that the two types of infinity\textsuperscript{43}, potential and actual/completed\textsuperscript{26}, are complementary. If Nature were using only the unending potential infinity (PI), in which every step toward the infinity is the necessary and sufficient condition for the next step, there will be two alternatives: either (i) PI can reach the limit or (ii) PI cannot reach it. Case (i) means that PI will surpass the limit and move further ad infinitum, while case (ii) means that the limit does not exist. In fact, in both cases (i) and (ii) the limit cannot exist. If Nature were using only the actual or rather completed infinity (CI) which always stops at the limit, there are two alternatives: either (iii) CI can reach the limit and then stop there or (iv) CI cannot reach it and can never stop there. Case (iii) means that Nature is finite but there is something beyond it (Fig. 10), whereas case (iv) contradicts the definition of CI as “a totality of things which exists all at once”\textsuperscript{26}. Only the union of PI and CI is perfect: thanks to PI, Nature is endless and open to brand new events still in ‘the unknown unknown’, while CI ensures that the limit can and will be reached, thanks to which there are finite things in Nature\textsuperscript{69}, such as 1m and 1min (see the discussion above).

2. The atemporal potential reality (Fig. 16), dubbed causal field, leads to physical theology (Table 1) in which God is presented as the union of two sets, colored and colorless (Fig. 8), viz. to the incomprehensible ‘set of all sets’ (if any) endowed with the self-action of Unmoved Mover.

3. To explain the creation of relative scale spacetime from ‘something else’\textsuperscript{59}, a pre-geometric plenum has been suggested, dubbed ‘hyperimaginary element’ (Eq. 2) and endowed with hyperimaginary “torsion” accompanying the two types of gravity in RS spacetime — force-free gravitational attraction (local “shrinking” of spacetime) and force-free gravitational repulsion (local “inflation” of spacetime). Notice that RS spacetime is wave-like theory and does not employ tensors nor spacetime curvature\textsuperscript{44}: the quantum-gravitational “wave” is presented as causal field residing in the potential future, being an intact\textsuperscript{29} potential reality.

In my (perhaps biased) opinion, this is the only way to explain the genidentity of particles\textsuperscript{62,63,64} and the “conservation”\textsuperscript{16} of energy\textsuperscript{13} as re-created “shadows” (Sec. 2), from proton’s mass\textsuperscript{64} to vacuum energy\textsuperscript{10,34}, including gamma-ray bursts.

To sum up, the theory presented here is indirectly falsifiable, in the sense that every alternative theory of spacetime must necessarily be wrong. I will be more than happy if the reader can suggest an alternative theory and prove RS spacetime wrong, because I won’t need to wrestle with some brand new “hyperimaginary numbers” based on still
unknown operators applicable to hypothetical sphere-torus transitions trespassing absolute infinity (Fig. 7) and corresponding to $x,y = 0$ in Fig. 14. This is the reason for delaying Paper III to 2018\textsuperscript{1}, hoping that meanwhile we will unravel brand new mathematical ideas, which perhaps are still in the realm of ‘the unknown unknown’.

The next Paper II\textsuperscript{1} (in preparation) will introduce the so-called biocausality\textsuperscript{2} by applying Ulric Neisser’s cognitive cycle\textsuperscript{61} to the Brain of the Universe, and will suggest novel topological properties of spacetime, resulting from the so-called causal field. The postulated hyperimaginary “rotation” of the causal field is supposed to include ‘spin UP’ (Fig. 19) and ‘spin DOWN’ (Fig. 20), referring to what Wolfgang Pauli dubbed ‘\textit{eine eigentümliche, klassisch nicht beschreibbare Art von Zweideutigkeit}'. In Fig. 19, the fingers of the right hand curl counter-clockwise; the thumb (not shown) points UP, while in Fig. 20 the fingers of the right hand curl clockwise; the thumb (not shown) points DOWN. Nature should have two “hands”, right and left (Fig. 14 and Fig. 7), also as ‘\textit{klassisch nicht beschreibbare Art von Zweideutigkeit}'. The unphysical axis of quantum spin minus its physical basis is the axis of right/left thumbs, presenting hyperimaginary degrees of freedom of the causal field (Fig. 16). What we call ‘gravity’ is exclusively macroscopic phenomenon (there is no gravity in the quantum world) interpreted as force-free Coriolis effect outlining a physical axis of galaxy rotation (David Wittman), yet such axis is not related to some physical rotor that could twirl a galaxy nor to some physical but “dark” (whatever) in its center.

