

# Unscientific behavior of the YARK theory of gravitation

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## Abstract

We ultimately show the unscientific behavior of the so-called YARK theory of gravitation (which applications have been published in both of non-mainstream and mainstream journals) by using Einstein's equivalence principle which has today a strong, unchallengeable empiric evidence.

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A completely non-metric gravitational theory, today self-called the YARK theory of gravitation from the initials of the proper surnames of its authors, has been originally proposed by the Turkish engineer T. Yarman in Foundation of Physics [1], which published a lot of wrong and non-standard results before G. 't Hooft's management [2]. After that, some papers on the YARK theory of gravitation have been published by T. Yarman and collaborators (the Turkish musicologist O. Yarman, the Belarussian experimental physicist A. L. Kholmet-skii and the Turkish physicist M. Arik. We refer to them as the YARK club hereafter) in non-mainstream, obscure journals and in proceedings of minor conferences [3 - 6]. Recently, other papers on the YARK theory of gravitation have been published by the YARK club in mainstream, serious journals [7 - 14], despite such journals are not particularly focused on gravitational theory. In all the works on the YARK theory of gravitation the YARK club also claimed that such a theory should replace Einstein's general theory of gravity (GTR) and that the GTR has various problems [1], [3 -14]. In addition, the YARK theory

of gravitation should be in agreement with various experiments on earth and astrophysical observations [1], [3 -14]. A issue of note is that the first paper submitted by T. Yarman to a mainstream, serious journal on the YARK theory of gravitation was rejected, as it has been stressed in [15]. It is very surprising and astonishing that papers on the YARK theory of gravitation, which is a completely non-metric theory of gravity as stressed various times by the YARK club [1], [3 -14], can be published in serious journals, because it is emphasized in university courses and standard textbooks of gravitation that completely non-metric gravitational theories macroscopically violate Einstein's equivalence principle (EEP), which has today a strong, unchallengeable empiric evidence, see C. Will [16]. We recall that the weak equivalence principle (WEP) states that the mass of the body is proportional to its weight [16], or, alternatively, that the trajectory of a freely falling test mass (i.e. a mass which is not acted upon by such forces as electromagnetism and too small to be affected by tidal gravitational forces) is independent of the mass internal structure and composition [16]. The WEP also states the *Universality of Free Fall*, which means that all the bodies fall with the same acceleration [16]. The EEP is a more powerful concept stating that [16]:

- a) WEP is valid;
- b) the outcome of any local non-gravitational experiment is independent of the velocity of the freely-falling reference frame in which such an experiment is performed (local Lorentz invariance, LLI);
- c) the outcome of any local non-gravitational experiment is independent of where and when in the universe such an experiment is performed (local position invariance, LPI).

C. Will [16] also stresses that if EEP is valid, then gravitation must be a "curved space-time" phenomenon. This means that the effects of gravitation are completely equivalent to the effects of living in a curved space-time [16]. In other words, gravity is not a force. Instead, it is inertia in a curved space-time manifold [17]. Thus, one sees that, if EEP is valid, then in local freely falling frames, one needs the laws governing experiments to be independent of the velocity of the frame (LLI), with constant values for the various atomic constants (in order to guarantee LPI) [16]. The only laws of Nature that fulfill this are the ones being compatible with the special theory of relativity, such as Maxwell's equations of electromagnetism, and the standard model of particles [16]. In addition, in a local freely falling frame, test masses appear to be not accelerated, and then moving on straight lines [16]. Such *locally straight* lines obviously correspond to *geodesics* in a curved space-time [16]. The strong, unchallengeable consequence of this argument is that the only viable theories of gravity are the metric theories of gravity, or possibly theories that are metric apart from very weak or short-range non-metric couplings [16, 17]. We stress that there is a rigorous mathematical demonstration of our last statement. Let us assume:

