

THE FINAL THEORY AND THE LANGUAGE OF PHYSICS

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Abstract

Which of our basic physical assumptions are wrong? The precise meaning of this question, and so its answer, depends on several other questions creating a dependency chain: Which are our basic physical assumptions? What is a wrong physical assumption? What is a physical assumption? What is each of our physical theories? What is a physical theory?

None of these questions has a precise answer, the reason is that, the concept of physical theory, and our main physical theories, are like *open concepts*: you cannot give them a precise definition. Our theories are still *open theories*. Most, if not all, of our fundamental concepts are open and imprecise concepts. We discuss how these and other aspects of language impose limits on science, and how can physics overcome it. But foundational physics has been guided by the wrong principles. The interpretation of a physical theory should provide the *precise and clear language to talk about the theory*, not a philosophical discussion relying over imprecise concepts. Foundational physical theories should provide a *precise meaning to our fundamental concepts* and the *worldview* that makes our theories *understandable*.

We argue that these questions have a precise answer *only for closed theories*, and then we discuss on the nature of, and how these questions can be answered for a closed theory. We clarify the notion of a *final theory of physics*, the fundamental closed theory that serves as the foundation for all physics. We show how to use this notion to clarify and also distinguish the concepts of *physical postulate* and *physical assumption*. We claim that the main wrong assumption of physics is actually a logical assumption: *the principle of excluded middle*.

1 Introduction

Which of our basic physical assumptions are wrong? Which are our basic physical assumptions? What is a wrong physical assumption? What is a physical assumption? What is each of our physical theories? What is a physical theory? These questions creates a dependency chain: one can only be truly answered after the following one has been answered. The first wrong assumption is that any of these questions has an in depth precise answer, but I will attempt to, at least, clarify them. ∞

What is a physical theory? The problem of answering this question is that, even if we could give a precise answer to what is a physical theory, we couldn't answer, for most physical theories, what an specific theory is. Let A be the name of a physical theory, for example: quantum mechanics, classical mechanics, quantum field theory, quantum chromodynamics, statistical mechanics, etc. Then for almost every physical theory A , there is not a precise and consensual answer to '*what is theory A ?*' or '*what is the definition of theory A ?*'. We can easily

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talk about a theory, explain it, show its results, make experiments, but we still cannot say what the theory really is. If, in general, we can't say what a single theory is, there is no way we can answer what is the nature of a physical theory.

This is not a problem of Physics, but actually, a property of language. Most physical theories are just like *open concepts*: you cannot specify a list of necessary and sufficient conditions for being a member of the concept; you cannot precisely define it. Most of our concepts are open concepts. Most physical theories are what we call *open theories*.

The opposed of an open theory is a *closed theory*. A closed theory is a theory that can be currently entirely formulated as a finite set of sentences in a way that everything that belongs to the theory, including its meaning, follows from its formulation. The formulation is *self-contained*. Every theory begins open, but explicitly closed theories should be our ideal of a physical theory. ∞

One might think that all our physical theories are closed theories since most of its results are contained or follows from its formulation within a good textbook; and, therefore, that the textbook would be the finite list of sentences that defines the theory. This is roughly true, however, it is not *precisely* true. The main reason is that the meaning or the interpretation of the theory are not really contained within the formulation of the theory. In other words, the meaning of the textbook is not self-contained, it depends on subjective elements outside itself. It depends on the meaning the reader associate to some concepts. *It depends on the reader's worldview.* ∞

Since the formulation and, mainly, the interpretation of our physical theories relies heavily on natural language, and, so, on many open concepts, it cannot have a precise meaning just like mathematics. I'm not saying that there are syntactic ambiguities, but semantic imprecisions. Most, if not all, of our fundamental concepts are for now open concepts, and, therefore, there isn't a consensus about their full depth. They are vague or even obscure. *World, universe, reality, to be real, existence, to exist, object, state, proposition, property, quantity, value, truth, observer, knowledge, information, probability, determinism, time, space...* are just a few examples of them. Once the interpretation of a theory relies over open concepts, it is necessarily an open theory. ∞

We cannot use language to state the precise meaning of our open concepts. We cannot state, using language, the definition of an open concept; actually, this is what defines the notion of an open concept. Therefore, we cannot communicate in depth the meaning of an open concept, and so it is simply impossible to establish a full consensus about its meaning. *Our communication is limited by the degree of precision of our language and our concepts. Science is limited by the degree of precision of our words.* ∞

