Contextual realism in physics

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Within the framework of a broadly wittgensteinian approach, we criticize metaphysical realism, structural realism and Platonism in philosophy of physics and propose to replace them with what we call "contextual scientific realism" (CSR). According to CSR, ontology is sensitive to context. Our view is illustrated with both ordinary and physical examples. In particular, we claim that the Higgs boson is a contextual object within the framework of the Standard Model and the practice of its application, and that, in a sense, the nature of the gravitational waves depends on the choice of a physical theory to describe them. A physical theory is interpreted as a Wittgensteinian rule (norm) for measuring physical reality within the language games if its applications. Contextual realism explains the success of our best scientific theories and (dis)solves the problem of pessimistic induction. It allows one to dissolve the so-called "problem of naturalness". In our view, it also corrects and deepens Porter Williams' "effective realism".

Keywords: metaphysical realism, structuralism, Platonism, effective realism, contextual realism, language game, rule-following, contextual entity

"Les normes, telles que je les concois – c'est là mon réalisme – n'ont d'autre vocation que d'appréhender les structures et réciproquement la structure est exactement ce qui est appréhendé par la norme là où celle-ci est appliqueé de la facon qu'il faut dans le context qu'il faut." (My translation: "The norms, as I understand them, – this is my realism – have no other vocation than to grasp structures. And *vice versa*: the structure is exactly what is grasped by the norm where it is applied in the right way and in the right context.")

Jocelyn Benoist, *L'adresse du réel*.

1. The Higgs boson as a contextual entity

On the one hand, the experimental discovery of the Higgs boson in 2012 confirmed the Standard Model (SM) of elementary particle physics while, on the other hand, the discovery had become possible only within its framework alone. The latter does not mean that the Higgs boson was constructed. It would be correct to say that it was identified in the context (and with the help) of the SM and the corresponding scientific practice of its application. In this sense, the Higgs boson is a *non-predetermined* (*contextual*) *entity*.

According to the realist point of view, the Higgs boson is real, and its reality does not depend on the way of its identification that reveals such or such aspect of the boson. The Higgs boson had existed before its discovery and even before the creation of the SM. Moreover, some philosophers and physicists claim that they had *known* about the existence of this particle before its existence was experimentally verified. According to the traditional approach to knowledge, knowledge is justified true belief. A non-empirical justification within the SM of the true claim about the existence of the Higgs boson might have been enough for knowledge.

At the same time, if the SM had not been developed and experimentally verified the Higgs boson would not have its identity; it would not be an *object*, a determinate item of objective reality – the "Higgs boson". It would continue to exist as an aspect of reality whose properties it does not make sense to ask about and where there is no sense in comparing it

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with other aspects of reality. In other words, the Higgs boson acquires a determinate (meaningful) being only within the correct application of the SM and the concept "Higgs boson".[2]

The position according to which ontology is sensitive to context is opposed to the point of view of metaphysical realism, according to which there exists external pre-determined reality consisting of autonomous objects, their properties and relations between them, and the point of view of structural realism, according to which there exist predetermined autonomous structures. That is, from the metaphysical point of view, objects, properties, relations and structures have intrinsic identity which does not depend on the context, the perspective, the language or the theory employed. As a consequence, it is assumed the existence of a privileged ideal language (description, representation), which can be put into correspondence with reality. Such a language would be a 'naturalized' one, deprived of a normative dimension. The metaphysical truth is the global correspondence with reality in the literal sense of its "mirroring". The metaphysical scientific realism assumes that the Higgs boson was literally "discovered" as a pre-determined object of the external world.

Metaphysical Platonism in mathematics and theoretical physics imitates metaphysical realism by introducing the view about the ideal world of (decontextualized) objects, which could be accessed only in the intuitive-contemplative way. The Platonist objects differ from the material objects of the "external world" only with their specific (ideal) nature.

On the contrary, within a contextual realism point of view, a real object is identified only within a (real) context in which it is rooted and which feeds it. The *meaning* of the Higgs boson *is* the correct *use* (in context) of the concept "Higgs boson", that is a Wittgensteinian language game. And this meaning is the fully-fledged meaning of the Higgs boson as a real thing itself. Truth is thus correspondence in context, that is, correspondence establishing, figuratively speaking, an intimate relation with reality

Being reveals itself as a contextual *object* within a *phenomenon* that implies a distinction between appearance and reality, playing the role of the norm. If the appearance does not correspond to reality, that is, the norm of the phenomenon is not satisfied, the phenomenon will be illusory. In the case of a genuine phenomenon, appearance corresponds to reality, and the appearing object is real and anchored in reality. In Wittgensteinian terms, such a (normative) phenomenon is a "language game", that is, a correct *use* of a norm/rule. The Higgs boson is identified, *given* within the phenomenon, language game of the use of the rule (norm, concept) "Higgs boson" and the practice of the SM application as a physical "form of life" (the formalism of the SM plays the role of the "grammar" or a system of "hinge propositions") in the sense of the later Wittgenstein. For Wittgenstein the application of concepts (rules, norms) is the process of measurement (of reality).

Contextual realism implies that there is something beyond the phenomenon (language game, object). That is a phenomenon is never autonomous. If the norm/rule, which the phenomenon presupposes, that is, the logic of the phenomenon, did not overpass it and in some way would be contained in it, the phenomenon could not be assessed in relation to this norm. The norm of the phenomenon overpasses it in the form of a metaphysical "call" of the norm of reality, which cannot manifest itself – the norm is ideal (so, one can also say that this is a call of the ideal) – but can be expressed by the language. The concept of the Higgs boson and the SM are instances of such norms/rules. In this sense, we interpret the physical theory as a "Wittgenstein rule" (hereinafter: "W-rule"), that is, a non-autonomous, but rooted in reality, physico-mathematical conceptual scheme [1]. (We use here the closely related terms 'norm', 'rule', 'concept', 'conceptual scheme' as equivalent.)