Fig. 19

Fig. 20

The general idea in Paper II\textsuperscript{1} is to present the physical component of the interface ‘here and now’ (Fig. 3 and Fig. 1 below) as a timeless “shadow” of the Brain of the Universe: a CPT-invariant quantum world in “small” RS spacetime, and a macroscopic world in “large” RS spacetime, with ‘no evidence of gravity’\textsuperscript{16}. The local “shrinking” of RS spacetime (see above) leads to irregular clumsy structures, while the local “inflation” of RS spacetime leads to smooth “dark energy”\textsuperscript{53}. The two force-free manifestations of gravity should be in a tug-of-war dynamic equilibrium to facilitate formation of structures. More in the excerpt from the forthcoming Paper II\textsuperscript{1} below.

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I have again perpetrated something relating to the theory of gravitation that might endanger me of being committed to a madhouse. (*Ich habe wieder etwas verbrochen in der Gravitationstheorie, was mich ein wenig in Gefahr bringt, in ein Tollhaus interniert zu werden.*)

Albert Einstein, letter to Paul Ehrenfest, 4 February 1917

1. Introduction

In the previous paper (Paper I, ref. 6-9 and 29), I elaborated on Thomson’s lamp paradox and suggested the rule for localization of quantum-gravitational Cheshire cats, to resolve the most widely known public secret in theoretical physics, shown at this [http URL](http://example.com) (more below). The grin of the Cheshire cat (Fig. 16 in Paper I) is like the [Macavity](http://example.com) (T.S. Eliot): it is not observable, in the sense that every time the “chained observers” (Plato) look at Macavity, it has already disappeared. We may call Macavity “vacuum”, but it is actually cognitive-and-quantum vacuum from which all quantum-gravitational cats emerge, like the physical states of Thomson’s lamp in Dirac notation, either |on> or |off>, leaving the lamp *per se* intact. Let me explain.

Consider pattern recognition and imagine a set of apples with different colors on a table in front of you, and divide them as follows: place all strictly red apples to the left, and all strictly yellow apples to the right. Now you can suggest the locations of all apples that are partly red and partly yellow, and place them between the two subsets of apples, as well as ignore all green and greenish apples, because they do not fit there. Easy, because you can see their colors. But what if you “see” with your mind only (pp. 7-8 in HBP.pdf), and instead of choosing specific color you choose specific meaning? No problem; check out the meaning of four sayings on p. 2 in HBP.pdf. Every human brain can estimate the “color” (meaning) of such different “apples” (sayings), although the underlying cognitive-and-quantum vacuum is UNSpeakable. Physically, it is like Macavity; I call it ‘potential reality’ (Fig. 5 and Fig. 16 in Paper I). And since the human brain works with ‘potential reality’, the Brain of the Universe may be doing the same, and perhaps much better. Let’s begin with the human brain.

The human cognition is based on (quantum) sets; therefore, we cannot define ‘set’ with itself (it will be like defining ‘heat’ with some tiny little and very hot particles).
For example, the very fact that we can think of ‘everything that is On’ shows the sets of ordinals. But the set itself is an indefinable ‘totality of things’ (Cantor), coupled with what this ‘totality of things’ is not: $A \cup \neg A$. In fact, we can think iff we can form a set $A$ defined with respect to ‘what is not-$A$’, $\neg A$. It’s all relative. The cognitive limits of our relational cognition are shown with the ultimate ‘set of all sets’ (if any), which is indefinable and undecidable to humans. But the Brain of the Universe may not have such limitations, as it includes what we could only call ‘Noumenon’: see the ‘eye of the Universe’ in Fig. 8 in Paper I.