The quest for giving a precise meaning to our fundamental concepts cannot be accomplished using natural language. Using natural language we always define a word using other words or expressions, but then, eventually, you get to a point where all definitions becomes circular. This point is precisely where our fundamental concepts live. Fundamental concepts are exactly the ones that serves as foundations for the others, and so, where our definitions in natural language becomes circular. Therefore, using natural language there will be always a set of fundamental concepts that we cannot give a definition. Therefore, all the derived concepts lack a precise meaning, even if they are closed concepts. Heisenberg has stated it clearly:

"This intrinsic uncertainty of the meaning of words was of course recognized very early and has brought about the need for definitions [...]. But definitions

can be given only with the help of other concepts, and so one will finally have to rely on some concepts that are taken as they are, unanalyzed and undefined.” [6, p. 115]

1.1 The True Legacy of Fundamental Physics

As philosophy is based on natural language, it cannot succeed in this quest. As mathematics is an abstract discipline not really interested in describing things outside itself, it can, at most, provide us the tools. Only physics has *currently* the tools for bringing full light into our fundamental concepts.

The idea that fundamental physics is supposed to develop theories which are understood *using* our fundamental concepts is essentially wrong. The fundamental theories of physics should *give a precise meaning* and thus *provide an understanding* of our fundamental concepts. Not the opposite. Fundamental physics should *provide us consistent and unified worldviews*, worldviews where our theories can be clearly understood and where there are no paradoxes. Physics has been far beyond a mere theory of motion. At this moment, physics is closer to bringing clarity into our deep philosophical notions, than philosophy bringing clarity to fundamental physics.

1.2 Why the Quest for Interpreting Quantum Theory has Failed

Physicists have been guided by the wrong principles. This is why the quest for interpreting quantum theory has failed. *Wrong assumptions have led us to a misunderstanding on what it means to interpret a physical theory.* We have been attempting to fit quantum theory within our worldview, but it is not clear and precise enough to allow the understanding of such an elegant theory; and it is strictly classical. There is an exceptionally wrong principle behind all this. *It is the theory which should provide us the conceptual framework in which it can be understood, not the existing worldview.* The interpretation of quantum theory should provide us a new worldview, the worldview that makes quantum theory understandable, and where all paradoxes are dissolved.

A similar radical view is also shared by Deutsch:

“If we are to understand the world on more than a superficial level, it must be through those theories and through reason, and not through our preconceptions, received opinion or even common sense. Our best theories are not only truer than common sense, they make far more sense than common sense does. We must take them seriously, not merely as pragmatic foundations for their respective fields but as explanations of the world.” [2, preface]

1.3 Worldviews

But what is a worldview? Our worldview provides us a conceptual and linguistic framework, and thus, it is the lens through which we see the world. It shapes our understanding (or misunderstanding) of the world outside or even inside us. *Something that does not fit our worldview cannot be understood or doesn’t make sense to us.* It is through our worldview that the world, or parts of it, begins making sense to us.

In the short book “*World views – From fragmentation to integration*”, a worldview is

described as:

“The main properties of a world view are ‘coherence’ and ‘fidelity to experience’. Because of the rational demand for coherence, a world view should be a consistent whole of concepts, axioms, theorems and metaphors which do not exclude each other but which can be thought together. A world view can only be faithful to experience if it does not contradict known experimental facts.” [7, p. 9]

Curiously, most of the characteristics that are expected of a worldview are what we expect of quantum theory together with its proper interpretation. Therefore, it is not hard to believe that quantum theory when correctly interpreted should provide the foundations for a new worldview. If a theory does not fit your worldview, it won’t make sense to you, it won’t be truly understandable. Quantum theory does not fit our classical and imprecise worldview.

∞

An open theory can never be truly self-contained since part of its meaning and interpretation depends on the reader’s worldview. Since there are multiple worldviews, there is no way we can get an in depth consensus around its meaning or interpretation. That’s the problem of open theories: although we can reach a total consensus around its mathematical formalism, we cannot reach the same level of consensus around its interpretation. There will be always subtle aspects of the interpretation where no consensus is reached. Even classical mechanics suffers from this problem. Roughly, there is a consensus about its interpretation, but if you ask what is time, mass or energy, then you will find no consensual answer. And yes, these questions should be answered by the interpretation of the theory, they are not simply philosophical.

