

Gravitational Wave Astronomy: RIP

D. Chakalov
35A Sutherland St
London SW1V 4JU, U.K.
Website chakalov.net

Abstract

As an epitaph of the project for so-called GW astronomy, I suggest the famous saying by Confucius: “The hardest thing of all is to find a black cat in a dark room, especially if there is no cat”. Specific examples are drawn from [GW150914](#) and [LISA Pathfinder](#), to explain why [GW astronomy](#) was born dead [from the outset](#). Since the issue of energy transport by gravity is crucial to General Relativity, in the second part of the paper I offer a hypothesis about the origin of gravitational radiation in Relative Scale (RS) spacetime, and outline hypothetical applications of spacetime engineering for producing ecologically clean and unlimited energy by polarization of the so-called light vacuum.

Comment: Due to the sensitive nature of [clean unlimited energy sources](#) from spin-0 gravitational radiation, the full paper is available only upon request ([Matthew 7:6](#)).

1. Is GW150914 a [fraud](#)?

I smell a rat.

The announcement of “the first direct detection of gravitational waves” on 11 February 2016^{1,2}, denoted as GW150914, is a shocking provocation to General Relativity (GR): we are fully aware of the inherent limitations of the linearized approximation of GR^{3,4} and know the *compulsory* requirements for detecting the “ripples” of spacetime metric⁵. This provocation is sharply exacerbated from the parallel claim of “the first observation of a binary black hole merger”¹, given the well-known fact that we still do not understand the hypothetical formation of “event horizon”^{6,7} and its interior spacetime⁸, if any. Moreover, the proponents of “GW astronomy” swept the garbage under the rug by ignoring the unsolved problems of gravitational wave (GW) astronomy, which were acknowledged in August 2002⁴, leaving the impression that this whole GW “discovery” could be a [fraud](#).

If needed, the detailed examination of such (certainly unsettling) possibility can be immediately provided, ensuing from the guiding principle of [Sherlock Holmes](#): *When you have eliminated the impossible, whatever remains, however improbable, must be the truth.*

In the first part below*, I will briefly explain two crucial errors of GW astronomy, which contradict General Relativity: bare spacetime ([NB1](#)) and GW parapsychology ([NB2](#)). In the [second part](#), I will elaborate on the alternative possibility that the transient signal, detected on September 14, 2015 at 09:50:45 UTC^{1,2}, was a genuine GW pattern, and will offer (i) an explanation of GW localization⁹ without “[gravitons](#)”, and (ii) hypothetical applications of spacetime engineering for producing ecologically clean and unlimited

* The latest version of the paper, with live links, can be downloaded from <http://chakalov.net>.

gravitational radiation by polarization¹⁶ of the so-called light vacuum⁹. Needless to say, Sherlock Holmes' principle will be implemented as well.

First, let me focus on the crucial proposal by Rainer Weiss from 1972, suggesting “phase measurements in a Michelson interferometer”² for detecting alteration of distances due to trespassing GW. Such transient changes of the interference pattern are the essence of all ground-based (LIGO, VIRGO and the like) and space-based (LISA Pathfinder) GW detectors.

In my opinion, Rainer Weiss made a **grave error** by braking the fundamental axiom of GR: there is no “bare” spacetime without matter. It is against the rules of GR to hypothesize that one could somehow suck out all matter from a spacetime region (see Fig. 11 in ‘The Spacetime’⁹) and end up with “bare” spacetime without any matter *whatsoever*, like the grin of the Cheshire cat *without* the cat. Yet this is exactly what all **GW astronomers** are trying to “measure”: a *bare* spacetime region defined *only* with wiggling ‘size’ due to trespassing GWs, which can be demonstrated with laser interferometers!