What matters here is that the human brain performs self-action: the brain — not its mind — acts on itself, since it has potential state in its future, and by itself, being also physicalized object in its past (Fig. 1). Physically, we can observe only the physical “footprint” of the brain cast in the past, because brain’s potential state is physically unobservable Macavity (it may have only mental “reflection” or qualia).

What if the Brain of the Universe also performs self-action, by acting on its own quantum-gravitational potential state placed in its future (Fig. 1)? If true, we may uncover the hyperimaginary numbers and develop the theory of quantum gravity.

In this Paper II, I will apply Neisser’s cognitive cycle to the quantum-gravitational potential reality, leading to self-action of the Brain of the Universe, performed along the atemporal axis $W$, shown in Fig. 1 and Fig. 4 in Paper I. Namely, I will elaborate on Neisser’s cognitive cycle by borrowing Escher’s ‘drawing hands’ and inserting there the interface ‘here and now’ (Fig. 1 below), shown previously in Fig. 3 in Paper I.

![Fig. 1](image)

**Fig. 1**

Time orientability (P. Chrusciel, p. 247)

Obviously, one cannot explain the non-linear negotiation of the two hands with what physicists call ‘time as read with a clock’: at any instant from the physical time (local mode of spacetime), their atemporal negotiation has been already (see Macavity above) completed, once-at-a-time. Subsequently, the set of intact potential states (Fig. 16 in Paper I) of all physical systems is dubbed ‘causal field’ (global mode of spacetime). In Sec. 2 below, a new form of retarded relativistic causality, called ‘biocausality’, will be introduced along an Arrow of Space: the Heraclitean flow of time is modeled as ‘change of space’ along the atemporal axis $W$, shown in Fig. 1 and
Fig. 4 in Paper I (global mode of spacetime), while ‘change in space’ pertains to the physical or coordinate ‘time as read with a clock’ (local mode of spacetime). Hence the rule ‘think globally, act locally’ is attributed to Einstein’s ‘God’s thoughts’.

Before moving to quantum sets (Sec. 2), let me comment on the paradoxes of motion (Eq. 1 in Paper I) and the interpretation of what Euclid called “that which has no part”. It is the ‘atom of geometry’, and its origin can be explained with the \((\varepsilon, \delta)\)-definition of limit (Fig. 10 and Fig. 12 in Paper I) used to derive the formula for the circumference of a circle (Fig. 2).

If we picture the sides of inscribed and circumscribed polygons as Thomson’s lamp, the obvious ‘limit’ is the atom of geometry called ‘point’ at which there is no ‘lamp’ anymore. To understand the inherent structure and dual topology of the atom of geometry (Fig. 1), check out the Flatland analogy in Sec. 5 of Paper I and keep in mind that the so-called causal field is not res cogitans nor res extensa\(^{69}\) (matter and fields) but an intact\(^{29}\) potential reality residing in the potential future of every “point” shown in Fig. 1. It also refers to completed or actual infinity, explained by David Hilbert as “a totality of things which exists all at once”, and to the definition of ‘set’ by Georg Cantor as ‘any gathering-together (Zusammenfassung) of determined and well-distinct objects into a whole (zu einem Ganzen)’.

Again, every ‘set’ is quantum set, and the question here is whether the Brain of the Universe can be explained as the union of colored reality and colorless non-reality, shown in Fig. 8 in Paper I. Obviously, ‘the set of all sets’ (if any) is incomprehensible, and all questions regarding qualia (if any) from the Brain of the Universe, such as the Universal Mind and The Holy Trinity, are considered absolutely undecidable and will not be discussed. We all will find out the answers, sooner or later (better latter!).