1.4 The interplay between two languages

Any physical theory is necessarily an interplay between two languages: math and ordinary language. Purely qualitative theories might be the only exception of this principle, but they are also the exception within physics. A theory without any connection with natural language and concepts of the real world might be a mathematical theory, but not physical one. Discussions, conclusions, principles, relation with experiments or applications, and the interpretation require the use of natural language, and there is no way to completely avoid it. The mathematical formalism is the only part of a theory where we can, at least in principle, avoid the use of natural language.

Our understanding of a theory is deeply related to our ability to express the notions or statements of the theory using natural language. Most of our thinking and oral communications require the use of natural language. Without this ability we might be able to write equations about the theory, but we cannot clearly speak about it and probably not even think about it; unless you have an exceptional skill for mentally manipulating equations. In the words of Heisenberg:

“Even for the physicist the description in plain language will be a criterion of the degree of understanding that has been reached.” [6, p. 115]

Most of the precision, power and consensus we have reached in contemporary physics come from the increasing use of math. On the other side, most of the ambiguities, misunderstandings, lack of consensus and contradictions results from and within the use of natural

language. More precisely, these problems arise mostly from the interpretation of our theories, not from their mathematical formalism. The best example: quantum theory and its multiple interpretations.

If there is not an absolute consensus, *can the interpretation of our theories be right? Can our interpretations become as solid as our mathematical formalisms?* But, first of all, *what is an interpretation of a physical theory?*

1.5 Interpretation of a Physical Theory

The interpretation of the theory *is not the philosophy* or the discussion of the theory. We might avoid philosophizing about a theory, but we cannot avoid giving it a minimal interpretation. Without a minimal interpretation, a physical theory becomes at most an abstract mathematical theory. The main purpose of an interpretation is to allow us to talk about the theory using natural language, so that we can think about it and really understand it. Therefore, I claim that:

The interpretation of a mathematical formalism is what establishes the connection between the mathematical terms or statements and the natural language used to talk about them.

With an interpretation we are able to read the equations and other expressions and then, we can say, in plain words, the meaning of the theory. I also claim that:

To interpret a mathematical term or statement is to provide means for reading it, or saying its meaning, in natural language.

We have been using a wrong notion of interpretation. When properly interpreted, we can talk about a theory using natural language with almost the same precision as if we were using math. An appropriate interpretation gives mathematical significance to some of our words and linguistic constructions. *This is how the full potential of a scientific discourse is reached, and it becomes objectively superior to a philosophical discourse.*

“There is no quantum world. There is only an abstract physical description. It is wrong to think that the task of physics is to find out how nature is. Physics concerns what we can say about nature...” Niels Bohr [8]

2 Closed Theories

The best way of understanding what is an open theory, is understanding its opposite, a closed theory.

The notion of a closed theory was firstly described by Heisenberg:

“By a closed theory we mean a system of axioms, definitions and laws, whereby a large field of phenomena can be described, that is mathematically represented, in a correct and non-contradictory fashion” [5, p. 123]

He also refers to the notion of a closed theory as a closed system, since it is also a self-contained system of concepts or conceptual framework:

“Each concept can be represented by a mathematical symbol, and the connections between the different concepts are then represented by mathematical equations expressed by means of the symbols. The mathematical image of the system ensures that contradictions cannot occur in the system.” [6, p. 54]

Once a concept is defined and represented within a mathematical formalism, it is a closed concept with complete precision in its meaning. Therefore, the conceptual framework of a closed theory is composed of closed concepts. This justifies why a theory that relies on open concepts is not a closed theory. Comparing the properties of a closed theory and a worldview, we can see that many of are very similar, and that a closed theory is itself or provides the basis for a worldview. This explains how a closed theory can be self-contained and independent of any worldview: *it contains or provides its own worldview, the worldview in which it perfectly makes sense and can be understood.* ∞

Quantum theory should be formulated explicitly as a closed theory. This is what will solve all its paradoxes, provides the proper interpretation and the correct worldview. Heisenberg’s assumption that classical mechanics, thermodynamics, electromagnetism and quantum mechanics are currently closed theories is wrong. These theories are potentially closed theories, but they have not yet been formulated in this way. They might be closed from the mathematical point of view, but not as a conceptual framework.