1. The existence of a continuous space-time manifold.
2. The validity of EEP.

Then, following [18 - 20], one supposes that no particles are accelerating in the neighborhood of a point-event with respect to a freely falling coordinate system ( $X^\mu$ ). Setting  $T = X^0$  we can write [18 - 20]

$$\frac{d^2 X^\mu}{dT^2} = 0, \quad (1)$$

which is locally applicable in free fall. Now, the chain rule gives [18 - 20]

$$\frac{dX^\mu}{dT} = \frac{dx^\nu}{dT} \frac{\partial X^\mu}{\partial x^\nu}. \quad (2)$$

If we differentiate eq. (2) with respect to  $T$  we get [18 - 20]

$$\frac{d^2 X^\mu}{dT^2} = \frac{d^2 x^\nu}{dT^2} \frac{\partial X^\mu}{\partial x^\nu} + \frac{dx^\nu}{dT} \frac{dx^\alpha}{dT} \frac{\partial^2 X^\mu}{\partial x^\nu \partial x^\alpha}. \quad (3)$$

Let us combine eqs. (1) and (3). Then we obtain [18 - 20]

$$\frac{d^2 x^\nu}{dT^2} \frac{\partial X^\mu}{\partial x^\nu} = - \frac{dx^\nu}{dT} \frac{dx^\alpha}{dT} \frac{\partial^2 X^\mu}{\partial x^\nu \partial x^\alpha}. \quad (4)$$

If one multiplies both sides of eq. (4) by  $\frac{\partial x^\lambda}{\partial X^\mu}$  one obtains [18 - 20]

$$\frac{d^2 x^\lambda}{dT^2} = - \frac{dx^\nu}{dT} \frac{dx^\alpha}{dT} \left[ \frac{\partial^2 X^\mu}{\partial x^\nu \partial x^\alpha} \frac{\partial x^\lambda}{\partial X^\mu} \right]. \quad (5)$$

By putting  $t = x^0$  and by using again the chain rule, one can eliminate  $T$  in favor of the coordinate time  $t$  obtaining [18 - 20]

$$\frac{d^2 x^\lambda}{dt^2} = - \frac{dx^\nu}{dt} \frac{dx^\alpha}{dt} \left[ \frac{\partial^2 X^\mu}{\partial x^\nu \partial x^\alpha} \frac{\partial x^\lambda}{\partial X^\mu} \right] + \frac{dx^\nu}{dt} \frac{dx^\alpha}{dt} \frac{dx^\lambda}{dt} \left[ \frac{\partial^2 X^\mu}{\partial x^\nu \partial x^\alpha} \frac{\partial x^0}{\partial X^\mu} \right]. \quad (6)$$

We recall that the bracketed terms involving the relationship between local coordinates  $X$  and general coordinates  $x$  are functions of the general coordinates [18 - 20]. In that way, eq. (6) gives immediately the geodesic equation of motion using the coordinate time  $t$  as parameter [18 - 20]

$$\frac{d^2 x^\lambda}{dt^2} = -\Gamma_{\nu\alpha}^\lambda \frac{dx^\nu}{dt} \frac{dx^\alpha}{dt} + \Gamma_{\nu\alpha}^0 \frac{dx^\nu}{dt} \frac{dx^\alpha}{dt} \frac{dx^\lambda}{dt}, \quad (7)$$

which can be re-written in terms of the scalar parameter  $s$  as the standard geodesic equation [18 - 20]

$$\frac{d^2 x^\lambda}{ds^2} = -\Gamma_{\nu\alpha}^\lambda \frac{dx^\nu}{ds} \frac{dx^\alpha}{ds}. \quad (8)$$

Thus, we have shown that the two assumptions of the existence of a space-time manifold and of the validity of EEP **rigorously imply that the gravitational motion must be geodesics**. In other words, the correct gravitational theory **must be a metric theory** (or a possibly theory that is metric apart from very

