

# Gravity-Matter Duality

D. Chakalov<sup>1</sup>  
[chakalov.net](http://chakalov.net)

## Abstract

Gravity-matter duality is suggested as the first step toward quantum gravity, ensuing from the idea that the phenomenon dubbed ‘gravitational field’ is a new form of reality, known as *Res potentia* – “just in the middle between possibility and reality” (Heisenberg, [Slide 7](#)). The essential similarities and differences between gravity-matter duality and wave-particle duality are briefly examined, with emphasis on the proposed joint solution to *exact* localization of gravity and “quantum waves” at spacetime points. The latter are endowed with brand new structure and topology due to the fundamental *flow of events* suggested by Heraclitus – *Panta rei conditio sine qua non est*.

## 1. Introduction

Perhaps the best way to launch a new interpretation of gravity is to compare it to the one it seeks to replace. Here I will briefly outline the metaphysical ideas in Einstein’s General Relativity (GR) – “Spacetime tells matter how to move; matter tells spacetime how to curve”, [John Wheeler](#) – leading to the “coupling” of gravity to matter ([Fig. 1](#)) and to the hypothesis that gravity were some “fictitious force”, as stated in current [GR textbooks](#).

Which goes first, [gravity \(Fig. 1.1\)](#) or [matter \(Fig. 1.2\)](#)? Is their mutual determination instantaneous, resembling [EPR correlations](#)? If it is not instantaneous, how is the *next* gravity-matter negotiation going to be accomplished, in order to produce gravitational radiation ‘in time’, as read with a clock? How was the *previous* gravity-matter negotiation fixed, in order to have the two consecutive negotiations “separated” by an [infinitesimal temporal difference  \$dt\$](#) ? If gravity is not a *bona fide* ‘force’, how could ‘the grin of the [Cheshire cat without the cat](#)’ ([Fig. 1.1](#)) *interact* dynamically, once-at-a-time  $dt$ , with the ‘cat’ ([Fig. 1.2](#)) placed in the right-hand side of [Einstein’s field equations](#)?



Fig. 1.1



Fig. 1.2

I don’t think there is consensus on these open questions in GR, so let me start *ab ovo*.

<sup>1</sup> Email: [dchakalov@gmail.com](mailto:dchakalov@gmail.com). No permanent address. Download the latest version ([gm\\_duality.pdf](#)) from [this http URL](#).

## 2. Gravity-Matter Duality

Let me stress that GR is still a work in progress – Einstein was searching for “a total field of as yet unknown structure” (p. 6 in [holon.pdf](#)) until his last days. To explain Einstein’s ‘total field’ (*Gesamtfeld*), it is instructive to point out what his *Gesamtfeld* is not.

Suppose you order a pizza, which is delivered at your doorstep, and then you bring it in your kitchen, as a contribution to your lunch. The pizza you have in your kitchen and the pizza you ordered previously are identical, so if you think of gravity as a pizza, you must conclude that the contribution of gravity to your lunch (placed in the right-hand side of Einstein’s field equations, see [Fig. 1.2](#)) is *exactly* the same ‘pizza’ that was delivered at your doorstep earlier. If true, gravity ([Fig. 1.1](#)) will be a *bona fide* physical field, and the conservation of mass-energy of the system ‘the pizza shop & your house’ will not be violated. It is like withdrawing cash from ATM (p. 3 in [CEN.pdf](#)). It may look simple and “intuitively clear”, only there is a problem: this is not the case chosen by Mother Nature.

We propose ‘gravity-matter duality’, based on the ontological distinction between all physical stuff, denoted with ‘matter’ ([Fig. 1.2](#)), and its *unphysical* gravitational “field” ([Fig. 1.1](#)), which we call ‘gravity’. Unlike gravity (ref. [19] in [spacetime.pdf](#)), matter can possess stress-energy-momentum and [angular momentum](#), and has the ontological status of ‘objective reality *out there*’ (e.g., the pizza [above](#)): at every instant ‘here and now’, it either ‘*is*’ there or ‘*is not*’ there (p. 25 in [spacetime.pdf](#)). No third option is available in classical physics. Gravity, on the other hand, nether ‘*is*’ nor ‘*is not*’. It is *Res potentia* – “just in the middle between possibility and reality” (Werner Heisenberg, [Slide 7](#)). Thus, gravity and quantum “waves” are neither *physically* real “pizza” nor some “fictitious force” (see [Addendum below](#)) viz. “state of knowledge”.