[2] Notice that in quantum physics, there is no sense talking about individual elementary particles.

The physical theory as a W-rule is not just a tool for predicting or manipulating phenomena. It also serves to describe and explain phenomena that have a conceptual (normative) structure and a metaphysical depth (as said, they are not autonomous).

From the point of view of contextual realism, a correct description of a real thing is a description of a real thing itself. In particular, a correct description of the Higgs boson within the SM is a description of it as a real thing itself, not a description of a Higgs-boson-for-us, that is a correlation between the Higgs boson (being) and the thought about it, presupposing that the Higgs boson (being) itself is not accessible to us. The hypothesis about the existence of the things-in-themselves, is rejected.

2. Realism and a physical theory

As is clear from the above description, language and, in particular, the language of a physical theory should not be decontextualized and, accordingly, deprived of its normative character and substantialized. In particular, one should not substantialize or treat as 'real' purely mathematical structures, formal rules.

At the same time, Steven Weinberg's appeal to take physical theories seriously is correct [2].[3] The symbols that theoretical physicists write on paper have something to do with reality.

In this regard, we note that Wittgenstein was sometimes misinterpreted as a linguistic idealist, precisely because he takes the language seriously: "In der Sprache wird alles ausgetragen" (everything is decided in language) [3, § 95, c. 143]. (This is about the alleged problem of harmony between the world and thought.)

In fact, ultimately, Wittgenstein is interested not in the words but in the things themselves (and theoretical physicists are interested not in the mathematical apparatus of a theory but in the physical reality it describes). To take the language seriously means to understand that it is able to identify, "grasp", describe, explain, and predict phenomena and entities, including the singular ones, in all their fullness and richness. The real language is not abstract, but is the very relation with reality. It is not separated from the things.

Let us explain what has been said with an ordinary example.

Benoist writes: . . . " Si nous nous demandons à quelle réalité préalable, par exemple, renvoie le mot "rouge", quelle réponse donner si ce n'est : *ce que nous appelons 'rouge' lorsque nous utilisons correctement le mot 'rouge'*?" (My translation: "If we ask about what the predetermined reality, for example, the word 'red' refers to, which answer can be given if not the following one: what we call 'red' when we use the word 'red' correctly") [4, p. 133].

The answer is tautological: the words refer what they refer to when used correctly. But the tautology is meaningful. It indicates the nature of language, including that of the scientific language, and the nature of the relation between language and reality. The concept "red" and its uses are not separated from each other, and were simultaneously elaborated in practice, as a result of interaction with reality and in the domain of reality where the red things exist. Before the concept was elaborated, these things had remained what they are, that is, they had had facticity, but they had not had identity, they had not been (determinate) objects.

In paradigmatic (established) cases, the referent of a term is pre-determined, fixed by definition. In new cases, a correct use of a concept is not pre-determined, justifiable *post factum*. That said, the role of the justification norm is played by the very concept (norm) being used. Equivalently, it can be said that a new correct application of a concept has a family resemblance with its paradigmatic applications, and a new correct judgement depends on those that have already been actually made (in this sense Wittgenstein speaks of

[3] Weinberg says: "Our mistake is not that we take our theories too seriously, but that we do not take them seriously enough. It is always hard to realize that these numbers and equations we play with at our desks have something to do with the real world" [2].

agreement in judgments [5, § 242]). In particular, "what we call 'measuring' is partly determined by a certain constancy in results of measurement" [5, § 242].

What has been said is also true for a physical theory as a W-rule (norm, conceptual scheme) [1], whose application to reality can be represented as a conceptual 'measuring' of it. A fixed predetermined metaphysical reality does not exist. As Jocelyn Benoist says, "the given does not precede reality; it rather refers to the fact that the latter is seen according to a norm which itself has real conditions" [4, p. 221]. An established physical theory is a norm, or a W-rule, of such a kind [1].

To the question: "What reality does the term 'Higgs boson' refer to?" the answer can only be the following: "What we call the 'Higgs boson' when we use the term 'Higgs boson' (and the SM) correctly". This is neither a "linguistic idealism" nor a constructivism, but a non-metaphysical contextual realism of the Wittgenstein type.

3. Appropriateness, Adequacy and Non-Falsifiability

So, from the point of view of the contextual realist approach, we treat an established and verified physical theory as a W-rule whose applications depend on the context. These applications, that is, Wittgensteinian "language games", are (normed) physical phenomena. The physical objects are given within them.

Language games are actions, which are multifarious and by definition are possible only in reality.[4] In particular, the judgement is being made. And it is being made in one or another way, depending on the context.

The truth (and certainty) of a theory as a W-rule is logical. Like concepts, such theories are either applicable or not, but they cannot be false. Thus, we reject Karl Popper's view that the criterion of scientificity of a physical theory is its falsifiability. For us, on the contrary, the criterion of an established and empirically verified scientific theory is its non-falsifiability.

