The Legitimate and Illegitimate in Physics

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Abstract: Physics is supposed to represent and reflect the reality of the physical world. However, modern physics is full of elements that do not represent or reflect any aspect of the reality of the physical world (or at least this is what they look like). Moreover, it contains theories and models whose representation of the physical reality is questionable. Despite the fact that physics in its theoretical side inevitably contains elements and theories that do not reflect directly the physical reality, there must be some criteria that determine what is allowed (or legitimate from this perspective) and what is not allowed (or illegitimate) of these elements and theories; otherwise physics can lose its status as a subject that acquires its legitimacy as a scientific discipline from representing and reflecting the physical world. In more simple words, we need some criteria that determine what is physical (and hence legitimate) of these elements and theories and what is non-physical (and hence illegitimate, i.e. delusional or metaphysical). The purpose of the present paper is to identify these criteria, but we should admit that identifying these criteria is not an easy or straightforward task. Moreover, the application of these criteria is another difficult task even if we supposedly succeed in identifying these criteria conceptually and theoretically. Therefore, we consider the present paper as a first attempt in identifying these criteria hoping that other researchers in this field contribute to this investigation to improve our suggestions. To be more complete and specific, the present paper will also suggest an initial sample of illegitimate elements and theories as an application of the suggested criteria (considering our previous admission about the additional difficulty of this task).

Keywords: Modern physics, theoretical physics, physical reality, metaphysics, delusions in physics.

Contents

1 Introduction

Physics, by nature and definition, is supposed to be the best reflection and representation of the reality of the physical world, and hence it ideally should be free of any contamination with delusional or metaphysical elements. Moreover, its theories and models must be all about the physical reality rather than about unfounded hypothetical objects and entities. However, a quick inspection of modern physics (and theoretical physics in particular) should reveal that modern physics in many aspects is far from this supposed ideal situation. For example, we meet in modern physics delusional concepts like dark energy, nonsensical models like the expansion of our Universe, entirely or largely hypothetical theories such as string theory or the theories about wormholes, and so on.

Although we did not reach this situation suddenly and recently, this trend of detachment of physics from its scientific status and attitude became increasingly obvious and dominant in recent times especially in certain subjects and disciplines such as cosmology, quantum gravity, particle physics, and the special and general theories of relativity. In fact, we can trace this trend back to the beginning of the twentieth century with the emergence and rise of modern physics (as represented largely by quantum physics and relativity theories) where excessive mathematization and theoretization took control of physics at the expense of its experimental feature and observational nature which largely characterized classical physics.

Despite our admission of the necessity of mathematics and theory in physics (and actually in science in general) which (i.e. mathematics and theory) allow the introduction of elements (i.e. concepts, models, ... etc.) of hypothetical nature into the science of physics, we should emphasize the necessity of keeping these elements under inspection and control (quantitatively and qualitatively) to avoid exceeding the allowed mathematization and theoretization limit by going beyond the physical reality and entering the zone of delusion and hallucination. The balance between what is allowed/disallowed of these hypothetical elements (for physics to remain a scientific and realistic subject) is actually very delicate and hence keeping physics a purely and entirely scientific subject is not an easy or clearly-identified task.

In this paper we try to address this issue by proposing certain criteria that should be considered in assessing what is physical and allowed in physics and what is non-physical and disallowed in physics (see § 2). We also propose a list of physical elements[1] which

[1] "Physical element" (or "element") is a general term that we use in this article to refer to things like notions, ideas, theories, models, and so on.

represent (in our view) a typical sample of what is illegitimate and non-physical in modern physics (see § 3). We finally conclude this investigation with an outline of the main achievements and conclusions of the present paper (see § 4).

2 Legitimacy Criteria

As indicated already, it is difficult to distinguish between what is legitimate and what is illegitimate in physics (as a scientific discipline that supposedly reflects and represents the reality of the physical world) due to the involvement of theory and mathematics in physics.[2] In fact, physics (like any theoretical structure) is in essence a high-level language that conceptualizes our experiences of the outside world (see [1, 2]). This means that physics (and science and human knowledge in general) cannot be restricted to our direct sensual[3] observations and experiences, and this primarily allows physically-illegitimate elements (such as illusions and hallucinations) to sneak into the structure of physics (noting that there are other, and rather secondary, reasons for this sneaking as indicated already in footnote [2]). As a consequence, it is difficult to put rigorous criteria for what is legitimate and what is illegitimate in physics from a scientific viewpoint.

Nevertheless, it is quite possible (and rather easy) to set a collection of mostly approximate criteria that can be used in their totality to distinguish roughly between the legitimate and illegitimate in physics. These criteria can distinguish and identify certain elements definitely (i.e. those elements of obvious and explicit nature) and distinguish and identify other elements tentatively (i.e. those elements of rather fuzzy and vague nature). In the following subsections we will try to set such a collection of criteria. However, we would like to insist on the following points:

1. These criteria should serve in most cases as general and rather loose guidelines and should be applied with common sense and caution. As indicated already, we call for other investigators in this field to participate in this discussion and debate to improve these criteria (as well as potentially adding new criteria or replacing some of these criteria with better criteria).

[2] "The involvement of theory and mathematics in physics" is the primary and more natural cause for this difficulty. However, there may be other causes for this difficulty such as the confusion and mix of physics with other subjects such as philosophy. In fact, the lack of distinction (regardless of being difficult or not) may be caused even by the invasion of physics by foreign elements such as religious beliefs (like Evangelical creation theories) and ideological dogmas (like Marxist and fascist or right-wing ideologies; some examples of which can be found in the Soviet Union and the Nazi Germany) which can sneak into the structure of physics under various banners and justifications.

[3] Sensual here means related to our senses.

2. The legitimacy/illegitimacy of any element should increase with the increase of the number of the criteria that apply to it (in positive/negative sense), as well as by the degree of clarity of being an instance and application of the given criteria.
3. There are potential clash between some of these criteria with regard to certain elements. For instance, a hypothetical element may be related indirectly to an authentic element (i.e. through a hypothetical element; see § 2.4) but it serves reasonably well in a legitimate theory (see § 2.5). An overall view and assessment should determine the final judgment about these elements and if they are legitimate or illegitimate.
4. These criteria may be classified broadly as unconditional (i.e. the failure to meet the criterion cannot be justified or tolerated at all) and conditional (i.e. the failure to meet the criterion may be justified and tolerated under certain conditions).[4] The obvious examples of the unconditional criteria are sensibility and physical nature (see § 2.1 and § 2.2), while most of the rest are largely conditional (although they usually require strong reasons to justify their violation such as being legitimized by other criteria; see point 3).