Recall also that in [wave-particle duality](#), which is the cornerstone of Quantum Mechanics (QM), there is no explanation of the *source* of “quantum waves” endowed with *complex* phase (Chen Ning Yang, ref. [36] in [spacetime.pdf](#)). Here we do not offer any hypothesis on the *source* of gravity either. Instead, we postulate **dual** existence of two *complementary* aspects of the world, in line with the doctrine of *trialism* ([Slide 14](#)).

As an illustration of gravity-matter duality, see [Fig. 2](#) ([Fig. 23](#), p. 25 in [spacetime.pdf](#)).



Fig. 2

The physical stuff dubbed ‘matter’ ([Fig. 1.2](#)) is like colorful nail varnish: we are ‘chained Eskimos’ ([Fig. 4](#) in [CEN.pdf](#) and [Fig. 6 below](#)), and can never see some **intact colorless** bare nails ([Fig. 2](#)), because they have **exactly zero chance** to be explicated as *physicalized* (colorized) reality. Surely we could not paint a picture ([Fig. 1.2](#)) without its *bare* colorless

“canvas” (Fig. 1.1), yet the two are ontologically different and *complementary* forms of reality, as we know since Plato.

An important difference between the two forms of duality is that the gravitational analog of entanglement (Fig. 11 and p. 11 in [CEN.pdf](#)) and spin ([gravity\\_rotation.pdf](#)) is observable from the length scale of galaxies ([holon.pdf](#)). Crudely speaking, the gravitational entanglement resembles the holomovement of a school of fish (ref. [11] in [hi\\_numbers.pdf](#) and pp. 89-90 in [gravity.pdf](#)). It is not present in gravitating systems of the size of the [Solar System](#) for which we can apply the *linearized* approximation of GR, at the expense of presenting gravity as “a powerless shadow” (Hermann Weyl, ref. [3] in [gwa\\_rip.pdf](#)). With the exception of gravitational radiation, such ‘spherical cow’ approximation of gravity is FAPP acceptable up to the [Solar System](#), just like we ignore all [quantum-wave](#) effects in [Newtonian mechanics](#). Keep in mind that the diameter of our [Solar System](#) is roughly  $10^{13}$  times smaller than the [observable universe](#), so it should not be surprising that many “dark” effects of gravity, including gravitational radiation (Sec. 3), require brand new theory of quantum gravity for their explanation (p. 5 in [holon.pdf](#)), and gravity-matter duality is the first step in this direction.

Let me briefly examine the localization of gravity, as perpetually changing colorful ‘nail varnish’ (Fig. 2). I trust the reader could easily compare it with the localization of quantum “waves” (Slide 7), as in both cases the *colorless intact* quantum-gravitational *Res potentia* (the *intact colorless* bare nails, Fig. 2) is not directly observable.

### 3. Gravitational Radiation

We can never observe the *intangible* energy of gravity ([Hermann Bondi](#)), just as we can never observe *Res potentia* (Werner Heisenberg, Slide 7). We can observe *gravitational radiation* only as perpetual energy-momentum nonconservation ([Hans Ohanian](#)): matter is [coupled to itself](#) via gravity, and Einstein’s *Gesamtfeld* (Sec. 2) cannot in principle be traced to any *tangible* form of energy in the right-hand side of [Einstein’s field equations](#) (Fig. 1.2). Physically, Einstein’s *Gesamtfeld* will be “dark”, because *Res potentia* does not emit nor reflect light – it is “before” light (Fig. 1 in [CEN.pdf](#) and A2 in Slide 19). In this sense, *Res potentia* is not *directly* observable: check out the explanation from John Polkinghorne on p. 12 and ref. [20] in [CEN.pdf](#), Kuchar’s perennials (p. 22), Rovelli’s non-metric “time” (p. 84), and Unruh-Wald “[nondynamical time](#)”. Were the global cosmic time *physically* observable, the “colorless nails” (Fig. 2) and the universal Unmoved Mover ([Aristotle](#)) will be *physically* exposed, and the theory of relativity will be demolished.