Surely Reiner Weiss, Kip Thorne, and all their colleagues knew very well that they are breaking the rules of GR. My explanation of their error is that they *deliberately* did it. But why? Perhaps because they cannot define the **transport of energy** by GWs and compute the **stresses** in the **material substrate**, produced by trespassing GWs. So they decided to “bypass” this *fundamental* requirement^{3,5}, as there can be no **stresses** induced on a light beam. Just “bare” distances coupled to “**spin-two**” GWs. Is the Brooklyn Bridge for sale?

NB1: If the proponents of GW astronomy¹ wish to use GR, their first off task is to explain the coupling of GW strain, leading to **stresses** induced in some solid object¹⁰ – not light beam. Say, a plastic bottle.

Consider an empty plastic bottle on your desk, trespassed by GWs from PSR J1603-7202¹¹, with *dimensionless* amplitude 2.3×10^{-26} , and explain the coupling of their wave strain to the plastic material of the bottle, leading to stresses¹⁰. How can gravitational radiation⁵ produce **work** to induce stresses¹⁰ *and* squeeze the bottle? Perhaps at 2.3×10^{-26} m?

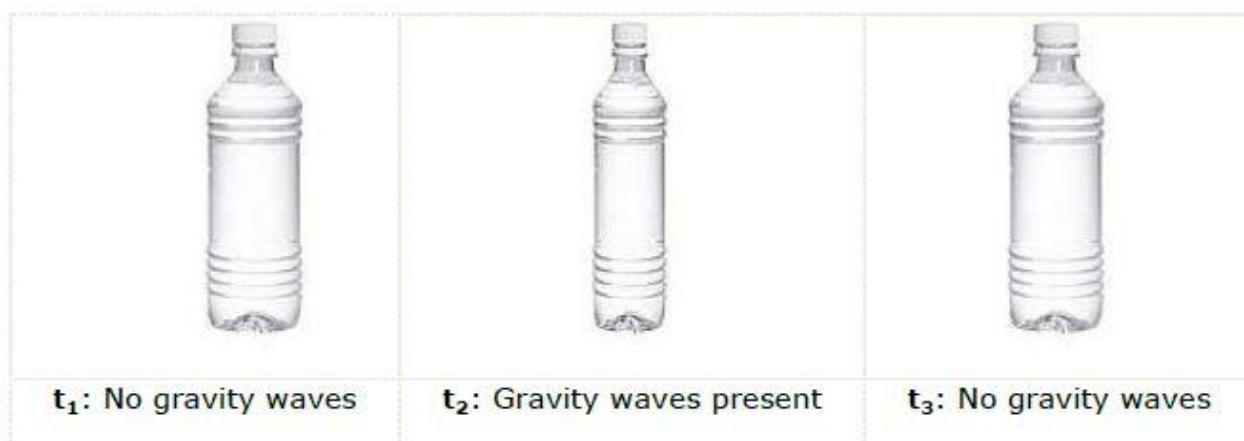


Fig. 1

Moreover, we have a second “miracle” related to the *bare* spacetime (the grin of the Cheshire cat *without* the cat) used in GW astronomy¹: no gamma-ray busts (GRBs) were detected on September 14, 2015 at 09:50:45 UTC. We were told (based on approximations in numerical relativity) that about 1.3 billion years ago, three solar masses were converted

to *bare* (see **NB2 below**) gravitational radiation, and $\sim 5.4 \times 10^{47}$ J of *bare* (see **NB2 below**) gravitational energy was released within a fraction of a second, but without “hot gas or stars swirl around them at far greater distances.”¹² It is indeed a “miracle”: an *enormous* explosion due to black hole merger^{6,7,8} that emits GW signal without *any* GRBs.