It is obvious that a physical theory as a W-rule must satisfy the conditions of appropriateness and adequacy. (Analogous conditions are satisfied by (genuine) concepts [6, p. 56].) The first condition means that a theory has an area of its applicability (that is, appropriateness is truth as correspondence to an area of reality); the second condition means that the use of a theory in a context within the area of its applicability is correct (that is, adequacy is truth as anchoring in reality. It is correspondence in a context, intimate connection with reality). The second condition is stronger than the first one. These conditions are satisfied in concrete circumstances. In the case of violation of the condition of appropriateness, the theory is not meaningful, but is a pseudo-theory. (Like a genuine theory, a pseudo-theory is not falsifiable, but it does not have an area of its applicability.) If the condition of adequacy is violated, the theory will not identify (describe, explain or represent) concrete things, and, therefore, will not be fully meaningful.

The 'gap' between theory and reality is logical. This is a gap between the W-rule and its application, or between the ideal and the real. The structure of this gap is that of the rule-following problem, which, according to Wittgenstein, is a pseudo-problem (it is closed in practice within a language game (action) of W-rule's application). This is also the structure of the contextual realism.

4. Contextuality of physical structures

Unlike a purely mathematical theory, a physical theory is "two-dimensional": it has both a mathematical and a physical meaning. It is the use of the concepts worked out in

[4] Of course, there are also fictitious contexts. But they are secondary and connected to reality indirectly.

interaction with physical reality, experience that distinguishes the latter from the former. The ultimate criterion of truth in physics is experience, not mathematical consistency.

A purely mathematical component of a physical theory can be contradictory or even meaningless. For example, as a rule, the functional integrals used in quantum field theory do not have precise mathematical meanings, although their use makes it possible to describe physical phenomena with great accuracy. At the same time, resolving the mathematical problems that arise in physics can often improve the understanding of physics.

The structures relevant to physical reality are physical, not mathematical. They acquire their physical meaning only as a result of physical applications of the corresponding theory.

A. Einstein's application of (pseudo) Riemannian geometry in the general relativity theory disproved the idea that Euclidean geometry represents space-time in a natural and unambiguous way. The algebraic reformulation of geometry and the use of algebraic methods for describing space-time, for example, the Einstein algebras or the non-commutative geometry of A. Connes [7], definitely destroyed the view that mathematical structures alone are able to reveal, at least approximately, the truth about the nature of reality. (See also [8].)

The fallacy of giving too much importance to the mathematical structure of a physical theory was well realised by W. Heisenberg. When Felix Bloch told him that space is a "field of linear operations", the answer was: "Nonsense. Space is blue, and birds fly through it." (Quoted in [9].) In the same spirit, Jocelyn Benoist writes: "La réalité, nous l'avons devant les yeux, sous l'espèce de cette portion de ciel bleu (…)." (The reality is right in front of us, in the form of this portion of blue sky) [4, p. 121].

Heisenberg's words should not be taken literally. Unlike the ordinary reality surrounding us, physical reality has no colour. Its nature is different. That is, there is no point in asking about the color of atoms, electrons, hadrons or quarks, except in a conventional sense, in which physicists talk about the 'colour' of quarks in the framework of quantum chromodynamics.

At the same time, the physical (that is, not purely mathematical) structural realism, if it is metaphysical, is also unsatisfactory.

From a contextual point of view, a physical structure of reality should not be understood as a predetermined, decontextualized structure. Reality is not formless. But outside the context of application of certain norms (concepts), its forms do not have identity, they are not determinate, cannot be identified. A determinate physical structure arises in one context or another. It is an explicit part of the corresponding physical theory understood as a W-rule rooted in reality (not literally "mirroring" reality). And this means that physical structures can vary, depending on the contexts of a theory choice and its applications. Benoist writes: "Les normes, telles que je les concois – c'est là mon réalisme - n'ont d'autre vocation que d'appréhender les structures et réciproquement la structure est exactement ce qui est appréhendé par la norme là où celle-ci est appliqueé de la facon qu'il faut dans le context qu'il faut." ("Norms, as I understand them, – this is my realism – have no other vocation than to grasp structures. And *vice versa*: the structure is exactly what is grasped by the norm where it is applied in the right way and in the right context") [4, p. 106].

However, a part of reality (experience), conceptualized by an established physical theory, is meaningful and has determinate structures (in this sense, certain meaningful structures exist by themselves). As mentioned above, the practice of application of a theory within the domain of its applicability is an instance of Wittgenstein's "form of life".

Our interpretation of the theory as a W-rule (norm), anchored in its paradigmatic applications, presupposes its ability to contextually identify, describe and explain not only structures, but also concrete things.

The nature of a contextual being (object) is determined by the nature of the corresponding W-rule and, accordingly, by the corresponding "form of life", to which, together with the theory and its paradigmatic applications, the relevant scientific practice also belongs.

Forms of life are pluralistic. The nature of ordinary objects surrounding us, such as chairs and tables, is different from the nature of microscopic physical objects, such as atoms and electrons. The nature of social reality is different from the nature of physical reality. Mathematical reality has its own nature. Etc.

5. Categories of the Real and the Ideal. Objects

In the previous sections, we implicitly accepted the distinction made by Benoist between the categories of the real and the ideal [4–6, 10–12]. The latter includes norms, rules, concepts, points of view, theories, attitudes, intentionality, meaning, etc.

An action or a discourse, if they are really an intentional action or a meaningful discourse, are rule (norm)-following practices. That is, they have a normative (conceptual) dimension.

As for the concept of reality, by definition, reality is simply what it is. By itself, it has no content, meaning, normative or conceptual dimension. As Benoist writes, "reality *is just what it is* – that is its definition – and, as such, does not mean" [13]. The determinate (meaningful) structures, objects, properties and relationships belong to a conceptualized reality, in which the real and the ideal are mixed.