Which is why at every 4D point ‘here and now’ (see [above](#)), Einstein’s *Gesamtfeld* is being *nullified* (akin to wave function “collapse”). It (not “He”) has *already* completed its *atemporal negotiation* for the present ‘here and now’, leaving only one negotiated state – one-state-at-a-time (see [above](#)), without any *physical* “gaps” (Fig. 4, p. 6 in [CEN.pdf](#)). Thus, the perpetual localization of gravity renders the spacetime of ‘the cat’ (Fig. 1.2) a *perfect* continuum of everlasting *re-created physicalized* universes – one-at-a-time.

Which is why we can eliminate the *intangible* ([Hermann Bondi](#)) gravitational source ‘by hand’ ([László Szabados](#)), just like we “[eliminate](#)” the wave function. Forget about [tensors](#) viz. their individual components “with respect to some explicit basis” ([Kevin Brown](#)): [tensor fields](#) are mathematical objects applicable *only* in classical physics, which describes the physical world as ‘objective reality *out there*’ - it either ‘*is*’ or ‘*is not*’, always with certainty ([Erwin Schrödinger](#)). In both cases of duality, quantum and gravitational, we face bona fide ‘potential reality’ or *Res potentia*, which neither ‘*is*’ nor ‘*is not*’ (see [above](#)).

The crux of the matter is the point-wise *physicalization* (Fig. 3) of quantum-gravitational universes, which requires brand new structure and topology of what we call ‘spacetime event’. The latter is the very *interface* (Fig. 3) between the potential future, inhabited by *Res potentia*, and the irreversible past made by accumulating ‘facts’, which build up the *physicalized* quantum-gravitational universes – one-universe-at-a-time.

This is the fundamental *flow of events* (dubbed ‘biocausality’ in [January 1990](#)), which must never be *physically* exposed, as explained in [Sec. 3 above](#).

#### 4. Structure and Topology of Spacetime Events

The structure of spacetime events ‘here and now’ was shown previously in [Slide 13](#) and in [Fig. 7, p. 8 in spacetime.pdf](#), reproduced below.

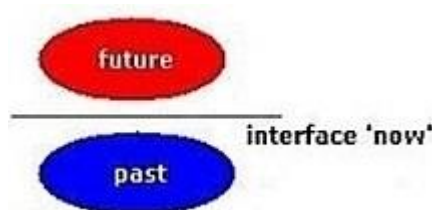


Fig. 3

Fig. 3 is obtained by rotating Fig. 1 [above](#) 90 degrees clockwise. The idea is very old – see the Dragon metaphor on p. 3 in [Penrose\\_diagram.pdf](#). Thus, we have *perfect* localization of *Res potentia* and explanation of the two forms of duality, quantum and gravitational.

We need quantum cosmology to explain the *dynamics* of gravitational radiation, as stated [above](#). The alleged ‘[block universe](#)’ is false. *Panta rei conditio sine qua non est* ([CEN.pdf](#)).

Needless to say, there are many outstanding mathematical challenges from the new model of spacetime (p. 6 in [Penrose\\_diagram.pdf](#)), dubbed Relative Scale (RS) spacetime (p. 5 in [holon.pdf](#)). By the end of 2018, I intend to post three brief video lectures at my YouTube channel, to explain the so-called hyperimaginary numbers (p. 9 in [hi\\_numbers.pdf](#)) and their implications to [point-set topology](#), [set theory](#), and [number theory](#) (p. 20 [therein](#)).