According to Bruce Allen¹², “For a tenth of a second [the collision] shines brighter than all of the stars in all the galaxies. But only (emphasis mine - D.C.) in gravitational waves.” Kip Thorne says that “other stellar explosions called gamma-ray bursts can also briefly outshine the stars, but the explosive black-hole merger sets a mind-bending record. (...) It is by far the most powerful explosion (emphasis mine - D.C.) humans have ever detected except for the big bang.”¹²

How come this “mind-bending record” of “the most powerful explosion” (Kip Thorne¹²) — $\sim 5.4 \times 10^{47}$ J released within $0.2s^2$ — was *not* detected as GRBs as well? For comparison, recall galaxy cluster [MS 0735.6+7421](#): its GRBs were duly detected, but there was no “GW signal”, while “the most powerful explosion” (Kip Thorne¹²) produced only a sneaky “GW signal”¹ and no GRBs whatsoever.

How can we safely separate (i) immensely violent explosions producing *only* GRBs but no “GW signal” from (ii) immensely violent explosions producing *only* one “GW signal” but no GRBs, as claimed by Bruce Allen and Kip Thorne¹²? Apparently by black holes^{6,7,8}, provided that they are *carefully* interpreted with selected approximations from numerical relativity. Is the Brooklyn Bridge for sale, again?

NB2: If the proponents of GW astronomy¹ wish to use GR, they must never use bare gravitational energy of some bare spacetime, resembling the grin of the Cheshire cat *without* the cat: GR does *not* admit such Biblical “miracles”. The object known in GR as ‘gravitational energy’ is like an adjective, say, ‘blue’. If they claim to have detected ‘blue’, they must explain *what* was ‘blue’, like in the example in Fig. 1 [above](#). In GR the grin of the Cheshire cat is *always* on its face ([Fig. 1](#)), that is, in the right-hand side of Einstein’s field equations. It contains *real* physical stuff, not some mythical “[gravitons](#)”.

Only in parapsychology people talk about “mental energy”, simply because they cannot answer the question ‘energy of *what?*’, so they called it “mental”. GR is *not* compatible with such GW parapsychology. We do *not* accept Biblical “miracles” either. **No way.**

To sum up, I conclude that GW150914¹ was most likely a plain [fraud](#): see Sherlock Holmes’ principle above. There is no *bare* spacetime (**NB1**) nor *bare* gravitational energy (**NB2**) in General Relativity. If the proponents of GW astronomy¹ wish to use [gravitons](#), their first off task is to prove beyond *any* doubt that some (still unknown) [renormalizable](#) (Sic!) [graviton](#) with upper mass limit at 2.16×10^{-58} kg and Compton wavelength “[roughly 1 light-year](#)” — not over 10^{90} km⁴ — does exist. And if they wish to talk about black holes, they also have to reformulate the so-called singularity theorems¹⁷ to include some “dark” [scalar field](#) that is [perfectly smooth](#) and violates the strong energy condition ([SEC](#)). [First things first](#). Without such *rigorous* validation, their announcement of “the first direct detection of gravitational waves and the first observation of a [binary black hole merger](#)”¹ is sheer jabberwocky.

But if [LISA Pathfinder](#) detects GW signal by [September 2016](#), it will require an explanation. It will be an incredibly interesting observation, resembling Fred Hoyle’s discovery of a [resonance in the carbon-12 nucleus](#) — we cannot use the so-called anthropic principle, for the same reason we reject GW parapsychology. They do not make sense, to say the least. Therefore, we will most likely need new physics⁹, which I will outline in Part 2 below.

2. How to detect and utilize physicalized gravitational energy?

Suppose, for the sake of the argument, that the signal detected last year¹ had gravitational origin. To explain how this event might have happened, I will use an old joke.

Three men in a mental clinic, Tom, Dick, and Harry, have to pass a test before they check out. The test is very simple: how much is $2 + 2$. The doctor asks Tom, and he replies: '11'. 'Are you sure?', asks the doc. 'Of course', says Tom, ' $2 + 2$ makes 11. What else?' 'Well, you'll have to stay here for another month or two, but you'll be fine'. Same question to Dick. He immediately replies: 'Tuesday'. 'Are you sure?' 'But of course', says Dick, ' $2 + 2$ makes Tuesday. What else?' 'Well, you will have to stay here for another month or two', says the doc. Finally comes Harry. Same question, and he immediately strikes back with 4. 'Congratulations', says the doc, 'you passed the test and may check out tomorrow. But how did you actually calculate it?' 'Easy', Harry replies, 'I divided Tuesday by 11 and got 4. What else?'