2.1 Sensibility

Sensibility (or logicality)[5] is the first and most important of the proposed criteria. All types and forms of human knowledge require for their legitimacy as such (i.e. as being human knowledge) to be sensible and logical, and hence any physical element that fails to meet this criterion must be rejected unconditionally because it is not qualified to be classified as human knowledge (which any physical element is supposed to be) although it may be qualified to be classified as other types or forms of intellectual products such as art (and hence it can be completely legitimate from this perspective).

Although we may not expect to find some explicitly nonsensical and illogical elements in physics (because physicists are generally too clever to allow this to happen), it is quite possible to find disguised and implicit forms of illogicality and nonsense in physics. For example, some models or theories may be too complicated to understand and digest and hence their nonsensical and illogical nature is not easy to notice and discover. Similarly,

[4] We may also say: some of these criteria are necessary for legitimacy (noting that none of these criteria is sufficient).

[5] "Logicality" may be understood as being about consistency with formal logic, while "sensibility" may be more lax and general since it can extend to realistic or physical sensibility (i.e. not only to logical sensibility) although "sensibility" may also be restricted to realistic or physical sensibility (and hence logicality and sensibility become distinct and different). Anyway, these issues are of little significance as long as this criterion applies obviously to its instances in some of these senses.

some paradigms and theories may not be nonsensical and illogical as they are but they have nonsensical and illogical implications and consequences (considering for instance their position within the entire body of physics and as combined with the rest of physics or compared to other physical elements).

2.2 Physical Nature

Physical nature (or non-physical nature on the opposite side) is the second most important of our legitimization criteria of physical elements. This is because physics is about the natural world and its observable phenomena and hence the physical nature of legitimate elements (and the non-physical or metaphysical[6] nature of illegitimate elements) must be second to none of these criteria (except sensibility; see § 2.1). Accordingly, no element can be legitimate unless it is of physical nature (or in other words no element can be legitimate if it is of non-physical or metaphysical nature).

It should be obvious that certain elements (such as the concepts of deity or angels or divine world or the theory of creation) are non-physical by nature (i.e. they are metaphysical or unequivocally non-physical) because they implicitly or explicitly assume the existence of supernatural entities and hence their domain falls outside or extends beyond the natural world. Moreover, there are certain elements (such as the concept of philosopher's stone or the theory of phlogiston) which may sound like physical elements but they are not, and hence they should also be classified as non-physical. So, both these categories should be considered as non-physical despite the difference in the degree and clarity of their non-physicality.

We should also note in this context that there is a connection between the criterion of "physical nature" (which is the subject of the present subsection) and the criterion of "testability" (which is the subject of the next subsection; see § 2.3) since all the elements of non-physical nature are not testable (although not all elements of physical nature are testable).[7] Accordingly, we could have considered the criterion of "testability" as a type

[6] We may distinguish between "non-physical" and "metaphysical" by claiming that the former is more general than the latter (i.e. "metaphysical" is a specific type of "non-physical") where we depend in this claim on the suggestion (which is largely attributed to historical factors) of "metaphysical" as being more explicit in its non-physicality. However, this may not be the view or understanding of others (noting that this is a trivial matter and it is indicated for more clarity).

[7] Testable elements must belong to the physical world and hence (by "contraposition") elements of non-physical or metaphysical nature are not testable. However, some elements of physical nature (or tentative physical nature) may not be testable because (for instance) their tests require impractical capabilities (e.g. unrealistically huge amounts of energy). We should also note that there are some elements whose nature (as physical or non-physical) is not clear because (for instance) they are similar

or a class of the criterion of "physical nature".[8] However, for further clarity (as well as for conceptual distinction which is useful and important) we preferred to distinguish between the criterion of "physical nature" and the criterion of "testability" despite their intimate relationship.

2.3 Testability

Testability (or observability)[9] is the third most important of our legitimization criteria of physical elements. This is because physics is about the natural world and its observable phenomena and hence testability (or observability) must be on the top of our list of legitimacy criteria (lower in rank only to sensibility and physical nature; see § 2.1 and § 2.2). Accordingly, an element that is not testable or observable lacks legitimacy from the perspective of this criterion.[10]

In fact, there are many aspects related to this criterion which require further investigation (and hence we repeat our previous call to other investigators in this field for more investigations in this regard). For example, what is the rigorous and exact definition of testability and observability (which does not seem clear or consensual in the literature although the majority of authors seem to rely on the linguistic and intuitive meaning of these words). This may be exemplified and manifested by the indirect testability and observability which may allow loosening the sense and meaning of these terms.

However, in our view testability and observability are neither absolute nor unique and hence we should have various forms of testability/observability and with various degrees of strength. For example, we have direct and indirect testability/observability and we have various levels of weak and strong testability/observability. Anyway, a certain (minimum) level of testability/observability (e.g. indirectly and through certain conceptualizations) seems to be a necessity for any element to be legitimized as a physical element that serves

to elements of physical nature (and hence they may be seen as on the border or blurry area between physical and non-physical and may be labeled as "physically-tentative elements").

[8] In fact, the relationship between "physical nature" and "testability" could be more subtle and complicated due to the involvement of certain factors or/and interpretations in their definitions and distinction. For example, these criteria may be considered practically (although not conceptually) identical or equivalent by considering testability as a sign or workable criterion for "physical nature" (i.e. being physical). Anyway, we think what is given in this article about them should be sufficient for our purpose and objective.

[9] "Testability" may suggest relation to experiment, while "observability" may suggest relation to observation (although the two are generally similar).

[10] "From the perspective of this criterion" indicates that it may be legitimized by another criterion (see point 3 of § 2). This generally applies to the other upcoming criteria (and hence we will not repeat this in the future).

a legitimate role in the body of physics (and science in general); otherwise such element could be totally dismissed and classified as a non-physical or metaphysical element (or at least as an illegitimate element regardless of these labels) that does not belong to physics.