As to the experimental predictions of RS spacetime, such as modulating inertia with REIM (p. 5 in [holon.pdf](#)), I strongly contest the murky assumption that the spacetime *manifold* might be asymptotically Minkowskian at each point (Fig. 3). As [Kevin Brown](#) acknowledged, Einstein’s GR ([Sec. 2](#)) “does not in any way explain or obviate the principle of inertia” and “we must simply rely on an intuitively plausible choice, based on our pre-existing notions of the topological arrangement of events and our identification of persistent entities through time.”

But how do we identify *persistent* entities (Fig. 2) through physically unobservable [Heraclitean flow of time](#), which is being *exactly re-nullified* ([Sec. 3](#)) at every 4D event ‘[here and now](#)’? Check out Ned Wright’s [balloon analogy](#) below (Fig. 4). As he explained:

“The expanding balloon analogy for cosmological models is shown below at two different times ( $t_1$  and  $t_2$  - D.C.). A common misconception is that the balloon is expanding into empty space that is “beyond the Universe” and that it is expanding from a single point in

the center of the balloon. But the balloon analogy is a 2-dimensional model, and the center of the balloon and the space around are not part of the 2-dimensional Universe. In our 3-dimensional Universe, these points could only be reached by traveling in a 4th spatial dimension (not the time dimension of 4-D spacetime), but there is no evidence that this dimension exists.”

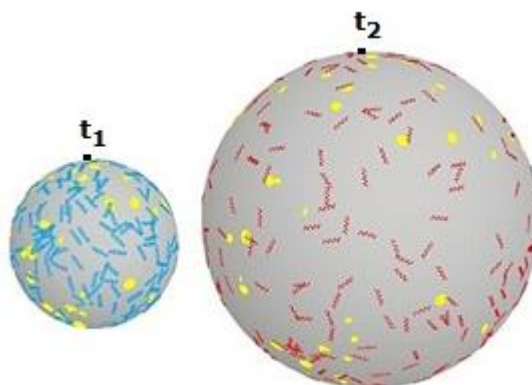


Fig. 4, adapted from [Ned Wright](#)

There is no evidence of some *preferred* “4th spatial dimension” ([Ned Wright](#)) in physics: the balloons are inflated along the hyperimaginary axis **W** ([Fig. 5](#)) matching their *unphysical* radii (not shown in [Fig. 4](#)). The two consecutive instances,  $t_1$  and  $t_2$ , pertain *simultaneously* both to the balloons and to their unphysical hyperimaginary axis **W** ([Fig. 5](#)). The latter reaches *all* spacetime points in the balloons *en bloc* (p. 105 in [gravity.pdf](#), A2 in [Slide 19](#), and [Fig. 9](#) in [hi\\_numbers.pdf](#)), and such *immeasurable* ([Sec. 3](#)) ‘global cosmic time’ produces crucial non-tensorial (Sic!) objects ([Laszlo Szabados](#)) and severe topological ambiguities ([Butterfield and Isham](#)). Physically, the hyperimaginary “thickness” of the balloon is *exactly zero* (A2 in [Slide 19](#)), like images on a movie screen ([Fig. 4](#) in [CEN.pdf](#)).

Again, the hyperimaginary axis **W** (see also [Fig. 4](#), [Fig. 8](#), and [Fig. 12](#) in [CEN.pdf](#)) is not topological dimension of the *physicalized* balloons at  $t_1$  and  $t_2$  ([Fig. 4](#)) viz. the Cheshire cat ([Fig. 1.2](#)). Physically, **W** ([Fig. 5](#) and [Fig. 21.1](#) in [spacetime.pdf](#)) is perpetually *re-nullified* “during” every infinitesimal increment of time  $dt$  ([Fig. 1](#) in [CEN.pdf](#) and A2 in [Slide 19](#)).