The problem of correspondence between the ideal and the real does not arise, because, firstly, they belong to different categories, and secondly, because the former is from the very beginning rooted in the latter, is developed from it. In particular, the genuine meaning (unlike pseudo-meaning) has its own real conditions; reality plays the role of a ground for it, is the condition of its possibility.

The metaphysical position criticized in the previous sections, which affirms the existence of an external objective or structural reality, in some absolute sense independent of us, our language, concepts, theories, points of view, context, is one of the variants of the philosophical myth of the *Given*. The metaphysical reality of objects, properties, relations or structures (pre)determines once and for all and in an absolute sense which statements, theories, points of view are true and which concepts are appropriate.

In fact, according to contextual realism, "il n'y a jamais *une* description unilatéral du perçu. Mais il n'y en a, contextuellement, de plus ou moins adéquates" ("there is never *one* unilateral description of what is perceived. But there are more or less adequate descriptions in context") [6, p. 102].

The "object" as such is the norm (principle, rule, concept) of identification. "L'objet, c'est la mesure du donné et non un donné en lui-même" ("the object is the mesure of the given and not a given in itself") [4, p. 214]. In this sense, it is ideal. Absolute (decontextualized) "objects" or "structures" of metaphysical realism, Platonism and structuralism are substatialized norms.

Real objects are contextual realizations of the corresponding norms (the ideal objects). They are entities that are being felt, (determinate) things themselves, rooted in reality, and having, on the one hand, the factual dimension, and on the other – the ideal (conceptual) one.

The Higgs boson as a concept is ideal. The Higgs boson as a real object is identified as the result of an application of the concept 'Higgs boson' to reality. That is, the Higgs boson is real, but not predetermined. It is located neither in the ideal Platonic world (theoretically, as a concept), nor in the external metaphysical reality (experimentally, as a natural object).

6. The physical circle as a simple physical theory

For Galileo, as is known, the Book of Nature is written in the language of mathematics: circles, triangles, and other geometric figures. Poets believe that it is written in the language of poetry. Darwin did not need mathematics to develop his theory of the evolution of natural species. And so on. This pluralism only means that “nature” as such (and, in general, reality as such) does not presuppose any “language”. This or that language arises when we do something with nature (reality). And what we do with it depends on us.

Such and such language allows one to distinguish (identify, describe) such and such aspect of reality. In such and such language of mathematics is written the Book of such and such *physical nature* (reality). Poetic reality has its own language, in which the use of certain metaphors can be correct or not, in one way or another refers or does not refer to one or another experience.

The concept of a physical circle can be considered as a simple physical theory which describes (identifies) real physical circles.

That is, in the spirit of what was said in the previous sections, two concepts of a circle should be distinguished: the purely mathematical circle, and the circle as a physical W-rule, that is, the circle anchored in its real (paradigmatic) applications to the physical world. The former is applied in the framework of pure mathematics. The latter allows one to identify circular objects in one or another context, depending on the variable contextual norm of the circle. The same fragment of reality can be an exact circle in one context or an approximate circle (or not even a circle at all) in another.

A circle drawn on the blackboard can be an exact circle, which allows one to prove a geometric theorem in a mathematically rigorous way. In a context, its materiality, “approximate character”, concreteness may play no role.

In fact, approximation and exactness are two sides of the same coin. Wittgenstein writes: “The correlation between visual space and Euclidean space. If a circle is at all the sort of thing we see, then we must be able to see it and not merely something like it. If I cannot see an exact circle then in this sense neither can I see approximations to one” [14, § 212]. Indeed, if the concept of an approximate circle can be correctly applied, then why cannot be correctly applied the concept of a circle, that is the concept of an exact circle?! Besides, an approximate application of a concept by definition presupposes that it can be applied exactly. Indeed, an approximate application of a concept is approximate only with respect to its exact application.

Benoist writes [10, p. 177]:

«Le “cercle exacte” n’est pas plus *difficle* à voir que le cercle approché. Si je peux voir l’un, je peux voir l’autre, et c’est en un seul et meme sens que je les vois: celui, constitutif de la notion de “donné”, dans lequel, précisément, je peux me demander si telle ou telle chose est “donné”, et donc telle ou telle configuration sensible devient “apparaitre” dont il faut juger: “est-ce bien un cercle, ou non?”» (“The ‘exact circle’ is not *harder* to see than the approximate one. If I can see one, I can see the other. And I see them in one and the same sense – in that which is constitutive to the notion of the ‘given’, and in which I can just ask if this or that ‘thing’ is given, and, therefore, this or that sensitive configuration becomes ‘appearance,’ which should be judged: ‘Is it a circle or not?’”)

This applies to physics.

Some authors believe that the requirement of exactness is satisfied only by the “fundamental theory”, and all other physical theories, in particular, effective field theories, are approximate.

For other authors, the answer to the question of whether a theory is exact or approximate is not obvious. For example, there are different points of view about whether quantum mechanics is an exact theory or an approximation to a deeper theory. The theoretical and mathematical physicist Anton Kapustin argues that quantum mechanics is an exact, not an approximate, theory for finite-dimensional systems [15].

In light of what was said in the previous sections and the above example with a circle, it is clear that a theory, tested in practice, by experience, that is, a theory as a W-rule (norm), can be regarded as exact in its domain of applicability. In particular, a theory (or a "law of nature") as a W-rule implies the existence of its paradigmatic applications (phenomena) that by definition are reliable and accurately described by it. The applications of the theory-rule in new contexts are more or less reliable and more or less precise.