D. Chakalov, 21 October 2015, 22:37 GMT

References and Notes*


6. The atemporal non-linear coupling (Fig. 18) of geometry (Fig. 16) to matter strongly resembles the so-called mind-body problem, in which we also encounter two alleged alternatives: either the mind can act on brain’s tissue, in which case it cannot be res cogitans but material stuff performing work (Sic!) on the brain and obeying Newton’s third law, or cannot act on its brain, in which case it will be some ghost totally detached from its brain. The solution was put forward by Gottfried Wilhelm von Leibniz, by means of pre-established harmony of res cogitans (mind) and res extensa (body), which spring jointly from a third (the doctrine of triallsm) entity viewed as their common source, the Universe as ONE (Luke 17:21) endowed with the self-action of the Unmoved Mover (Aristotle). Ever since The Beginning, the physical explications (res extensa) of the Universe have been perfectly fine-tuned and pre-correlated with all future (Sic!) requirements for life and cognition (res cogitans), which supports what physicists call anthropic principle and rejects the mythical “multiverse”.


9. Albert Einstein, Philosopher-Scientist, ed. by Paul A. Schilpp, Tudor Publishing Company, New York, 1951, p. 75. See also: A. Einstein, Dialog über Einwände gegen die Relativitätstheorie, Naturwissenschaften, 6(48), 697-702 (29. November 1918), S. 700: “Man kann deshalb weder sagen, das Gravitationsfeld an einer Stelle sei etwas Reales, noch es sei etwas bloß Fiktives.” (…) “dem Gravitationsfeld an einer Stelle entspricht also noch nichts physikalisch Reales, wohl aber diesem Gravitationsfelde in Verbindung mit anderen Daten.” (“One can say that the gravitational field at a point is neither real nor merely fictitious.” (…) “nothing “physically real” corresponds to the gravitational field at a point, only to the gravitational field in conjunction with other data.” Translated by A. Afriat and E. Caccese.


13. Sir Hermann Bondi, Conservation and non-conservation in general relativity, *Proc. R. Soc. Lond.* A 427 (1990) 249-258, cf. p. 249 at this http URL; Hans C. Ohanian, The Energy-Momentum Tensor in General Relativity and in Alternative Theories of Gravitation, and the Gravitational vs. Inertial Mass, arXiv:1010.5557v2 [gr-qc], cf. p. 3 at this http URL; T. Padmanabhan, *Gravitation: Foundations and Frontiers*, Cambridge University Press, 2000, cf. pp. 211-213 at this http URL. To quote from Wikipedia (accessed on 30 September 2015), ―in fact, it turns out to be impossible to find a general definition for a system’s total mass (or energy). The main reason for this is that “gravitational field energy” is not a part of the energy-momentum tensor; instead, what might be identified as the contribution of the gravitational field to a total energy is part of the Einstein tensor on the other side of Einstein’s equation (and, as such, a consequence of these equations’ non-linearity).”

14. Demetrios Christodoulou, Mathematical problems of general relativity I. *Eur. Math. Soc.*, February 2008, Sec. 3.1, p. 35, Definition 32 available at this http URL; more mathematical jabberwockies in Fig. 9 and at http URLs here, here, and here.


16. Paul J. Steinhardt, Inflationary cosmology on trial. Talk at Vanderbilt University, March 17, 2011; watch an excerpt (Steinhardt.mp4, 2 min, 6.7MB) at this http URL. Merced Montesinos, The double role of Einstein’s equations: as equations of motion and as vanishing energy-momentum tensor, arXiv:gr-qc/0311001v1, cf. p. 5 and Eq. 23 at this http URL.


20. Max Tegmark, On the dimensionality of spacetime, arXiv:gr-qc/9702052v2, footnote 4 and Fig. 1.

21. Only biological systems⁶, such as the human brain, may obtain qualia from potential reality, experienced as an extended moment ‘now’⁶¹ from our psychological
time: we observe the world and, at the same time (Fig. 16), are aware of doing so.

22. Kevin Brown, Reflections on Relativity, Lulu, August 2015, cf. Sec. 5.8, The Field Equations, pp. 384-395, available at this http URL; sec. 8.11, Paths Not Taken, pp. 610-617, available at this http URL; and Sec. 9.9, Locality and Temporal Asymmetry, pp. 671-677, available at this http URL.