Fig. 5

Physically, the *hyperimaginary* axis **W** will be *atemporal* and “omnidirectional”, being “beyond the Universe” (Fig. 4) and “beyond” the space ship (Fig. 5). Not surprisingly, Einstein’s GR (Sec. 2) “does not in any way explain or obviate the principle of inertia” (Kevin Brown, excerpt here).

Check out also my invitation to many experts in gravitational physics and mathematical relativity on p. 6 in [holon.pdf](#). We must be *extremely* careful with the origin of gravity (Sec. 3). Remember Einstein’s *heuristic arguments in 1905*, leading to his innocuous  $E=mc^2$ ? Nobody could anticipate that forty years later 130,000 people may be killed in [Hiroshima and Nagasaki](#). Unlike  $E=mc^2$ , I do believe that my evolution equation (still in symbolic form, see Eq. 1 in [CEN.pdf](#)) cannot be misused *in principle* (p. 11 in [CEN.pdf](#)), but what if I have missed some dangerous loophole?

Moreover, we can never know ‘the unknown unknown’. If it is the *Noumenon* or ‘*Das Ding an sich*’, it cannot qualify to be a ‘set’ in the first place, not even the so-called *empty set* (p. 4 in [hi\\_numbers.pdf](#)). Perhaps we cannot even *think* about the *Noumenon*. It may be quietly residing in what physicists call ‘vacuum’ (e.g., the *zero-point field*), as well as in the unspeakable *cognitive vacuum* – try the experiment with your brain on p. 2 in [hi\\_numbers.pdf](#). If our physical world (*Res extensa*) and mental world (*Res cogitans*) are fleeting “localizations” of the underlying physical-and-cognitive *vacuum*, the latter will be beyond human comprehension: we are 4D Eskimos (Fig. 6) and could not even imagine elephant’s trunk (the doctrine of *trialism*, Slide 14) rooted on ‘the unknown unknown’.

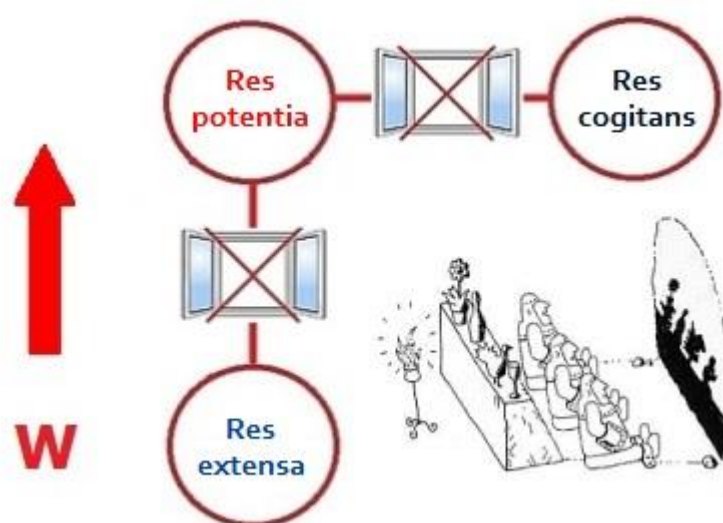


Fig. 6, adapted from Slide 14

Eskimos can only see “arm” (*Res cogitans*) and “nose” (*Res extensa*), but never the underlying “trunk” due to the absence of “windows” (Slide 14). The physical world or “nose” (*Res extensa*), placed always in the irreversible *past* (Fig. 3), is not just physical “pizza” (see above), because *Res extensa* is rooted on the *dual* entity known as *Res potentia* (Fig. 6). Our mental world or “arm” (*Res cogitans*), placed always in the potential *future* (Fig. 3), also springs from the same *dual* entity dubbed *Res potentia* (Slide 14). Thus, *Res potentia* is the genuine ‘monad without windows’ (Leibniz, Slide 14), endowed with “arm-nose” duality, depending on how we (4D Eskimos) choose to look at it, by calling it “trunk”: *via* the “arm” (*Res cogitans*) or *via* the “nose” (*Res extensa*). This is the ultimate case of duality, dubbed *trialism* (Slide 14). It requires maximal extension of set

theory (maximal set theory), new mathematical presentations of ‘zero’ and ‘finite infinity’ (p. 6 in [Penrose\\_diagram.pdf](#)), and physical theology (Sec. 6 in [spacetime.pdf](#)).