Thus, quantum mechanics or another well-established physical theory in its domain of applicability can be regarded as an exact theory. But its application can be exact or approximate. The false claim that any, or at any rate existing, formulations of the laws of nature and physical theories, including well-established formulations and theories, are only approximate, results from a confusion between the categories of the real and the ideal in the course of which the real is compared with a substantialised norm (concept) – Platonic idea.[5]

In the section 8, we will briefly outline Porter Williams's position, which, in our view, can be interpreted as a step towards contextual realism and thereby confirms our approach [16]. In the next section we refer to Williams's view in connection with the so-called "naturalness problem".

7. The "naturalness problem" in physics is a pseudo-problem

Taking into account the categorical distinction between the normative (the ideal) and the real within the framework of contextual realism makes it possible, in our view, to dissolve the so-called "naturalness problem" in physics and philosophy of physics.

We propose to interpret the so-called "principle of naturalness" (see e.g. [17]) in high-energy physics as a logical (tautological) rather than substantial truth and, consequently, the problem of the violation of naturalness as a pseudo-problem, generated by the metaphysical view of reality. In fact, "naturalness" as the absence of an interscale sensitivity of low-energy physical phenomena to high-energy phenomena (and *vice versa*) and its violation – "the naturalness problem" – are two sides of the same coin. "Naturalness" means the absence of a "correlation" (by definition) between the different fields of applicability of various experimentally verified and established theories, or, respectively, different physical contexts or "forms of life". Similarly, two concepts have their own domains of applicability which are not "correlated" with each other (the absence of a "correlation" simply means that there is a conceptual difference, so to speak, a conceptual "gap" between them). On the other hand, there is a context in which two theories (respectively, contexts) are compared, "correlated". The semi-classical approximation of quantum theory in the border classical-quantum region is an example of the correlation between classical and quantum "forms of life" (normative practices) in a wider context, which takes account of the connections between the two theories. A more general theory can not only be valid in a wider (new) domain of reality, but also describe new effects in a domain initially considered to belong to a less general theory (for example, there are macroscopic quantum effects: superconductivity, superfluidity, etc.).

Let us explain what has been said above using the example of the application of contextual realism to the philosophical understanding of music. Benoist writes that in Western music, for a long time only variations in the pitch of sound were taken into account, and not variations in its timbre. A piece of music performed by a symphony orchestra and a piano was considered to be one and the same thing. In other words, musical norms were such that timbre was deactivated, not considered as an authentic dimension of musical sound.

[5] That being said, in a broader context, classical mechanics can be considered as an approximation to quantum mechanics. The latter – as an approximation to quantum field theory. Etc.

Timbre was attributed to the reality of sound, as a "residue" of the pitch, but it was not taken into consideration. On the contrary, in certain contemporary musical works, the timbral component is decisive. These works do not lend themselves to musical transcription which results in a change in timbre. The possibilities and impossibilities here are not factual, but logical (normative) [4, p. 327].

Similarly, logical (in accordance with a particular norm), not factual, are the possibility and impossibility of correlation between physical phenomena belonging to different scales. In accordance with the "principle of naturalness", correlations between them are deactivated. And *vice versa*: taking into account physical correlations between different scales means a transition to a different norm.[6]

Some authors argue that in effective quantum field theories, the principle of naturalness and the decoupling theorem, which separates the low-energy parameters of the theory from its high-energy parameters, indicate the existence of an ontology of quasi-autonomous domains. The positive aspects of this point of view are anti-fundamentalism and pluralism. Other authors, such as Porter Williams [17], argue that the violation of the naturalness principle refutes the idea that there are quasi-autonomous domains and that, as far as decoupling is concerned, it is compatible with a violation of naturalness and in itself does not confirm the existence of a quasi-autonomous ontology.

We partially (and only partially) agree with Williams. On the basis of our logical interpretation of the principle of naturalness, we argue that the metaphysical ontological pluralism of fixed quasi-autonomous domains, with their own laws and ontologies, should be replaced by the (non-metaphysical) contextual pluralism, according to which autonomous ontological domains arise in determinate contexts, between which one can establish certain relations in some (perhaps more general) contexts. Ontological autonomy is relative, or better to say sensitive, to context. This is not a relativism, but a contextualism.

The shortcomings of traditional scientific realism have been criticised by various authors. One such recent approach is Porter Williams' "effective realism" [16], described in the next section. It focuses on theories that have a wide variety of empirical applications. We share Williams' critique of the traditional realist approach in the philosophy of science, and believe that his effective realism can be strengthened and explained in terms of a more radical – contextual – realism and our understanding of a theory as a W-rule, i.e. a physico-mathematical conceptual structure rooted in its paradigmatic applications, experience, physical reality [1].

8. Porter Williams' "Effective Realism"

Williams criticizes the traditional realist approach to understanding the physical theory which looks for an interpretation of a hypothetical rigorous mathematical description at all length scales and, accordingly, the fundamental ontology. "The theory to be interpreted is assumed to provide a true and exhaustive description of the physical world in all respects, including at all length scales" [16, p. 3]. A realist interpretation of the empirically validated effective field theories, which explicitly limit the scope of their applicability and do not have a strict mathematical description, is rejected [16].

Williams calls his own realist position "effective realism". This means that attention is focused on theories that have a wide range of empirical applications. Following Weinberg's

[6] Williams says: "I argue that the naturalness principle is well-grounded both empirically and in the theoretical structure of effective field theories, and that it was reasonable for physicists to endorse it." [17, p. 82] All norms are grounded empirically and theoretically. But this does not mean that they lose their normative (ideal) status. What is true is that this status can change. In a context, the normative can be transformed into the empirical, and *vice versa*. This is also true for the naturalness principle.

appeal (see § 2), physical theories, including the effective quantum field theories, are taken seriously [2].