2.4 Connectivity to Authentic Physical Elements

Let us first distinguish between authentic physical elements whose physical reality is obvious or is well established,[11] and hypothetical physical elements whose physical reality is tentative due, for instance, to being required by a given theory rather than being directly observable.[12]

Now, it is obvious that the legitimacy of the authentic physical elements is intrinsic and cannot be disputed as long as their physical reality remains obvious or the evidence for their reality remains valid and well established.[13] With regard to the hypothetical physical elements, their legitimacy should be acquired from their connection and relationship to authentic physical elements. In other words, for any hypothetical physical element to be legitimate it should be ultimately connected to authentic physical element(s) so that it gets some legitimacy from the legitimacy of the authentic physical element(s). Now, the amount of legitimacy that the hypothetical physical element acquires from its connection and relationship to the authentic physical element(s) should be proportional to the strength of this connection and relationship.

As a simplistic example, let assume that A is an authentic physical element, and B is a hypothetical physical element that is directly connected to A, while C is a hypothetical physical element that is connected to A through B. Accordingly, B could get a strong legitimacy from A but C should get a weaker legitimacy (or no legitimacy at all). In other words, we may accept B as a legitimate physical element (because it has sufficient legitimacy due to its direct connection to A) but reject C and consider it as an illegitimate physical element (because it does not have a sufficient legitimacy due to its indirect connection to A). In short, as we go further along the legitimacy chain (by moving away

[11] Examples of authentic physical elements may include things like atom, electron, heat, light, matter, galaxy, planet, the laws of classical physics (e.g. in mechanics or thermodynamics or geometric optics), and so on.

[12] Examples of hypothetical physical elements may include things like quark, graviton, magnetic monopole, dark matter, dark energy, cosmic inflation, wormhole, white hole, Big-Bang theory, string theory, and so on.

[13] The talk here is about the legitimacy from the reality perspective although authentic elements may require extra or additional legitimacy from the perspective of their role and contribution within the body of the physical knowledge (especially in the long-term) which determine their merit and eligibility to exist and remain within this body (see for instance § 2.8).

from the authentic physical elements) we get less and less legitimacy (and at certain point we may not get legitimacy at all).

2.5 Serviceability[14]

Any physical element (whether authentic or hypothetical; see § 2.4) generally serves certain elements and is served by other elements within certain chains or networks of elements that form a given theoretical framework or structure. Now, the legitimacy of any element within the framework or structure should be partly acquired from its serving role and contribution within the framework and structure and within the body of physical knowledge in general (i.e. how much it is useful and productive within its framework and structure and within the wider knowledge of physics).

Accordingly, active physical elements that serve other elements (as well as their frameworks and structures) and hence contribute positively and significantly to the general physical knowledge should get more legitimacy than inert (or lazy) elements that are served by other elements without giving in return a valuable contribution that justifies their existence within the body of physics and the efforts and resources which are spent on serving and maintaining them.

For example, we meet in theoretical and particle physics certain hypothetical objects or concepts or particles (or ... etc.) which are the product of certain mathematization and theoretization exercises, but they have no positive role or valuable contribution in the body of physical knowledge. In contrast, their actual role and contribution is to consume considerable amounts of efforts and resources in contemplating and deliberating about them and hence they represent black holes that suck and destroy huge efforts and resources. Accordingly, they have very little or no legitimacy from this perspective because of their negligible or negative service and contribution to the physical knowledge and hence they are eligible to be dismissed and excluded from physics.

In short (and in more simple words), we may identify serviceability (or contribution) chains or networks where those elements which are on the perimeter or peripheral in these serviceability chains and networks get less legitimacy than other elements (and may not get legitimacy at all) because they are parasites and burden on the science of physics and human knowledge in general because they contribute little (or nothing) to the progress and advancement of physics while they consume considerable amounts of efforts and resources.

[14] We may also title this subsection as "Contribution". However, "serviceability" may be more inclusive.

2.6 Requirement by Experiment or Theory

Another important legitimacy criterion for physical elements is the requirement by experiment/observation or by theory/contemplation, i.e. whether the given physical element is required to justify and explain experimental data and observations or it is required to justify or fix or establish a certain theory (or contemplative argument or model or ... etc.). As physics is primarily a natural science (i.e. it is about the natural world and its observable entities and phenomena), the requirement by experiment should provide more and stronger legitimacy than the requirement by theory (which may not be sufficient to provide any legitimacy at all, such as the case when the element is required to fix a broken theory).

In fact, this requirement is related directly to the issue of which should lead the physical investigations and research (and science in general): experiment/observation or theory/contemplation. Classical physics was largely built and developed by the experimental/observational methodology. This is vividly demonstrated and exemplified by the work of Copernicus, Galileo, Tycho Brahe, and Kepler (among other scholars) which led eventually to the emergence of the Newtonian mechanics (as represented largely by the laws of motion and gravity) which marks the birth of modern science. Almost all the theoretical and mathematical investigations that followed this development and revolution in classical physics were based on this experimentally established theory and its branches and offshoots as well as its inherently-empirical methodology (and hence they are essentially and largely experiment-led efforts).

Another vivid example in this regard is Maxwell's equations which are largely based on four previously developed laws that emerged as a result of extensive experimental and observational work of a number of scientists (such as Faraday and Ampère). In fact, even the emergence and development of the mechanics of Lorentz transformations are largely based on these experimentally and observationally founded results due to the central role of Maxwell's equations in the emergence and development of Lorentz mechanics (see [3]). So, even Lorentz mechanics (which is widely regarded as one of the precursors and pillars of modern physics) is actually and ultimately a result of the experimental/observational methodology.

On the other hand, we see that large parts of modern physics (especially theoretical physics and cosmology in the last decades) are constructed and developed by the theoretical/speculative methodology. This is vividly demonstrated and exemplified by the speculative investigations in cosmology and gravitation (which are largely based on general relativity) as well as certain aspects of modern quantum physics and related subjects and theories (such as quantum gravity and string theory). A quick inspection of the preprint repositories and scholarly journals in these fields should reveal the massive extension and dominance of this theoretical/speculative methodology in modern physics.[15]

A simple example in this regard is the current trends and efforts in particle physics (see § 3.6) which is led largely by the theoretical and speculative approach where the physicists start from a certain theory or model that predicts the existence of certain particles, and this is followed by dedicating and spending huge amounts of efforts and resources (experimental as well as theoretical) to find these hypothetical particles (where in many cases these efforts and resources go in vain). In fact, current particle physics is one of the biggest black holes in modern physics since it consumes huge amounts of efforts and resources with little return (compared to the efforts and resources which are spent on these investigations). If these efforts and resources were spent wisely and appropriately in other areas of physics or/and by following a better methodology, modern physics (and science in general and possibly even particle physics) will be in a much better situation.