26. David Hilbert, Über das Unendliche, Mathematische Annalen 95 (1926), S. 161-190. Translated by Erna Putnam and Gerald J. Massey at this http URL.


28. To the best of my knowledge, the term ‘finite infinity’ was first suggested by George F R Ellis54, see: Ellis G F R, Relativistic Cosmology: Its Nature, Aims and Problems, in: General Relativity and Gravitation, Ed. B. Bertotti et al., Reidel, 1984, pp. 215-288; Sec. 5.2 and Fig. 11(c).

29. The solutions to the measurement problem in Quantum Mechanics (Schrödinger’s cat) and to the most widely known public secret in theoretical physics (shown at this http URL) will be examined in Paper II1. If we use classical description of a quantum system, as suggested in current literature (e.g., GianCarlo Ghirardi3), we will never understand the quantum world, just as an Eskimo could never understand elephant’s trunk by measuring it with two complementary devices, “nose” and “arm” (see pp. 7-8 in HBP.pdf). The quantum state 7 can only be described as an intact quantum “trunk”, which is neither “particle” nor “wave”, does not “collapse” nor “decohere”, and is not “uncertain” but flexible: God casts the die, not the dice (Einstein).


37. Yif Magic, Lightspeed Teleportations, posted on YouTube on December 3, 2012; watch a video clip (33Mb, mp4 format) from this http URL. A demonstration of “levitation” by Steven Freyne is available at this http URL. No, it’s not “magic”.


40. Robert M. Wald, *Space, Time, and Gravity*, University of Chicago Press, 1992, p. 120; excerpt available at this http URL.


44. Hyun Seok Yang, Towards A Background Independent Quantum Gravity, arXiv:1111.0015v3 [hep-th], pp. 1-2. To quote from Hyun Seok Yang (p. 2), “the flat spacetime in general relativity behaves like an elastic body with tension although the flat spacetime itself is the geometry of special relativity. (...) That is, the (flat) spacetime behaves like a metrical elasticity which opposes the curving of space. But this picture rather exhibits a puzzling nature of flat spacetime because the flat spacetime should be a completely empty space without any kind of energy as we remarked above. How is it possible for an empty space of nothing to behave like an elastic body with tension?”

45. Lewis Carroll, *Alice’s Adventures in Wonderland*, Macmillan, 1865, Ch. 6 available at this http URL.

46. Philip Gibbs, Where is the centre of the universe? Online article, 1997, retrieved on 24 September 2015 from this http URL.


584; see the “definition” of the boundary exactly at $\Omega = 0$ on p. 565 at this http URL.

50. Jerry B. Griffiths, Jiri Podolsky, Exact Space-Times in Einstein’s General Relativity, Cambridge University Press, 2009, Ch. 6.4, p. 83; see Fig. 6.8 at this http URL.

51. Robert Geroch, Asymptotic Structure of Space-Time, in Asymptotic Structure of Space-Time, ed. by F. Paul Esposito and Louis Witten, Plenum, 1977; see an excerpt at this http URL.

52. E. T. Newman, K. P. Tod, Asymptotically flat spacetimes, in General Relativity and Gravitation: One Hundred Years After the Birth of Albert Einstein, Volume 2, ed. by Alan Held, Plenum, 1980, p. 2; see an excerpt at this http URL.


54. George F. R. Ellis, Physics in the Real Universe: Time and Spacetime, arXiv:gr-qc/0605049v5, see Fig. 4 at this http URL.

55. Tamara M. Davis, Charles H. Lineweaver, Expanding Confusion, arXiv:astro-ph/0310808v2; see an excerpt at this http URL.

56. Peter G. Bergmann, Observables in General Relativity, in Gravitational Measurements, Fundamental Metrology and Constants, ed. by Venzo De Sabbata and Vitaly N. Melnikov, NATO ASI Series Volume 230, Kluwer, 1988, pp. 15-18; see an excerpt at this http URL.