Williams also rejects the other extreme which consists in taking the mathematical structure of a physical theory too seriously. The traditional realist approach that he criticizes, precisely because it focuses on toy, fundamental, imaginary, or unverified theories, is prone to this extreme.

"Effective Realism" avoids this extreme by analysing the empirical applications of the theory and its theoretical structure. This allows us to separate the purely mathematical and accessory elements of the theory from those elements that have physical meaning, referring to physical objects, properties, relations and structures.

The position is anti-reductionist. Williams does not reject the search for and the existence of a fundamental theory, but points out that many theories confirmed by experience cannot be reduced to a fundamental theory. For example, it is known that the behavior of hadrons cannot be described only on the basis of a description of the behavior of their constituent quarks and gluons. In particular, it is necessary to take into account the global phenomenon of confinement of quarks. Notice also that strictly speaking, on the hadron scale, due to confinement, the concept of quark loses its meaning. Thus, not just quarks and gluons, but also hadrons, should belong to the ontology of the physical world. Some stable elements of effective theories have a realist interpretation and should be preserved in one way or another in a fundamental theory.

It seems to us possible to interpret effective theories as W-rules having their own scope of applicability. In this light, Williams's "effective realism" is transformed into contextual realism. The latter corrects and deepens the former.

9. The Notion of a Fundamental Theory

A fundamental theory can be understood as a theory that describes the most simple elements of reality or its basic structure. However, as Wittgenstein writes, "The question 'Is what you see composite' makes good sense if it is already established what kind of complexity – that is, which particular use of the word – is in question" [5, § 47]. So, there could not be *the* fundamental theory. And there could not be *the* fundamental structure or order of reality. Again Wittgenstein speaks: "We want to establish an order in our knowledge of the use of language: an order with a particular end in view; one out of many possible orders; not *the* order" [5, § 132].

In particular, the question of whether the nature of hadrons is fundamental, considered by Williams [16], makes sense only within the framework of a scientific "language game". Being irreducible to their constituents, so to speak in their own context, hadrons can be considered as simple, fundamental particles. On the contrary, within the framework of "partial reduction", when the emphasis is placed on the quarks and gluons that make up hadrons, the latter are not fundamental particles. In turn, within the framework of string theory, the so-called "elementary particles" are different modes of excitation of the same string.

Castellani and de Haro write: "What is viewed as 'elementary' in one description gets mapped to what is viewed as 'composite' in the dual" [18, p.11]. "In one description, the bosonic particles are the elementary particles, while the fermions only emerge as solitons in the high-energy limit. In the dual description, it is the reverse. (…) In one description the electric particles are elementary (and the magnetic particles are then solitons or 'composite'), while in the other description it is the opposite" [18, p. 15]. "What is fundamental (…) is not fixed once and for all by the ontology, but depends upon the description" [18, p. 19]. We agree. However, Castellani and de Haro think that this is only epistemic, but not ontological "relativity". On the contrary, for us, what is fundamental (fundamental ontology) is sensitive to context. In general, ontology is sensitive to context. A correct description refers to the corresponding entity; it indeed describes what it describes. As Benoist writes, “Toute identité qui lui [chose] échoie d’une procédure d’identification correcte et contextuellement adéquate est sa “vraie” identité. En revanche, il n’y en a pas qui soit indépendante de toute procédure et situation d’identification.” (“Any identity that it [thing] derives from a correct and contextually adequate identification procedure is its ‘true’ identity. On the other hand, there is none that is independent of any identification procedure and situation”) [6, p. 114].

In the domain of its applicability (and only in this domain), any theory is able to describe accurately all aspects of reality and for all scales. But this truth is analytical (tautological). To talk about a/the fundamental theory that would describe all aspects of reality for all scales, without regard to the domain of its applicability, does not make any sense.

From the contextual realism point of view, ontology is pluralistic. Along with the “elementary particles”, not only hadrons and other composite particles actually exist, but also nonrelativistic quantum systems described by nonrelativistic quantum mechanics, classical physical objects described by classical physics, and so on.

Below we will consider some examples of contextual interpretations of physical phenomena.

10. Physical Pluralism

Benoist gives the following example. One and the same fragment of reality, depending on context, can be described as a “table” or as a “set of atoms” [6, p. 60]. These descriptions are not interchangeable. The collection of atoms can be changed in one way or another, and it will remain a collection of atoms, but it can cease to be a table. We are dealing with two different objects, determinate real beings, things themselves.

The following question arises [6, p. 60–61]: «Mais est-ce à dire que, dans la réalité, il y aurait, rangés bien gentiment l’un à coté de l’autre, d’un coté la table et de l’autre le système d’atomes, comme si cela avait un sens de se référer à l’un ou l’autre de ces items indépendamment d’un certain point de vue que nous adoptons à l’endroit de ce qu’il y a, point de vue qui renvoie lui-meme à une certaine interaction dans laquelle nous sommes pris avec le reel, à un certain régime de relation avec lui, dans une situation donnée.» (But does this mean that, in reality, there would be, nicely arranged one beside the other, on one side the table and on the other the system of atoms, as if it made sense to refer to one or the other of these items independently of a certain point of view that we adopt regarding what there is, a point of view that itself refers to a certain interaction in which we are caught with reality, to a certain regime of relationship with it, in a given situation.)