2.7 Probation

Any physical element (whether authentic or hypothetical; see § 2.4) should have a beneficial role and a positive impact on the progress of our scientific knowledge; moreover it should prove this (i.e. its role and impact) within a reasonable time frame that is appropriate and commensurate to its expected role and significance. In other words, no physical element should be allowed to take more time than what is necessary to prove its merit and value to the development and advancement of our physical knowledge. Accordingly, any element that fails to prove its merit and value within its allowed time frame (which we may call it "probationary period" as the title of the present subsection suggests) should be discarded and thrown away with no regret; otherwise it will become a draining sink for our efforts and resources.

To put it in a colloquial tone, we can tolerate a certain "hypothetical" theory (for instance) to remain in physics for a given period of time (which is sufficient to give it the chance to prove its merit and qualification as a real and useful physical theory) but we cannot tolerate this for more than this period, and hence it should be expelled from

[15] In fact, we can cite in this regard thousands of such studies and investigations but we avoid any citation in this regard to avoid personalizing these issues. Anyway, the examples that we will give in § 3 (as well as the last paragraph of this subsection) should give a taste of this kind of studies and investigations and illuminate their theoretical/speculative methodology and nature.

physics after that period of allowance; otherwise the theory will become a black hole that keeps sucking and consuming our efforts and resources with no benefit or progress.

We think there are many physical elements within modern physics which are given more time than sufficient and necessary to prove their legitimacy and merit (as real and useful physical elements) but without any real or significant progress, and hence their expulsion from physics in the near future should be considered seriously to avoid the continuation of the sucking black hole scenario.

In this regard we may consider string theory (see § 3.5) and dark matter and energy (see § 3.9 and § 3.10) as potential examples of such elements noting that no sufficient progress has been made toward their validation and verification as they remained for sufficiently long time within the hypothetical space of physics. As it is widely acknowledged, string theory failed to move from the theoretical or hypothetical space to the observational or experimental space to become a worthy and legitimate science (noting that some of its aspects are not testable or verifiable at all) despite the desperate efforts and considerable resources in the last decades to do so. Similarly, dark matter and dark energy (by their nature as "dark" objects) remained theoretical and hypothetical and hence they failed to prove their physical authenticity and legitimacy (despite the desperate efforts of some academic and research circles over the last decades to give them legitimate roles in modern physics and prove their authenticity and legitimacy).

2.8 Overall Impact

Regardless of its validity (or legitimacy or authenticity or ... etc) and invalidity (or illegitimacy or non-authenticity or ... etc), any physical element should have an overall impact (which usually becomes clear in the long term) on the development and progress of physical knowledge. In fact, any physical element (whether theory or model or concept or ... etc.) is like a member (or individual) in a community who contributes (usually in the long term) to the community positively or negatively regardless of his physical and moral characteristics at the personal level (such as being tall or strong or ugly or kind or polite or otherwise). This overall (and usually long-term) impact is what is most important to the community and what gives this member his position and determines his status within the community as a good (or useful) member that should remain within the community or as a bad (or useless or harmful) member that should be expelled from the community. For instance, a good-hearted member of a community who frequently makes silly mistakes (i.e. with good intention) is eligible to be expelled from the community despite his good heart because he brings shame and harm to the community and hence his good heart has no value to the community (or at least it is costly to the community).

The situation in physics is similar where certain elements may exist in physics for good reasons and they possibly have sufficient justifications to remain in physics based on their own characteristics and qualifications. However, they prove sooner or later (and usually later and in the long run) that they have negative impact (or they are too costly) to the progress and development of physics (and science and human knowledge in general). In short, although these elements are supposedly of good character (or at least they are acceptable or tolerable), their overall contributions to the entirety of the physical knowledge is bad (or their good contributions are not justified by their overall cost).

An example of this may be general relativity[16] (see § 3.2) which started as a theory that is partly based on the experimental/observational methodology and partly based on the theoretical/speculative methodology[17] and hence it may be regarded as an acceptable (or at least tolerable) theory despite its excessive mathematization and theoretization (see § 2.6). However, general relativity has proved over its rather long history that it has serious negative impact on the progress of physics by incubating and hatching delusional and nonsensical ideas and driving the physical research in questionable directions and orientations (as well as promoting bad scientific traditions and culture; see [4]). So, even if we assume that general relativity is largely and essentially correct, its overall impact may necessitate considering its position in physics in the future (e.g. by looking to alternatives; see § 2.9) and hence its supposed good characteristics and contributions may not justify its cost.

2.9 Existence of Alternative

Another criterion that should motivate or justify considering the legitimacy (or at least the optimality) of certain physical elements is the existence (or potential existence) of a better alternative (or even an alternative regardless of being better). The best example in this regard may be the Geocentric model of the solar system versus the Heliocentric model.

[16] In fact, even special relativity may be an example of this but special relativity suffers from a deeper defect (i.e. logical inconsistency; see § 3.1).

[17] The experimental/observational methodology may be demonstrated by the convergence to the Newtonian gravity or by the perihelion precession of Mercury (which are intentionally and premeditatedly considered by and incorporated within the theory), while the theoretical/speculative methodology may be demonstrated by the excessive use of complex mathematical machinery (mainly differential geometry and tensor calculus) and very abstract arguments and subtle ideas (such as the equivalence principle and general covariance at least in some of their variations and interpretations).

Although the Geocentric model was generally functioning and it was able to make definite and correct predictions, it was not an ideal model from certain aspects and perspectives (such as being too complicated and counter intuitive and hence it can hinder the progress of physical knowledge). This justified the expulsion of the Geocentric model and the adoption of the Heliocentric model (where this event may be considered as one of the main milestones in the development of modern science).

It is important to note the following remarks about this criterion:

1. This criterion may not illegitimize the inferior alternative entirely and hence it may not lead to a mandatory exclusion of the inferior alternative. Nevertheless, it is a criterion (or an optional criterion) for excluding certain alternatives (or making them inferior without total exclusion), and this should justify our inclusion of this criterion in this list.
2. The existence of more than one valid theory (or model or paradigm or ... etc.) for the description, theoretization and conceptualization of a single physical phenomenon or situation (which should justify, for instance, the replacement of a valid theory by an alternative valid theory, or the search for an alternative to a valid theory) is based on our belief in what we call the principle of non-uniqueness of science. For further details, we refer the readers to [2].
3. Sometimes considering alternatives is justified even when the inferiority and superiority of the alternatives are not established or obvious. This is to inspect the overall impact (see § 2.8) or even to make potential novel advancements (or only for the sake of breaking the habit). This should justify even looking and searching initially for alternatives (i.e. without complaint from an existing theory or without the actual existence of an alternative), and should be seen as a motive and drive for modernizing and improving our scientific knowledge (and human knowledge in general).