weak or short-range non-metric couplings, but this is NOT the case of YARK theory). We stress that the YARK club did not understand this key point in [10]. In fact, in [10] they verbatim claim that “said derivation (i.e. the above one) is exclusively restricted to the domain of a purely metric theory”. This is incorrect. We indeed did NOT assume that the gravitational theory must be metric. We assumed ONLY the existence of a continuous space-time manifold and the validity of EEP. Through our rigorous mathematical computation we have shown that these two assumptions imply that the gravitational theory must be purely metric. In other words, this was a conclusion and a result. It was NOT an assumption, contrary to the claims of the YARK club in [10]. In addition, in [10] the YARK club generated further confusion by verbatim adding that “in YARK theory the derivatives  $\frac{\partial X^\mu}{\partial x^\nu}$  already do not depend explicitly on spatial coordinates, but only on the static gravitational binding energy”. This is another basic mistake which is connected with the issue that the YARK club claims that YARK theory permits to localize the gravitational energy [1], [3 -14]. In the opinion of the YARK club the gravitational energy should remain a non-vanishing quantity in all plausible frames of reference [1], [3 -14]. This should permit to write down, explicitly, a stress-energy tensor for the gravitational field [1], [3 - 14]. Clearly, T. Yarman and collaborators do not understand the real meaning of EEP. In fact, another consequence of EEP is that one can always find in any given locality a reference’s frame (the local Lorentz reference’s frame) in which ALL local gravitational fields are null. No local gravitational fields means no local gravitational energy-momentum and, in turn, no stress-energy tensor for the gravitational field [17]. In fact, the hypothetical presence of a gravitational energy will immediately generate a breakdown of both LLI and LPI, and this is in contrast with tons of experimental data [16]. Also in this case, the YARK club claims that this statement is again strictly applicable only to metric theories, as is the case with the GTR [10]. This is again wrong. In fact, it is well known that this is a mere consequence of Einstein’s ‘happiest thought’ that a freely falling body has not weight [21]. Einstein’s ‘happiest thought’ is indeed at the foundation of both of WEP and EEP. In other words, EEP has two rigorous consequences:

- \* Gravitational motion must be geodesic.
- \*\* The gravitational energy cannot be localized.

Both of points \* and \*\* are consequences of EEP and, in turn, one does NOT need the assumption that a gravitational theory must be metric to verify points \* and \*\*. The metric behavior of a gravitational theory is **a consequence** of point \* instead of an a priori assumption.

Clearly, based on the extreme precision on which the EEP is today tested and verified [16], the demonstration that we have reviewed above - i.e. that geodesic motions arise from the EEP - **ultimately rules out YARK theory**. In fact, that theory is founded on the absence of curvature[1], [3 - 14] and so has a unscientific and non-viable behavior. Despite the claims of the YARK club that the YARK theory of gravitation should be in agreement with various experiments on earth and astrophysical observations [1], [3 - 14] (but we have

shown in [20] that the YARK club is basically wrong in its YARK interpretation of the Mössbauer rotor experiment), the YARK theory of gravitation is indeed in macroscopic contrast with the strongest observational constrain that a gravitational theory must satisfy, that is the EEP, which is founded on tons of experimental data [16].

Recently, the YARK club wrote a clumsy reply to the first draft of the current paper by adding confusion to confusion [22]. In particular they claim that [22]:

1. We do not understand the Mössbauer effect methodology.
2. In YARK theory, eq. (1) of this paper does not yield the geodesic equation (8) due to the fact that the first derivative  $\frac{dX^\mu}{dx^\nu}$  already determines the static binding energy, whose variation represents the origin of a real force in YARK theory. This should violate our statement that “these two assumptions (i.e., the existence of continuous space-time manifold and the validity of Einstein’s Equivalence Principle imply that the gravitational theory must be purely metric”.
3. The recent detection of the GW150914 and GW151226 signals by the LIGO Scientific Collaboration interpreted as the first observation of gravitational waves (GWs) resulting from the merger of two stellar-class black holes leaves YARK theory as the single alternative to GTR which provides its own explanation to these signals.
4. We insinuated that the YARK club uses the acronym YARK for the sake of self-advertisement.
5. The principal postulate of YARK theory concerns the variation of rest mass of any object in the presence of gravity.
6. As we claim that the correct gravitation theory must be a metric theory the YARK club asks: “But who said this? And what experimental proof does support this?”
7. The YARK club claims that the GTR has problems with the implementation of the energy conservation law.