58. Karel V. Kuchar, The Problem of Time In Quantum Geometrodynamics, in The Arguments of Time, ed. by Jeremy Butterfield, Oxford University Press, 1999, see an excerpt from p. 193 at this http URL; Demetris T. Christopoulos, A simple definition of time, ResearchGate, 16 June 2014, retrieved from this http URL.


61. Ulric Neisser, Cognition and Reality. Principles and Implications of Cognitive Psychology, Freeman, 1976, Fig. 2 and Ch. 2 and 4.

62. John A. Wheeler, p. 1215: “No acceptable explanation for the miraculous identity of particles of the same type has ever been put forward. That identity must be regarded, not as a triviality, but as a central mystery of physics.”

63. Consider, for example, the proton per se (Fig. 16) keeping all physicalized protons (Fig. 17) ‘the same”. Suppose there are roughly $10^{82}$ protons in the observable
universe. What makes their genidentity is that all protons are physicalized “shadows” (Fig. 1) cast from their intact potential quantum state\(^\text{29}\) — the proton per se — which has zero probability for physical observation: “one of the greatest mysteries of Nature”\(^\text{64}\). As to whether the proton per se has a distinctive qualia\(^\text{21}\), and whether one can temporarily cancel what we call inertia by “free fall” (REIM) to fly like an Alien Visiting Craft (AVC), such questions are related to spacetime engineering (Paper III) and will not be discussed here. Suffice it to say that if the RS spacetime of AVCs can be “inflated” with respect to our RS spacetime by \(10^3\) (\(S_{AB} = 1000\), see Fig. 14 and Eq. 2), and if our guests in the AVC fly with, say, 1 m/s (3.6 km/h) in their RS spacetime, an observer in our RS spacetime (e.g., Kenju Terauchi) will expect from the AVC to “slow down time”, just a bit, by flying with 1 km/s (3600 km/h) with respect to our RS spacetime. Yet all people, included our guests in the AVC, will enjoy “the same” time rate 1 s/s. Besides, taking “sharp turns” with 1 m/s (3.6 km/s) won’t break the AVC. It’s all relative.

64. A.D. Dolgov, Cosmic antigavity, arXiv:1206.3725v1 [astro-ph.CO]; an excerpt from pp. 13-14 is available at this http URL.

65. José M.M. Senovilla, Singularity Theorems in General Relativity: Achievements and Open Questions, arXiv:physics/0605007v1, p. 6: “Singularities in the above sense clearly reach, or come from, the edge of space-time. This is some kind of boundary, or margin, which is not part of the space-time but that, somehow, it is accessible from within it. Thus the necessity of a rigorous definition of the boundary of a space-time.”

66. Adam D. Helfer, Are Negative Energy Densities Detectable? arXiv:gr-qc/9709047v1, p. 1: “T. S. Eliot described a ‘mystery cat,’ Macavity, responsible for all sorts of mischief, But when the crime’s discovered, Macavity’s not there! I investigate the negative energy densities predicted by relativistic quantum field theories, and find they have a similar character. The energy in a region, plus the energy of a device which detects it, must be non-negative. Indeed, as far as has been checked, the total four-momentum density, of the field plus the observing device, must be future-pointing. In consequence the semi-classical Einstein equation can at best describe negative energy-density effects only as long as no observers are present to test it: Macavity, Macavity... he breaks the law of gravity.”


69. Every carpenter can understand the essence of Archimedean topology (E. Rosinger, arXiv:0903.0296v2, pp. 5-6): if you have two timbers of different size, say, \(A = 3m\) and \(B = 10m\), you can always find a positive integer \(0 < k < \infty\), such that if you multiply the smaller \(A\) by \(k\), you can produce a timber larger than \(B\), say, if \(k = 4\), \(4 \times 3 = 12 > 10\). But you can never reach some “infinitely large” timber and stop there, as with the largest beer in Fig. 10. Ditto to the opposite case of reaching “zero timber” (Eq. 1).

**NB:** Only the physical footprint in the past (Fig. 3) has Archimedean topology.

* All emphasis and comments in the references and notes are mine - D.C.