3 Sample of Illegitimate Elements

In this section we investigate briefly specific elements in modern physics from the perspective of their legitimacy where we largely use the criteria that we discussed in the previous section (see § 2). In fact, we believe that modern physics is infested with illegitimate (or potentially illegitimate) elements (noting that most of which are introduced in the last few decades). So, the following list (which is presented in the following subsections) is just a sample of what we believe to be illegitimate physical elements (or at least potentially illegitimate physical elements and hence their legitimacy requires inspection and investigation).[18] As we will see, the items of this list (i.e. the candidates for illegitimacy) vary in many aspects and perspectives (such as being theories and concepts as well as branches of physics that contain illegitimate elements, or being obvious and less obvious candidates, or being instances of various legitimacy criteria, and so on) and hence it can be considered (to some extent) a representative sample despite the limits on its size and details.

3.1 Special Relativity

We should first distinguish between the mechanics of Lorentz transformations as a scientific theory (or *formalism*) that has some supporting evidence, and the theory of special relativity which (in our view) is an epistemological *interpretation* (of the *formalism*) that has logical inconsistencies and hence it is illegitimate theory. We refer the readers for more details about this issue to [3, 5].

Now, special relativity in our view is an obvious candidate for illegitimacy from the perspective of the sensibility criterion (see § 2.1) due to its rather obvious logical inconsistencies (or at least the logical inconsistencies of some of its implications and consequences) as demonstrated by (at least some of) its "paradoxes" (see for instance [3, 6]). So, we can say categorically that special relativity as an interpretation of the mechanics of Lorentz transformations is fundamentally flawed and illogical.

We think this should be more than enough to exclude special relativity from physics (as an epistemological, as well as an allegedly-scientific, theory) although other legitimacy criteria (such as overall impact and existence of alternative; see § 2.8 and § 2.9)[19] may also be considered as additional reasons for this exclusion.

3.2 General Relativity

General relativity (or at least some of its aspects and perspectives) should be a candidate for illegitimacy due to a number of reasons and violations of legitimacy criteria. Examples

[18] It is important to note that the following list contains certain branches of physics (i.e. quantum theory and particle physics) which contain illegitimate elements, so their illegitimacy is about certain elements and aspects and not about these branches as a whole.

[19] Special relativity has a bad record from the perspective of overall impact since it introduced, justified and even encouraged non-logical thinking and hallucination in physics. Moreover, there are alternative interpretations to the mechanics of Lorentz transformations which are generally better than special relativity. In fact, there may also be alternatives to the mechanics of Lorentz transformations itself (i.e. not only to its special relativistic interpretation).

of the violated criteria (demonstrated by a small sample of illegitimate aspects in the theory of general relativity) include:[20]

1. Sensibility (see § 2.1): the theory contains a number of nonsensical aspects and implications such as:

   • Warping of spacetime around massive objects (noting that spacetime is a purely abstract entity which should not be influenced by physical objects and forces).

   • Prediction of singularities which are entirely hypothetical/mathematical entities that cannot be physical.

   • Prediction of wormholes (see § 3.7).

   • Prediction of white holes (see § 3.8).

   • Prediction of time travel.

   If these examples (and their alike) cannot be classified as nonsensical in the logical sense (i.e. being irrational), they can at least be classified as nonsensical in the physical and realistic sense (i.e. being highly hypothetical, artificial and counter intuitive) and hence they can be examples for violation of sensibility in this sense as well as violation of other criteria (such as physical nature; see § 2.2) which will be discussed next.

2. Almost all the remaining criteria which include (see the subsections of § 2):

   • Physical nature (as may be demonstrated by some of the examples in the previous point or by dark matter and dark energy).

   • Testability (as may also be demonstrated by some of the examples in the previous point).

   • Connectivity to authentic physical elements (noting that some elements and aspects of general relativity have very weak connection to authentic physical elements and aspects due to excessive mathematization and theoretization).

   • Serviceability (noting that some elements in the theory have very poor contribution to the actual and realistic physical knowledge and hence they can be classified as parasites and burden on the science of physics).

   • Requirement by experiment or theory (noting that general relativity is partly based on and constructed by the theoretical/speculative methodology).

   • Overall impact (noting that the long-term impact of general relativity is largely negative).

   • Existence of alternative (noting that there are alternatives to general relativity, or at least such alternatives can be developed, but they are resisted and rejected by the

[20] The illegitimate aspects in the theory of general relativity are discussed in more details in our book [4] which we refer the interested reader to.

establishment). In this regard, general relativity is like special relativity which is the favorite of the establishment despite its obvious defects and despite of the existence of better alternatives (see § 3.1).

In short, general relativity is a major source and fertile ground for growing nonsensical fantasies and illusions and breeding bizarre ideas such as warping of spacetime, wormholes, white holes, time travel and dark energy. The methodology of general relativity has also contributed to the incubation of more questionable ideas and theories (such as the string theory). In fact, general relativity should be given the main credit for transforming physics from its rational classical methodology to its irrational modern methodology. This should point out to fundamental defects in this theory that lead to such disastrous consequences (or at least there should be something defective in its methodology, philosophy and epistemology), and hence its overall impact over its rather long history was largely negative which means that it should be considered as a good candidate for illegitimacy from various aspects and perspectives and hence physics should look for better alternatives to this theory.

3.3 Big-Bang Theory

The Big-Bang theory in its entirety is a strong candidate for illegitimacy according to our legitimacy criteria. Some of the considerations and factors that illegitimize the Big-Bang theory are:

1. Non-sensibility of the expansion of Universe (see § 2.1): expansion of something requires a space in which the expansion takes place. For example, when we pump air into a balloon it expands into the space of the room which we are located in. Now, according to the Big-Bang theory, the space of the Universe itself expands, which is nonsensical because there is no space above the space of our Universe that allows this expansion to take place (or even rationalize it and make it reasonable and imaginable). In other words, there is no higher-rank space that engulfs the space of our Universe to make such an expansion sensible and logical. Any alleged existence of a higher-rank space is either nonsensical or metaphysical (see § 2.1 and § 2.2).
2. Non-sensibility of the beginning of time (see § 2.1): the idea of the beginning of time (which is supposedly marked by the Big-Bang event) is nonsensical because this requires a higher-rank time that marks the beginning of the time of our Universe (which, in its non-sensibility, is like the expansion of the space of our Universe according to the argument in the previous point).