The answer is obviously correct, but Harry's calculation is like the so-called "graviton"² that cannot, not even in principle, solve the cosmological constant problem: "the worst theoretical prediction in the history of physics!"¹³. This is 'the proof of the pudding' of the mythical "graviton", if any. The proponents of GW parapsychology (see **NB2 above**) never acknowledged this fact about their 'pudding', although they know perfectly well that any hypothetical "graviton"² *must* explain the contribution of the [quantum vacuum to gravity](#). This is *conditio sine qua non* for the alleged "fundamental cosmological [scalar fields](#)" and [Higgs boson](#) as well: Why is the universe larger than a [football](#)?

Now, can we explain the origin⁹ of the 'correct answer' without dividing Tuesday by 11? Perhaps we can, but we won't be able to trace back any local astrophysical source: metaphorically speaking, the *origin* of GWs could be a global holistic "school of fish"¹⁴ created by non-linear interactions between every local fish and the entire 'school of fish'.

What if the *correction* to the mass, energy-momentum, and angular momentum of every 'fish' ([Fig. 1](#)) is delivered by the *entire* 'school of fish' in terms of gravitational radiation? Such corrections and contributions to the transient state of every quasi-local¹⁵ fish¹⁴, due to non-linear interactions between every fish and the *holistic* 'school of fish' it is "part" of (similar to [particle's self-energy](#)), could be miniscule¹⁰ ([Fig. 1](#)). There will be no need for some "powerful explosion"¹² somewhere in the cosmos. No need for dedicated "gravitons" to carry such corrections either, as non-linear GWs "transport" their own source⁵ spread over the entire 'school of fish'. In this sense, the gravitational energy is non-localizable¹⁵.

Perhaps we encounter non-localizable¹⁵ gravitational energy density of the holistic 'school of fish' (placed in what is currently the left-hand side of Einstein's field equations), which becomes *physicalized* upon its point-wise (Sic!) localization⁹, by providing perpetual *corrections* to the mass, energy-momentum, and angular momentum of every *quasi-local* fish ([Fig. 1](#)) placed in what is currently the right-hand side of Einstein's field equations. Locally, the gravitational energy is *never* "conserved"⁹, as it comes from, and goes back to the non-localizable¹⁵ holistic 'school of fish'⁹: the entire spacetime *en bloc*. But again, this hypothesis will be put forward iff [LISA Pathfinder](#) detects genuine GW signal by [September 2016](#). Once we have such indisputable fact, I will be happy to launch my explanation^{9,16}, after which I will suggest possible ways to harness such *physicalized* spin-0 gravitational radiation by spacetime engineering. (Please read the comment [above](#).)

References and Notes[†]