The answer to this question is that the table exists, is real, given as a determinate real being (object), identified in one context, and the system of atoms – in another context. Finally, there is a context in which the two descriptions refer to *one and the same* object – a *table consisting of atoms*. Thus, in different context, two descriptions can refer to different things or to the same thing.

The absolutist point of view, asserting that in one and the same area of space-time, these two things (and, perhaps, an infinite number of others) coexist, is meaningless.

Wittgenstein considers the phenomenon of seeing a figure “sometimes as an F, sometimes as the mirror-image of an F” [19, § 1]. This is an example of the well-known phenomenon of the aspect change.[7] How can it be interpreted?

[7] One more Wittgenstein’s example: “You could imagine the illustration [Wittgenstein draws a picture] appearing in several places in a book, a text-book for instance. In the relevant text something different is in

The figure by itself is not a phenomenon, but a fragment of reality. It turns into a phenomenon when one or another concept is being applied to it: the concept ‘an F’ or the concept ‘the mirror-image of an F’. Changing the aspect – seeing the figure sometimes as an F, sometimes as the mirror image of an F – is a more complex phenomenon.

The concept of a *phenomenon* implies a difference between reality and appearance. The latter may or may not correspond to the former. That is, a phenomenon implies the application of a norm/rule (therefore we treat it as a ‘language game’). Within a genuine phenomenon (language game), a real being (thing) itself is given. Wittgenstein writes: “Do I actually see something different each time; or do I only *interpret* what I see in a different way? – I am inclined to say the former.” [19, § 1].

So, from one point of view, we can see one thing, and from a different point of view we can see a different thing. And this means that both things actually exist. If somebody can see only one aspect of the figure, then such “blindness” to an aspect means either the absence of the corresponding concept or failure to use it.

As we have already said, contextualism is not relativism. On the contrary, it is an antidote to relativism. For a relativist, a statement or belief is true not in itself, but depending on a point of view or the standards used for its evaluation, which are considered on a par with each other. The relativist, therefore, denies the existence of an objective (“absolute”) truth. But the concept of truth by definition implies its objectivity. Relative truth is not truth. The expressions “true from my point of view”, “true for me”, “true from the point of view of such or such standard” violate the “grammar” of truth [10]. The norm/standard of truth can depend on the context. But when the context is fixed, it is fixed. That is, the statement (or belief) in context is either absolutely true or absolutely false.

Let us apply what has been said to the philosophy of physics.

The nature of the physical reality is not unambiguously quantum or some other, described by a more “fundamental” theory of all kinds of interactions. In one context “the same” fragment of reality could be treated as quantum, and in another – as classical.[8] In ‘borderline’ cases, “the same” (non-conceptualized) empirical data can be interpreted both within the framework of classical theory and within the framework of quantum theory. Both interpretations could be correct. That is, actually there could be not one, but two different phenomena with different nature. (According to the relativist, on the contrary, one and the same “phenomenon” could have different nature.) It also seems that at least in some cases, the semi-classical phenomena could have their own specific ontology. That is, the classical referents of some semi-classical descriptions using classical as well as quantum concepts are not always purely fictional. In particular, some classical trajectories in semi-classical quantum mechanics should not be considered as mere calculational devices. Finally, there could be a context in which some fragments of reality are treated as “fundamental”.

For example, in a quantum-optical experiment proposed by Yakir Aharonov and co-authors, the resultant pressure exerted by light on the surface of a mirror can be explained

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question every time: here a glass cube, there an inverted open box, there a wire frame of that shape, there three boards forming a solid angle. Each time the text supplies the interpretation of the illustration.

But we can also *see* the illustration now as one thing now as another. —So we interpret it, and *see* it as we *interpret* it” (PI, p. 165e).

Wittgenstein also analyses the duck-rabbit picture [5, p.166]. “It can be seen as a rabbit’s head or as a duck’s” [5, p. 165e].

Physical example: Classical mechanics and quantum mechanics are two aspects of Mechanics (Gestalt switch from commutative to noncommutative variables).

[8] For Niels Bohr, for instance, the epistemic boundary between the quantum and the classical regions depends on the context. However, according to many researches (not to everybody), Bohr believed that the physical ontology is purely quantum. In our view, Bohr’s position can also be interpreted as an ontological contextualism.

both from the classical point of view ('in the classical limit') and from the quantum point of view [20]. However, within the classical framework, it is explained by light, which is putting pressure on it from the outside of the interferometer, whereas within the quantum framework – by light, which is paradoxically pulling it inside the interferometer. Thus, the classical and the quantum causal (ontological) pictures turn out to be completely different. There is no continuous transition (classical limit) at the level of ontologies. Contextualism asserts that physical ontology (determinate physical beings, objects) is sensitive to context. Thus in the Aharonov experiment, we are dealing not with one but with two different phenomena: the classical and the quantum one. In this sense the nature is ambiguous.

Another example is given by gravitational waves, which, as is known, are described both by means of a geometric approach within the framework of the general theory of relativity, and also within the framework of field theory. Two approaches complement each other in many ways [21]. Should we then consider gravitational waves as the ripples in space-time or as a physical field in a flat (or curved) space-time? Moreover, in some approximation the effect of a gravitational wave on a measuring instrument can be described within the framework of Newton's theory [21]. Contextualism, as we understand it, asserts that there is a diversity of phenomena of different nature [22–25].

Benoist writes: «(…) En changeant notre point de vue, nous changeons notre prise sur la réalité et nous basculons d'une *dimension* de la réalité dans une autre, dans laquelle il n'y aurait purement et simplement aucun sens à chercher à trouver de nouveau "le meme" élément de réalité.» (By changing our point of view, we change our way of grasping reality, and we suddenly move from one dimension of reality to another, in which there is simply no point in trying to find 'the same' element of reality) [4, p. 84].