3. Creation (see § 2.2 and § 2.3 as well as § 3.12): the Big-Bang theory (at least in some of its versions and variations) requires the concept of creation which is non-physical or metaphysical.
4. The two pillars of the Big-Bang theory are general relativity and the so-called Hubble's law (or discovery) about the expansion of Universe, and both these pillars are questionable. As for general relativity, its illegitimacy was discussed in § 3.2 and hence we do not repeat. With regard to Hubble's law, it is also questionable (in its expanding Universe model interpretation) because there are other interpretations of Hubble's law that do not require the expanding Universe model, and these interpretations are at least more sensible than the expanding Universe model interpretation (see the first two points). Accordingly, the Big-Bang theory itself becomes questionable as a legitimate physical theory due to the questionability of its two main pillars.
5. Overall impact: the Big-Bang theory (like the general relativity theory) proved (over its rather long history) to be a fertile ground for growing nonsensical fantasies and illusions and breeding bizarre ideas and hallucinations. Examples of these illusions and hallucinations include the cosmic inflation theory[21] and the illusory scenario of the birth of our Universe as exemplified by the following excerpt (which we quote with minor modifications):
   "At $t = 10^{-43}$ s, the universe was extremely dense, small and hot. The universe spanned a region of 10^{-33} cm. Matter and energy were indistinguishable. The temperature of the universe was 10^{32} K. In a tiny fraction of a second, the universe expanded rapidly and doubled in size many times ... etc.".
   This kind of science (or rather nonsense) should sound like fairy tales.

We should finally note that we could have made cosmology the subject of this subsection (and hence titled this subsection as "Cosmology" instead of "Big-Bang Theory"). However, we preferred "Big-Bang Theory" because of its dominance over modern cosmology (as well as being the main "offender" and source of illegitimacy in modern cosmology).

3.4 Quantum Theory

Although quantum mechanics (which represents the scientific part of quantum theory; i.e. the formalism of the theory) is a well established theory, quantum theory in general (i.e. including its epistemological and interpretative part) contains some illegitimate elements

[21] This theory may be illegitimized by the sensibility, physical nature and testability criteria (see § 2.1, § 2.2 and § 2.3) and possibly by other criteria.

(mainly in its interpretations). For example, the Many-Worlds interpretation is an obvious candidate for illegitimacy due to violation of a number of legitimacy criteria. These criteria include (for instance) physical nature and testability (see § 2.2 and § 2.3 as well as § 3.11).

In fact, there are many aspects in the quantum theory in its extended sense (which includes its various branches, interpretations, combinations with other theories, and so on) that require further inspection and close examination from the perspective of physical legitimacy (as determined largely by our criteria; see § 2).[22] In this regard we would like to draw the attention to the following issues (noting that there are other similar issues which deserve attention and inspection):

1. The nature of the reality of the quantum world noting that this reality seems to be different in certain aspects from the reality of the macroscopic world that we live in and which we developed our scientific (and general) knowledge from our experiences of this macroscopic world. This could mean that our concepts and models (and physical elements in general) which we use in the construction of the quantum theory are invalid (or at least rough and approximate) in depicting and representing the quantum world. In fact, this may explain the lack of acceptable interpretation of the quantum physics (as we cannot identify any reasonable interpretation among the existing interpretations of the quantum physics). For further details about these issues we refer the reader to our book [7].
2. Potential negative impact of the quantum theory on certain fields and branches of modern physics (and science in general) such as quantum gravity (although the blame in this example may belong to or shared by general relativity).
3. The potential negative contribution of quantum physics in the birth and development of the string theory (see § 3.5) although the blame may belong to or shared by general relativity (noting that string theory may be regarded as a "marriage" between quantum physics and general relativity).

3.5 String Theory

String theory (or rather theories) in our view is a good example of unworthy and illegitimate physical theory although it may be a legitimate and acceptable theory from another perspective (e.g. as a mathematical or philosophical theory). String theory fails a number

[22] We note that we do not adopt specific views in this paper about these aspects due to their complexity and the requirement of investigations that are beyond the scope and size of the present paper although we may deal with some of these issues in our future publications (noting as well that some of these aspects have been investigated in our book [7]).

of our legitimacy criteria. For example:

1. Physical nature and testability (see § 2.2 and § 2.3): these criteria should apply negatively to the string theory (or at least to some of its aspects) noting that the theory in general (or at least fundamental parts and aspects of the theory and certain versions of it in particular) is non-physical and non-testable.[23]
2. Requirement by experiment or theory (see § 2.6): string theory heavily relies on the theoretical/speculative methodology noting in this regard the negative impact of general relativity (and even quantum physics) on the string theory.[24]
3. Probation (see § 2.7): string theory may be a typical example and instance of the probation criterion noting that the theory has sucked and consumed (over about half a century) huge amounts of efforts and resources without making significant progress that matches the cost spent and justifies the continuation of this largely-futile enterprise. So, string theory is given sufficient time to prove its merit and legitimacy as a scientific theory but without success and hence it should go (i.e. it should be expelled from physics although it may be eligible to remain within the mathematical or philosophical domain for instance).
4. Overall impact (see § 2.8): string theory should also be a typical example and instance of the overall (and long-term) impact criterion noting that the theory has produced (over its rather long lifetime) a lot of delusions and hallucinations which do not belong to physics or science and hence it proved to be damaging to the overall progress and advancement of physics and science.

3.6 Particle Physics

Fundamental aspects and elements of particle physics (including its methodology) are subject to serious criticisms which are largely directed toward the Standard Model of particle physics and the theoretical/speculative nature of the subject (see the last paragraph of § 2.6). For example, despite the extensive investigations by particle colliders many theoretical predictions have not been confirmed experimentally or substantiated by definitive evidence for many predicted particles, and this resulted in questioning the validity of some theoretical aspects and models (including the Standard Model of particle physics

[23] Actually, even sensibility (see § 2.1) may apply negatively to the string theory noting that it may lead to certain nonsensical implications and conclusions. However, we do not go through these details in this paper due to limited scope and space.