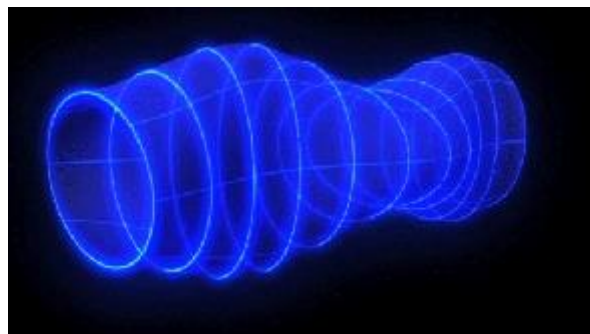
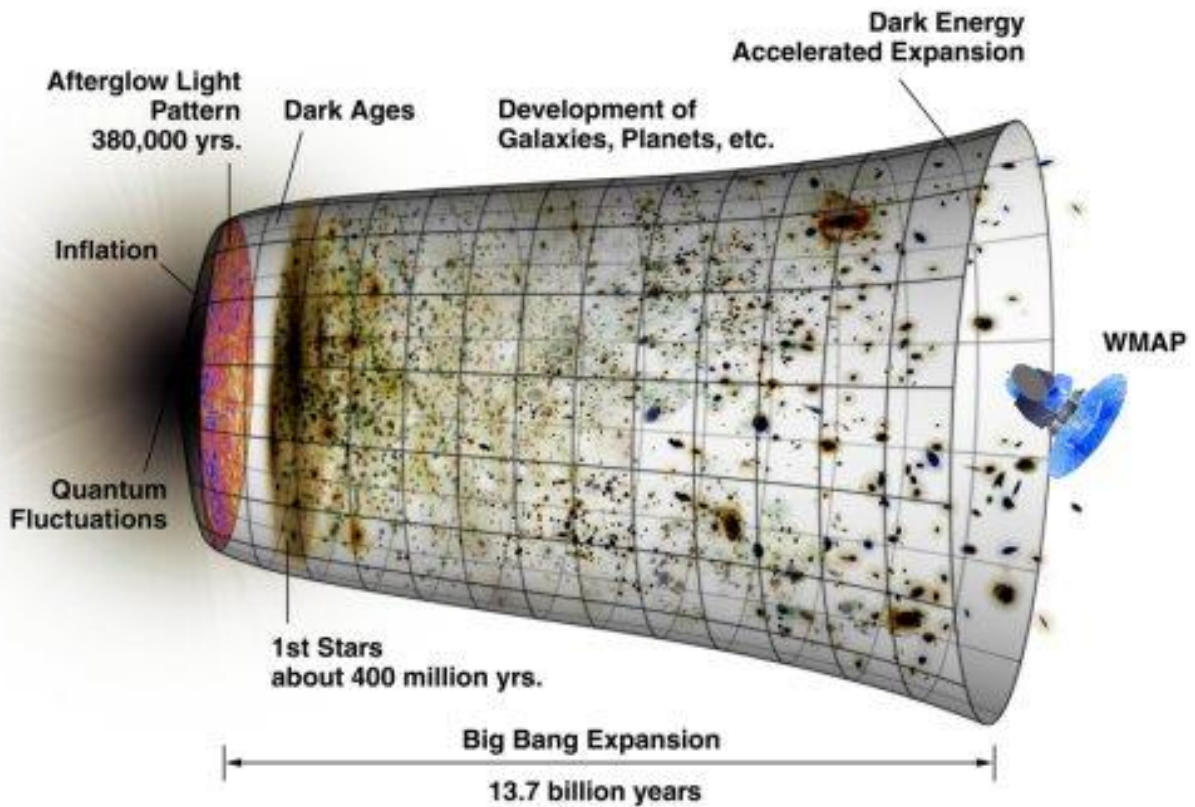
1. The LIGO Scientific Collaboration, the Virgo Collaboration, Observation of Gravitational Waves from a Binary Black Hole Merger, [arXiv:1602.03837v1 \[gr-qc\]](#). From the abstract: “On September 14, 2015 at 09:50:45 UTC the two detectors of the Laser Interferometer Gravitational-Wave Observatory simultaneously observed a transient gravitational-wave signal. (...) This is the first direct detection of gravitational waves and the first observation of a [binary black hole merger](#).”
2. E. Berti, Viewpoint: The First Sounds of Merging Black Holes, [arXiv:1602.04476v1 \[gr-qc\]](#).
3. Hermann Weyl, How Far Can One Get With a Linear Field Theory of Gravitation in Flat Space-Time? *American Journal of Mathematics*, Vol. 66, No. 4 (Oct., 1944), pp. 591-604. Available in PDF format at [this http URL](#). Hermann Weyl: “At its present stage our theory (L) accounts for the force which an electromagnetic field exerts upon matter, but the gravitational field remains a **powerless shadow**. From the standpoint of Einstein’s theory this is as it should be, because the gravitational force arises only when one continues the approximation [beyond the linear stage](#). We pointed out above that no remedy for this defect may be found in a gauge invariant gravitational energy-momentum tensor.”
4. [B. Schutz](#) (2 August 2002), Mathematical and Physical Perspectives on Gravitational Radiation, in *50 years of the Cauchy problem in General Relativity*. Cargèse Summer School on mathematical general relativity and global properties of solutions of Einstein’s equations, July 29 - August 10, 2002. Excerpts and download links at [this http URL](#).