Time is God’s way to keep everything from happening all at once (p. 4 in [hi\\_numbers.pdf](#)). We can never know the future, because it is always ‘open’ to brand new events, which may emerge like *creatio ex nihilo* from what is currently ‘the unknown unknown’.

We need new [Mathematics](#).

30 July 2017

Latest update: 18 August 2017, 12:00 GMT

## ADDENDUM

What is the *origin* of inertia? We know that if an apple falls from a tree, it may hit your head (as observed by [Newton](#)), but what is the *origin* of gravitational potential in [Newtonian gravity](#)? The modern (and essentially incomplete, see [Sec. 2](#)) model of gravity involves some sort of “[fictitious force](#)” ([Joy Bloomfield](#)) in the [gravitational acceleration](#), and the *origin* of inertia is explained as “mass *there* governs spacetime geometry *here*” ([Ciufolini and Wheeler](#)). Governs? By means of *what*? By [non-tensorial Christoffel symbols](#)? It will be like saying that planets are orbiting Sun *by* solving [differential equations](#).

We have no *explanation* of inertia ([Kevin Brown](#), see excerpt [here](#)), which is supposed to be “dictated by the curvature of spacetime” ([Wikipedia](#)). In order to *explain* (not vaguely describe) the appearance of inertia in a space rocket ([Fig. 5](#)), we must *reduce* ‘inertia’ to some global spacetime phenomenon pertaining to the *entire* universe, which “governs spacetime geometry *here*”, just as we explain ‘heat’ by *reducing* it to [kinetic energy](#). This should (hopefully) explain the *origin* of inertia.

Sixty-five years ago, on 19 August 1952, [Dennis W. Sciama](#) submitted his groundbreaking paper on the *origin* of inertia for publication, suggesting that “inertia effects arise from the gravitational field of a moving universe”; two excerpts from the published version, from [1 February 1953](#), can be found [here](#). Pity the great Dennis Sciama could not complete his theory.

Notice that we need to uncover the *interaction* ‘think globally act locally’ ([Fig. 1](#)) between “mass *there*” and “spacetime geometry *here*” ([Ciufolini and Wheeler](#)). In 1998, James F. Woodward offered his insights (p. 90 in [gravity.pdf](#)), but unfortunately the notion of “distant future out there” is not mathematically precise ([Penrose\\_diagram.pdf](#)).

Any ideas on the *origin* of inertia? I will not comment here on my interpretation of “moving universe” ([Dennis W. Sciama](#)) along hyperimaginary axis **W** ([Fig. 5](#)), endowed with hyperimaginary spin (Sic!), leading to *physicalized* inertial effects ([colorized nails](#), [Fig. 2](#)), because the hypothesis was explained, many times indeed, in my [online papers](#). Instead, I prefer to explore all possible ideas on the *origin* of inertia, suggested by prominent experts in theoretical physics (invitation list on p. 6 in [holon.pdf](#)).

To those not familiar with the so-called “[fictitious force](#)” in the current (and essentially incomplete, see [Sec. 2](#)) model of gravity, let me offer two simple examples of *fictitious* (also d’Alembert) force. As [Courtney Seligman](#) explained, you watch the night sky and notice “the motion of the stars in the sky westward each day, which is caused by our

eastward motion around our axis of rotation. To an observer outside the Earth, it appears that the stars are essentially immobile, or “fixed” in space, since their actual motions are very small compared to their vast distances. But to an observer on the ground, the stars seem to circle around the sky, in uniform circular motion, which should require a force, pointing toward the center of the circular motion, called a centripetal force. If the ground-based observer supposed that there really was such a force, the outside (Sic! - D.C.) observer would call that a [fictitious force](#).”