[24] As indicated already, string theory may be regarded as a marriage between quantum physics and general relativity.

or at least some of its aspects). To some extent, particle physics in the last few decades became (like general relativity and string theory; see § 3.2 and § 3.5) a fertile ground for growing fantasies and illusions.

Some criticisms are also directed toward some practical aspects such as the high cost of particle physics research (which in part is caused by the dominance of the theoretical/speculative methodology which controls and steers even the experimental projects and investigations). This may be demonstrated and exemplified by the huge cost of constructing, maintaining and running the Large Hadron Collider (LHC) of Conseil Européen pour la Recherche Nucléaire (CERN).

So, certain aspects and elements of particle physics are obvious candidates for illegitimacy according to some of our legitimacy criteria (see § 2) such as requirement by experiment or theory and overall impact (and may be even physical nature, testability, and connectivity to authentic physical elements).[25] In fact, even the aforementioned practical aspects may be included within our legitimacy criteria. For instance, the high cost of particle physics research may be included in the overall impact criterion (see § 2.8) due to the bad effect of lavish spending on the overall progress of physics since particle physics became a black hole for consuming efforts and resources which are better spent on other aspects and branches of physics and science.

3.7 Wormhole

Wormhole is one of the fantasies and hallucinations of general relativity. The existence of "wormhole" is predicted through the existence of mathematical solutions to the field equations of general relativity and hence it is entirely hypothetical. Accordingly, it is a typical example of illegitimacy by the criterion of requirement by experiment or theory (see § 2.6). It may also be an example of illegitimacy by the criterion of sensibility (see § 2.1) due to the absurdity of the existence of holes in the abstract notion of spacetime.[26] Moreover, it can be an instance of the criteria of physical nature and testability (see § 2.2 and § 2.3) as well as other criteria (such as connectivity to authentic physical elements, serviceability, probation and overall impact). In short, "wormhole" is an entirely illegitimate element and

[25] For example, the research about quarks led to reasonable confirmation by "indirect observation". On the other hand, extensive and long-term research about graviton or magnetic mono-pole did not produce satisfactory results so far and hence they may be subject to some of the above criteria (and possibly even to probation).

[26] Wormholes can supposedly connect distant points in spacetime or act as bridges between different universes. The latter (in particular) should invoke the criteria of physical nature and testability (see § 2.2 and § 2.3) due to the metaphysical nature of multiversism (see § 3.11).

hence it should be excluded from physics (to preserve the valuable efforts and resources which are spent on such luxurious and useless investigations).

3.8 White Hole

White hole is another vivid example of the fantasies and hallucinations of general relativity, and hence what we said about wormhole (see § 3.7) applies almost entirely to white hole. In fact, the unfounded speculations about white holes extend beyond their existence and alleged attributes to reach other areas and forms of hallucination and fantasy such as their relation to black holes, wormholes and the Big-Bang.

In this context we should comment on the illegitimate elements related to the subject of black holes. Although "black holes" originates in classical physics (rather than general relativity as it is commonly and wrongly believed)[27] and seem to get good supporting evidence from astronomical observations in the last years, there are many illegitimate elements and aspects about many of their details which are investigated within the theoretical framework of general relativity. Accordingly, "black holes" is one of the fertile subjects for incubating and hatching illusions and fantasies due (largely) to the involvement of general relativity (see § 3.2). In fact, we have discussed some of these details in our book [4] and hence we do not repeat.

In short, various aspects and elements related to the subject of "black holes" in modern physics are strong candidates for illegitimacy (due to almost all of our legitimacy criteria; see § 2) even though the existence of "black holes" (with some reasonable characteristics and realistic attributes) seem to be supported by direct and indirect observational evidence.

3.9 Dark Matter

Although the existence of certain amounts of ordinary matter that cannot be observed directly (except possibly by its gravitational influence) cannot be ruled out entirely in many astronomical systems and within legitimate astrophysical models that are fundamentally based on direct and indirect observations, the concept of "dark matter" in its excessive

[27] Black holes (as very compact massive objects that trap even light although they are not labeled as black holes) have historical roots in the literature of classical physics where some classical physicists and scholars (including Laplace) have contemplated about the possibility of the existence of such astronomical objects prior to the emergence of general relativity, and hence black holes are neither an invention of general relativity nor an exclusive feature of this theory (and so their supposed discovery is not an evidence for general relativity since it can be explained within classical physics). For more details about these issues we refer the reader to our book [4].

use and within certain forms and conceptualizations in modern physics (mostly within the investigations of general relativistic gravitation and cosmology) should be rejected and illegitimized by some of our legitimacy criteria such as physical nature, testability, requirement by experiment or theory, and probation (see § 2).

To be more clear about this issue we may distinguish between two types of dark matter:

1. Ordinary matter that is "dark" because it cannot be observed directly such as dim stars and cold interstellar gas or dust.
2. Non-ordinary matter (i.e. a form of matter that we are not familiar with from our terrestrial and celestial observations) such as the alleged non-baryonic matter (at least in some of its forms such as WIMP's and axions) which is hypothesized in some astrophysical and cosmological models.

Primarily, we reject only the existence of the second type (mainly on the basis of being a non-physical entity). However, even the existence of the first type in any particular circumstances should be accepted only if it is based on a credible physical evidence that is independent of our theories and models (i.e. it is not used as an *ad hoc* fix for our failing theories and models). Accordingly, even the first type of dark matter should be regarded a non-physical entity if there is absolutely no evidence for its existence other than being a convenient fix for our theories. More discussion about this issue should be found in our book [4].

To sum up, non-ordinary dark matter should be considered an illegitimate element due mainly to being non-physical or metaphysical (as well as for other reasons and criteria). Similarly, the excessive and unfounded use of ordinary dark matter to fix our broken gravitational theories (whether classical or general relativistic) should also be illegitimized for reasons and criteria similar to those of non-ordinary dark matter.

3.10 Dark Energy

In our view, the reasons and foundations for rejecting dark energy are stronger than those of dark matter although they share in their rejection almost the same legitimacy criteria (which we already indicated in § 3.9 and hence we do not repeat). This may be justified by the following reasons (among other reasons):

1. Dark energy is entirely hypothetical while dark matter (at least in its ordinary form; see § 3.9) may have some physical foundations and justifications.
2. Dark energy is related to the cosmological constant which is arbitrarily and wishfully

introduced in the field equations of general relativity (and which is manipulated and exploited randomly later on). For example, the cosmological constant was introduced initially to create a *static* universe model, but it was reinvented subsequently to explain the alleged accelerated expansion of the Universe (and hence explain a *non-static* universe model). This should reveal its nature as an arbitrary element that can be manipulated and exploited wishfully to support something and its opposite (like a transformer toy or Lego).