5. Jose G. Pereira, Gravitational waves: a foundational review, [arXiv:1305.0777v3 \[gr-qc\]](#). Excerpts from p. 8 at [this http URL](#). Notice that, by using the ‘powerless shadow’³, the proponents of “[GW astronomy](#)” killed *from the outset* their chance of detecting GWs.
6. Matt Visser, Physical observability of horizons, [arXiv:1407.7295v3 \[gr-qc\]](#): “Mathematically, one needs to know the entire history of the universe, all the way into the infinite future, and all the way down to any spacelike singularity, to decide whether or not an event horizon exists right here and now.”
7. Pankaj S. Joshi, Daniele Malafarina, Recent developments in gravitational collapse and spacetime singularities, [arXiv:1201.3660v1 \[gr-qc\]](#): “We can now say with confidence that one cannot formulate censorship in a rather general way such as, ‘Collapse of any massive star makes a black hole only’, or, ‘Any physically realistic gravitational collapse must end in a black hole only’, as there are now many counter-examples to such statements. (...) Specifically, one must examine the collapse scenarios carefully and isolate the features that cause a [naked singularity](#) to arise.”
8. Vyacheslav Dokuchaev, Is there life inside black holes? [arXiv:1103.6140v4 \[gr-qc\]](#); notice the possibility for *advanced* Russian civilizations lurking “inside black holes”. See also: Yen Chin Ong, Black Hole: The Interior Spacetime, [arXiv:1602.04395v1 \[gr-qc\]](#): “A textbook on general relativity typically mentions that one can analytically continue the Schwarzschild manifold to the Kruskal-Szekeres manifold, which contains another asymptotically flat region inside the black hole, on the other side of the [Einstein-Rosen bridge](#). There are at least two issues with this picture.”