Another example: you stay at the balcony of your flat ([inertial frame](#)) and look down in the street, and notice there a car at rest, waiting for green signal. At the instant it moves on with *acceleration* (see ‘[acceleration in a straight line](#)’, [Fig. 7](#)), all passengers in the car will lean backwards due to their weight viz. inertia. But you are *outside* their car, at the balcony of your flat ([inertial frame](#)), and will call such inertial effect “fictitious”, because it emerges due to the requirement that the net force on the passengers in the accelerating car is [zero](#).

However, you and the car share *the same spacetime*, which is not the case in Einstein’s *Gedankenexperiment* in 1907, depicted in [Fig. 5](#). Therefore, if you wish to speculate about gravity as some “[fictitious force](#)”, facilitated by non-tensorial [Christoffel symbols](#) and “dictated by the curvature of spacetime” ([Wikipedia](#)), you have to switch from the balcony of your flat to some *ideal* observer “beyond the Universe” ([Fig. 4](#)) and “beyond” the space ship ([Fig. 5](#)). Even Chuck Norris and Roger Penrose could not help you trespass the “edge” of spacetime: check out the [Penrose-Norris Diagram](#). This is one of the reasons to suggest hyperimaginary axis **W** ([Fig. 5](#) and [Fig. 6](#)) and hyperimaginary spin to the “moving universe” ([Dennis W. Sciama](#)), as stated above. In my (not so humble) opinion, this is the only way to solve the puzzle of the *origin* of inertia.

As to the hypothetical ‘reversible elimination of inertial mass’ or REIM (see [above](#)), we always keep the requirement  $(ma) = (-ma)$ , as explained in [Wikipedia](#) ([Fig. 7](#)).



[Fig. 7](#), adapted from [Wikipedia](#)

If we can access the spacetime phenomenon (supposedly in the right-hand side of the evolution equation, see Sec. 3 in [CEN.pdf](#)) producing  $|ma|$  and carefully tweak it to reach  $(ma) = (-ma) \approx 0$ , the entire ‘car’ will become [weightless](#). We keep **W** ([Fig. 5](#)), but make carousel’s hyperimaginary spin ([Fig. 2](#) in [holon.pdf](#)) [zero](#). Many people will probably consider it “[magic](#)” (Sec. 4 in [holon.pdf](#)), although it is *spacetime engineering* (Sec. 4 in [hi\\_numbers.pdf](#)) – any sufficiently advanced technology is indistinguishable from “[magic](#)” (Clarke’s [third law](#)).

To sum up, Einstein’s *Gesamtfeld* is the Platonic source of gravity. It becomes *physicalized* at the [instant](#) at which it [alters](#) the non-gravitating matter (placed in the right-hand side of [Einstein’s field equations](#)), and at [the same instant](#) the *Gesamtfeld* becomes [nullified](#). If we denote the sizes of different pizzas (see [above](#)) with 4, 5, 6, 7, etc., there can be no integral conservation law for the sequence:  $(5+0) \rightarrow (4+0) \rightarrow (6+0) \rightarrow (8+0) \rightarrow (7+0)$ , etc. As [Hermann Bondi](#) stressed, “a non-localizable form of energy is inadmissible, because any form of energy contributes to gravitation and so its location can in principle be found.” In



the symbolic example above, we have five *gravitized* pizzas, denoted with **5, 4, 6, 8, 7**, all of which with **exact** localizations in spacetime (**Fig. 3**), like a fish from a school of fish (Fig. 3 in [holon.pdf](#)). Sure enough, they will display gravitational radiation (p. 94 in [gravity.pdf](#)).

I will be happy to discuss the whole bundle of issues related to the *origin* of inertia with experts in gravitational physics and mathematical relativity (p. 6 in [holon.pdf](#)). Also, don't hesitate to comment on "GW astronomy": check out *readme.html* in [chakalov.zip](#).

10 August 2017

Latest update: 29 August 2017, 12:50 GMT