3. Dark energy (according to its inventors and developers) has very strange physical properties and attributes such as having negative pressure (which seems non-physical, if not nonsensical, and counter-intuitive).
4. Dark energy supposedly makes most of the total energy of our Universe (estimated to be about 70% of the total energy) which adds more oddity to its hypothetical existence and mysterious nature.
5. Dark energy is supposedly related to the alleged accelerated expansion of the Universe which is a nonsensical idea (see § 3.3).

In short, dark energy is one of the big illusions and hallucinations of modern physics (noting that the main credit for this invention is general relativity and modern cosmology which is largely based on general relativity and the Big-Bang theory; see § 3.2 and § 3.3). Also see more discussion about dark energy in our book [4].

3.11 Multiversism

Multiversism cannot be a physical concept and hence it is illegitimate to exist in physics (although it may be legitimate to exist as a philosophical or theological or religious or mathematical concept for instance). This is because any observable "universe" must belong to our Universe and hence it is not "other universe", while any "other universe" must be unobservable and hence it is not physical. So, multiversism is an illegitimate element in physics due mainly to the criteria of physical nature and testability (see § 2.2 and § 2.3) noting that it can also be an instance of other criteria such as requirement by experiment or theory and overall impact (see § 2.6 and § 2.8).

We can identify a number of fields and disciplines in modern physics (and science in general) which embrace multiversism as a physical idea. For instance:

1. Quantum theory through the embracement of the Many-Worlds interpretation (as a supposedly-legitimate interpretation).
2. General relativity through the embracement of ideas (such as wormhole; see § 3.7) that

imply multiversism.
3. Cosmology through (for instance) the embracement of the idea of cosmic inflation which leads (in some of its variations and scenarios) to multiversism.
4. String theory which may be regarded as the natural home for multiversism.

3.12 Creation

Creation is another non-physical or metaphysical idea which is embraced by a number of branches and disciplines of modern physics (and science in general) as a legitimate physical idea. For instance, we can meet creation (in some shape and form) in:
1. Cosmology through (for instance) the Big-Bang theory.
2. Quantum theory in some of its branches and interpretations which allow (for instance) the creation of certain particles from vacuum fluctuations or "virtual particles" (although some physicists try to present and envisage this as a non-creationist process).
3. Certain physical disciplines and models which allow (for instance) the violation of energy conservation.

As a metaphysical idea, creation is an illegitimate element in physics due mainly to the criteria of physical nature and testability (see § 2.2 and § 2.3) noting that it can also be an instance of other criteria such as requirement by experiment or theory and overall impact (see § 2.6 and § 2.8). In fact, creation may even be subject to the criterion of sensibility (see § 2.1) in the sense of being physically-irrational and absurd idea (although it may be sensible and legitimate in philosophy or theology or religion for instance).

We should finally note that there are current trends supported by certain groups and lobbies that try to infiltrate modern science (including physics) through creationist ideas and theories (in the religious, and specifically biblical, sense of creation).[28] Although these attempts currently seem insignificant and marginal, they may gain momentum in the future and hence represent serious challenges to real science noting that these attempts can get considerable funding and propaganda in the future. In fact, there are a number of factors and causes that can make these trends gravely-serious threat to real science such as:
1. The rise of fascism (and especially religious fascism) in recent times. Although fascism is usually seen as a political phenomenon (or rather disease), it is actually and essentially a culture and a model for personal characteristics and identity, and hence no aspect of

[28] In fact, this seems to have started much earlier (e.g. with the proposal of the Big-Bang theory by a Catholic priest, i.e. Georges Lemaître, which was subsequently accepted and even embraced by the Catholic church and possibly other churches).

human life is safe from the pathological effects of fascism. Despite the fact that politics and social life are the primary natural homes and fields for the infestation of fascist ideas and practices, religion became another home and field for these ideas and practices. So, even science can become a home and field for fascism (noting that there are emerging signs for the start of this process).

2. When we see "great scientists" embracing nonsensical ideas and advocating blatant hallucinations (some of which are more nonsensical and illusory than religious creation, as seen earlier) we should not be surprised if scientists of this type and caliber embraced and advocated creationist ideas (of religious and biblical types) and incorporated them within modern science. Modern science seems to have lost its immunity against irrationality and superstition.
3. The interaction between science and other branches of human knowledge and intellectual activities (especially religion, theology and philosophy) is a natural and continuous epistemological process (as can be observed by reading the history of science and human knowledge in general). Hence, the influence of other branches of human knowledge on science (and even infiltration of science by these branches) cannot be ruled out at any stage of the evolution of science and human knowledge. Accordingly, even the dominance (for instance) of religious institutions (whether in their physical or moral manifestations) over science in some shape and form (as it happened in the middle ages, although it may not be in that fashion and extent) cannot be ruled out entirely.

4 Conclusions

We outline in the following points the main achievements and conclusions of the present paper:

1. We proposed in this article a number of criteria for the distinction between what is legitimate in physics (as a natural science) and what is illegitimate. These criteria are generally based on some fundamental considerations and factors, mainly: logicality and sensibility of all types of human knowledge and epistemological products and activities, and the status of physics as a scientific discipline whose subject is the natural world and its observable objects and phenomena.
2. We presented in this article a number of examples that represent (in our view) a good and representative sample of illegitimate elements in contemporary physics, and identified the criteria (which we proposed earlier) that apply to these examples as illegitimate

elements.

3. We identified (and warned against) actual and potential trends and schools of thought in modern physics (and contemporary science in general) that try (intentionally or unintentionally) to take physics and science to areas and zones beyond its natural domain and realm by introducing elements (i.e. ideas, models, theories, ... etc.) which are foreign to physics as a natural science.
4. We also expressed our concern that science may become a primary target for infiltration by certain (religious and non-religious) ideologies, and this could be facilitated by the infestation of modern science by illegitimate non-scientific elements which reduce the immunity of science against irrationality and superstition.
5. We invite other researchers in this filed to participate in this discussion and debate by proposing their own criteria of legitimacy and examples of illegitimacy, as well as by assessing our proposals about the criteria and examples which we presented in this article.

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