[†] All comments and emphases in the references and notes are mine - D.C., March 6, 2016.

9. D. Chakalov, The Spacetime. Online paper, February 28, 2016, 22 pages; see Sec. 4 and Sec. 7 in spacetime.pdf at [this http URL](#).
10. Robert M. Wald, *Space, Time, and Gravity*, University of Chicago Press, 1992, p. 120; excerpt available at [this http URL](#).
11. LIGO Scientific Collaboration and Virgo Collaboration, Searches for gravitational waves from known pulsars with S5 LIGO data, [arXiv:0909.3583v4 \[astro-ph.HE\]](#).
12. Adrian Cho, Gravitational waves, Einstein's ripples in spacetime, spotted for first time. *Science Magazine*, Feb. 11, 2016, 10:30 AM, posted at [this http URL](#).
13. M. P. Hobson, G. P. Efstathiou, A. N. Lasenby, *General Relativity: An Introduction for Physicists*, Cambridge University Press, 2006, see p. 187 at [this http URL](#).
14. D. Chakalov, Holomovement of Fish, 14-12-2015, <https://www.youtube.com/watch?v=0YDqxC9fzT4>
15. László B. Szabados, Quasi-Local Energy-Momentum and Angular Momentum in General Relativity (revised on 7 December 2012), *Living Rev. Relativity* 12 (2009), 4; excerpt from p. 31 at [this http URL](#).
16. Regarding the proposal for polarization of the so-called light vacuum⁹, notice that many outstanding puzzles in theoretical physics, such as [proton's mass](#), the [anthropic principle](#), and the *non-zero* value of the cosmological “[constant](#)”, share an astonishing **precision** (Sic!) by which “positive” and “negative” constituents of the non-localizable quantum-gravitational ‘school of fish’¹⁴ are being **cancelled** – not just once, but at every instant ‘here and now’⁹, leading to perfectly correlated and bootstrapped *evolving* Universe (resembling [human development](#)). In the case of proton's mass, the error margin for this cancellation is **one part in 10⁴⁵**, and for the [fine-tuned Universe](#) and the cosmological “[constant](#)” the *precision* of this cancellation is much higher (forget about “[multiverses](#)”). In my opinion, this is a complex phenomenon, which requires a brand new approach to quantum gravity⁹. To avoid ‘[dividing Tuesday by 11](#)’, I strictly follow Sherlock Holmes’ principle above, and will suggest *the* only possible (to the best of my knowledge⁹) solution. It is indirectly falsifiable, in the sense that any other solution must *necessarily* be wrong. The [full paper](#) is available upon request ([Matthew 7:6](#)).
17. Roger Penrose, Gravitational Collapse: The Role of General Relativity, *General Relativity and Gravitation*, 34(7), [1141-1165](#) (2002); see [p. 1146](#), “the hypersurface $r = 2m$ as the *absolute event horizon*”. Robert Geroch, What is a singularity in General Relativity? *Annals of Physics*, 48, [526-540](#) (1968), [p. 527](#): “We shall not be concerned here with so-called “coordinate singularities”. This term refers to a spacetime which has been expressed in an improper coordinate system. Thus, for example: 1. The Schwarzschild ([Hilbert-Droste-Weyl](#) - D.C.) solution has a coordinate singularity at $r = 2m$ because Schwarzschild originally chose coordinates for his solution which are not applicable on this surface. (...) The presence or absence of a coordinate singularity is not a property of the spacetime itself, but rather of the physicist who has chosen the coordinates by which the spacetime is described.”

And now the “GW astronomers” (see [above](#)) will have to reconcile this whole “singularity” mess^{6,7,8} with perpetual *energy non-conservation* (Paul Steinhardt) due to perpetual influx of positive energy densities (Sean Carroll) from the “dark” you-name-it¹³.

As a start, they have to define the *unique* reference frame at which all astronomical objects are “stationary” while *at the same time* the space *itself* is being “stretched out” (Mike Jones), to explain the Hubble flow and ‘time from the scale factor’, as read with a clock (see Fig. 13 in ‘The Spacetime’⁹). Tough challenge, because in this *unique* reference frame “one has canonical clocks (e.g. the temperature of the cosmic background radiation) that not only break Lorentz invariance defining a cosmic (global) time but break the Galilei invariance defining observers which are *at rest* (Sic! - D.C.) with respect to the cosmic background radiation” (Luca Lusanna *et al.*). Yet only in this *unique* reference frame the “GW astronomers” (see [above](#)) could define the perpetual *energy non-conservation* (Paul Steinhardt), in order to eventually explain the “*accelerated expansion*” (see the drawing below) of the universe *and* speculate about some “signal”¹ from *genuine*⁴ (not *fake*) GWs:



First things first. And once the “GW astronomers” do their homework by reformulating the current geodesic equation ($\nabla_\mu T^{\mu\nu} \neq 0$ at all geodesic points), they can move further by fixing the “localization” of gravitational energy¹⁵ and the singularity “theorems”¹⁷, or whatever is left from them, and finally announce their double discovery: “the first direct detection of gravitational waves and the first observation of a binary black hole merger.”¹



In summary, if the “GW astronomers” wish to use Einstein’s General Relativity, they must follow its rules:

1. Do not use the linearized approximation⁵: check out Hermann Weyl³.
2. Do not use “bare” distances (**NB1**) nor “bare” gravitational energy (**NB2**): there are no “spin-2 gravitons” in GR.
 - 2.1. If they wish to use “gravitons”, they must reformulate the geodesic equation:

Using local coordinates on M , we can write the **geodesic equation** (using the summation convention) as

$$\frac{d^2\gamma^\lambda}{dt^2} + \Gamma_{\mu\nu}^\lambda \frac{d\gamma^\mu}{dt} \frac{d\gamma^\nu}{dt} = 0 ,$$

where $\gamma^\mu = x^\mu \circ \gamma(t)$ are the coordinates of the curve $\gamma(t)$ and $\Gamma_{\mu\nu}^\lambda$ are the Christoffel symbols of the connection ∇ .