Point 1 is false. In [20] we have shown that it is instead the YARK club which understands neither their proper Mössbauer effect methodology nor the clock synchronization in the relativity theory. In fact, we have stressed various times to the YARK club, not only in [20] but also in private communications, that in order to correctly perform the clock synchronization between the fixed frame and the rotating frame, one must consider the effect along the **whole** trajectory of the photons rather than along the sole trajectory of the photons between the detector of  $\gamma$ -quanta and the resonant absorber as it is done by the YARK club in [22]. This is quite elementary, despite the YARK club does not understand this issue in their papers [9, 22]. Of course, if the YARK club does not understand this elementary issue is not our guilty.

Point 2 is completely unscientific. We have shown that eq. (1) of this paper yields the geodesic equation (8) starting from two fundamental assumptions and through a rigorous mathematical treatment. Thus, the YARK club cannot dismiss our rigorous mathematical treatment through a simple, unclear statement. Instead, they have only few different options. i) They must show that our assumptions are wrong. ii) They must show that our rigorous mathematical treatment is wrong. iii) They must use additional assumptions which show through rigorous mathematical formalism that our rigorous mathematical treatment can be circumnavigated. Their claim that “the first derivative  $\frac{dX^\mu}{dx^\nu}$  already determines the static binding energy, whose variation represents the origin of a real force in YARK theory” is completely insufficient. In fact the YARK club also claims that in YARK theory the gravitational force continues to exist, but it is exactly counterbalanced by a “fictitious force” acting on the particle in the accelerated frame [22]. Clearly, even admitting that this static binding energy does not violate the LLI (which is already unscientific), the “fictitious force” will generate an energy which will contribute to the first derivative  $\frac{dX^\mu}{dx^\nu}$  counterbalancing the effect of the static binding energy.

Point 3 is pure nonsense. It is well known that the recent detections of the GW150914 and GW151226 signals by the LIGO Scientific Collaboration do NOT rule out extended theories of gravity if the deviation from the GTR is weak, see for example [23]. Only a perfect knowledge of the various GW polarizations will permit to discriminate among the GTR and alternative theories [24]. But at the present time, the sensitivity of the current ground based GW interferometers is not sufficiently high to discriminate among the various possible GW polarizations. A network including interferometers with different orientations is indeed required and we’re hoping that future advancements in ground-based projects and space-based projects will have a sufficiently high sensitivity. In any case, it is clear that this discussion on GWs is very far beyond the knowledge and understanding of the YARK club.

Point 4 is again false. We insinuated nothing. We merely wrote that the YARK club self-called the YARK theory of gravitation from the initials of their proper surnames. This is merely the truth. If this acting is badly seen within the scientific community is not our guilty. Clearly, the YARK club here has a guilty conscience.

Point 5 is again pure nonsense. In fact, the rest mass of any object does not change during inertial motion while it changes during gravitational motion in YARK theory. Clearly, this generates a strong breakdown of the WEP, contrary to the claims of the YARK club.

Point 6 shows that the YARK club does not understand the EEP. It is indeed the strong, irrefutable empiric evidence of the EEP that implies that the correct gravitation theory must be a metric theory. This is clarified for example by Will in [16] despite we find this issue very intuitive. For example, the supposed presence of a static binding energy will immediately generate a macroscopic breakdown of the LLI, which has never been seen in more than a century by analysing tons of data. Again, if the YARK club does not understand this elementary issue is not our guilty.

Point 7 is again pure nonsense. The implementation of the energy conservation law in the GTR is guaranteed by the null divergence of the stress-energy tensor in the right hand side of the Einstein equation. Thus, the energy conservation law works despite the gravitational energy cannot be localized. In fact, this is clarified by the Nobel Laureate G. 't Hooft in [25], verbatim: “The energy and momentum of the gravitational field is completely taken into account by the non-linear parts of the original equation. This can be understood and proven easily, as I explained in the main text.” Once again, if the YARK club does not understand this elementary issue is not our guilty.

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