This does not preclude the existence of contexts in which some descriptions can be considered not as descriptions of genuine phenomena, but only as approximations for more accurate or fundamental descriptions that reveal the nature of the phenomena more correctly or deeply.

Contextualism does not mean that *anything goes*.

The Copernican heliocentric system is a W-rule, whereas we consider the Ptolemaic geocentric system, forced to introduce new epicycles to explain the new celestial phenomena, as a 'phenomenological' theory. One of the significant differences between them is that the theory-rule has a certain rigidity, due to which it does not need to be modified to explain (describe) new phenomena. The rigidity of the W-rule guarantees a wide range of its applications (and *vice versa*). That is, the flexibility of a theory applications is the reverse side of the theory rigidity. On the contrary, the phenomenological theory is compelled to adapt to the 'experimental data', to modify its rules. At the same time, the distinction introduced between W-theory and phenomenological theory is not absolute, but is itself context-dependent.

The rigidity of the W-rule determines its certainty and the certainty of its applications. For Wittgenstein, certainty is not a psychological concept: "The certainty with which I call the colour 'red' is the rigidity of my measuring-rod, it is the rigidity from which I start" [26, p. 329]. The certainty of the W-rule is logical. The certainty of the applications of the theory as a W-rule – physical phenomena, or language games – is epistemic.

On the other hand, heliocentric and geocentric systems are two points of view (within the frameworks of two different forms of life) on the same fragment of experiential (not conceptualized) reality, which in itself is not a *phenomenon* presupposing the concept of appearance. Wittgenstein's position (see the reference in [10, p. 79]) is that it cannot be said that in a natural way it *seems* that the Sun revolves around the Earth (and not *vice versa*). On the same grounds, it would be possible to say that what we see in the sky is the appearance of the rotation of the Earth around the Sun. It makes sense to speak about the *appearance* only within the framework of a certain language game, when concepts are being used, judgments are being made.

Within the geocentric system, the appearance is that the Sun revolves around the Earth. Strictly speaking, this appearance is illusory only from the point of view of the heliocentric system. From the point of view of the geocentric system, the norms (rules) are such that it is not illusory. Nevertheless, as is known, preference was given to the heliocentric frame of reference. That is, the heliocentric ‘form of life’ and its norms turned out to be more successful.

11. Conclusion

Thus, we propose to replace traditional (metaphysical) scientific realism, structural realism and Platonism in the philosophy of physics by a contextual scientific realism[9], which states that depending on the context some fragment of reality can be described in different ways. At the same time, different descriptions can be not only more or less adequate descriptions of the same real item (object in a broad sense[10]), but also descriptions of different objects. Ontology is sensitive to context.

A physical theory is interpreted as a “Wittgensteinian rule” (W-rule) (norm) for measuring physical reality, that is, identifying physical items (objects, properties, relations, structures), within the language games of its applications.[11] That is, the problem of access of the ideal physical theory to reality (the measurement problem in quantum mechanics) is a pseudo-problem because the gap between them is closed in practice.

Applied to physics, contextual realism reveals the contextual nature of physical objects. In particular, we argue that the Higgs boson is a contextual item (object) within the Standard Model and the practice of its application, and that the nature of quantum-optical phenomena and gravitational waves depends in some sense on the choice of physical theory to describe them. We also claim that contextual realism allows to dissolve the “naturalness problem” in physics, and it corrects and deepens Williams’ “effective realism” [16; 17; 30].

According to Putnam’s “no miracles argument”, the realist position is the best explanation of the success of our best physical theories: they are successful because they are true. At the same time, metaphysical realism cannot resist the so-called pessimistic induction argument, which claims that with the development of science, old physical theories and ontologies are discarded as false. Trying to find a compromise, structural realism argues that the success of our theories is due to the preservation of the fundamental structures and only them.

In our view, it is the contextual realism that allows one to satisfactorily explain the success of physical theories and, at the same time, to respond to the pessimistic induction argument. It also admits the existence of concrete objects (not only structures). In fact, successful (established and empirically verified) physical theories are true, but they have their own limited areas of applicability. Physical structures and objects are real, but sensitive to context.

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[9] Note that V. N. Porus suggests extending the principle of contextualism to the philosophy of science in [27]. Our approach also has connections with ”constructive realism” (or “activity realism”) proposed by V.A. Lektorskii [28].

[10] We define an “object in a broad sense” as a real item having identity (a conceptualized, identified fragment of reality). “La grammaire de l’objet est celle de l’identité” (“the grammar of the object is that of the identity”) [10, p. 150] For example, quantum objects are objects in a broad sense.

[11] Our view that theories as W-rules (norms) are ideal accords with S. Frenchs’s view that “there are no such things as theories” [29].

The development of physics is an extension of the domain of the existing knowledge of physical reality and its aspects – the study of new contexts. It is not accompanied with a literal replacement of one ontology by another.

Let me to repeat Jocelyn Benoist's words: «(…) En changeant notre point de vue, nous changeons notre prise sur la réalité et nous basculons d'une *dimension* de la réalité dans une autre, dans laquelle il n'y aurait purement et simplement aucun sens à chercher à trouver de nouveau "le meme" élément de réalité.» (By changing our point of view, we change our way of grasping reality, and we suddenly move from one dimension of reality to another, in which there is simply no point in trying to find 'the same' element of reality) [4, p. 84].

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