Notice the dubious non-tensorial second-kind Christoffel symbols in the excerpt above.

3. Do not ignore the unsolved problems of “GW astronomy”, which were acknowledged in August 2002⁴. It is a widely known fact that the gravitational energy *cannot* be conserved

([Carl Hofer](#)). As [Sean Carroll](#) acknowledged, “in general relativity spacetime can give energy to matter, or absorb it from matter, so that the total energy simply isn’t conserved.” Therefore, the assumption that 3 solar masses¹ were “carried away” by GWs, in order to fulfill the “conservation” of total energy (after [Hulse and Taylor](#)), is **false**.

Once the proponents of “GW astronomy”^{1,2} complete tasks 1-3 above, they will be ready to address the issue of “black holes”^{6,7,8} above.

But how they can connect the dots, I wonder.

Well, these 1000+ “[GW astronomers](#)” enjoy a very long list of supporters¹:

“The authors gratefully acknowledge the support of the United States National Science Foundation (NSF) for the construction and operation of the LIGO Laboratory and Advanced LIGO as well as the Science and Technology Facilities Council (STFC) of the United Kingdom, the Max-Planck Society (MPS), and the State of Niedersachsen, Germany, for support of the construction of Advanced LIGO and construction and operation of the GEO 600 detector. Additional support for Advanced LIGO was provided by the Australian Research Council. The authors gratefully acknowledge the Italian Istituto Nazionale di Fisica Nucleare (INFN), the French Centre National de la Recherche Scientifique (CNRS), and the Foundation for Fundamental Research on Matter supported by the Netherlands Organisation for Scientific Research, for the construction and operation of the Virgo detector, and for the creation and support of the EGO consortium. The authors also gratefully acknowledge research support from these agencies as well as by the Council of Scientific and Industrial Research of India, Department of Science and Technology, India, Science & Engineering Research Board (SERB), India, Ministry of Human Resource Development, India, the Spanish Ministerio de Economía y Competitividad, the Conselleria d’Economia i Competitivitat and Conselleria d’Educació, Cultura i Universitats of the Govern de les Illes Balears, the National Science Centre of Poland, the European Commission (Sic! - D.C.), the Royal Society, the Scottish Funding Council, the Scottish Universities Physics Alliance, the Hungarian Scientific Research Fund (OTKA), the Lyon Institute of Origins (LIO), the National Research Foundation of Korea, Industry Canada and the Province of Ontario through the Ministry of Economic Development and Innovation, the Natural Sciences and Engineering Research Council of Canada, Canadian Institute for Advanced Research, the Brazilian Ministry of Science, Technology, and Innovation, Russian Foundation for Basic Research, the Leverhulme Trust, the Research Corporation, Ministry of Science and Technology (MOST), Taiwan, and the Kavli Foundation. The authors gratefully acknowledge the support of the NSF, STFC, MPS, INFN, CNRS and the State of Niedersachsen, Germany, for provision of computational resources.”

Which means that these “GW astronomers” (see [above](#)) don’t have to do *anything*. They already managed to fool their supporters (including the [European Commission](#)), and even a highly prestigious [scientific journal](#). They got the money they need – taxpayers’ money – and now they can play [Sergeant Schultz](#): “I hear nothing, I see nothing, I know nothing!”

What will *you* do, my dear reader? Keep silent? Or openly praise [Emperor’s new clothes](#)?

D.C., March 6, 2016