2.1 Formulation and Elements of Closed Theories

The mathematical formalism of a closed theory is a formal mathematical theory, in other words, it is an axiomatic system together with all the theorems that follows from it. As always might be unknown theorems, there is no way to entirely write down a theory, but we can list all its axioms. Therefore, formulating the mathematical formalism is simply listing all its axioms.

The interpretation of a closed theory should ideally allow us reading in natural language each of the theory’s axioms and theorems. Therefore, it allows us talking about each of the mathematical results of the theory. As far as we restrict ourselves to saying only what follows from the interpretation, everything we say has a clear and precise meaning, and can be translated into a mathematical statement. It can then be proved or disproved mathematically.

To state it clearer, the interpretation should provide us means to translate mathematical terms and formulas to natural language expressions and sentences and also the opposite. First we define that:

- *An interpretative statement is as a kind of statement that establishes a mapping between mathematical terms or formulas and sentences or expressions in natural language.*

Now we can state:

- *The formulation of a closed theory is a set of mathematical statements and interpretative statements.*

The theory comprises all that follows logically from its formulation.

- *The axioms of a closed theory are the mathematical statements from its formulation.*
- Therefore, axioms are the mathematical statements that serve as starting point for reasoning about the theory; they are the premises.

- *The mathematical formalism of a closed theory is the mathematical theory defined by its axioms.*

It comprises all the mathematical statements that follow logically from the axioms of the theory.

- *The interpretation of a closed theory is the set of all interpretative statements of the theory.*

The interpretation establishes a kind of mapping or translation between mathematical objects and a subset of natural language.

- *The language of a closed theory is the subset of natural language that can be translated using the interpretation of the theory into mathematical statements, formulas or terms.*

Therefore, the language of a closed theory is a language with formal meaning or formal semantics. Each sentence maps into a mathematical statement. Each of its sentences are meaningful by definition; and its meaning is the corresponding mathematical statement; it is valid if the corresponding statement holds. While we are restricted to this language, at any moment during our line of thought, we can simply stop and calculate to check if our sentences are right.

The relation between concepts, words or expressions within this language would be precisely defined. Each of them would have a completely precise meaning. We could prove how they are related. The language of closed theory would be only a small subset of natural language, but it would have *absolute precision and formal semantics*; it would be *the language of a consistent and unified worldview*. This language would also be part of the realization of Leibniz's dream of a *characteristica universalis*: an universal formal language for science, mathematics and metaphysics. For such language to be possible, he says it would require:

"... a kind of general algebra in which all truths of reason would be reduced to a kind of calculus. At the same time, this would be a kind of universal language or writing, though infinitely different from all such languages which have thus far been proposed; for the characters and the words themselves would direct the mind, and the errors - excepting those of fact - would only be calculation mistakes. It would be very difficult to form or invent this language or characteristic, but very easy to learn it without any dictionaries." [9]

The general algebra is simply the closed theory. The interpretation allows us to translate sentences in natural language to mathematical statements whose validity could be then mathematically calculated. ∞

- *The postulates of a closed theory are the statements of its formulation and the interpretation of each of them, that is, their readings in natural language.*

Therefore, a postulate might be a statement in ordinary language, but it is required for it to have a precise meaning, in other words, it should be part of the theory's language. Using this distinction, the postulates of quantum mechanics might be called postulates, but not axioms, since they are expressed in natural language.

This shows that, the notion that we can first formulate the principles of a theory and then derive its mathematical formalism and interpretation, is essentially wrong. *We can express a physical principle in mathematical language only if we already have an interpretation or framework that allows us making this connection.* The only way to assure that the principle was correctly expressed mathematically is if there is already one interpretation.

2.2 Commensurability of Closed Theories

The comparison of two closed theories is simply the formal comparison of their formulations, so we are simply comparing sets of statements. If both of them could be written in the same language, this process can be done with complete precision.

Basically, two closed theories can always be formulated in a common language, unless there are two incompatible mathematical languages, a supposition I doubt. Now we can define:

- *Two closed theories are said to be commensurable if the similarities and differences of their formulations could be expressed as sets of statements in the language they were formulated.*

Therefore, in general, two closed theories are always commensurable, and two commensurable theories can be compared with complete precision. Comparing them is just like comparing two mathematical sets.

- *When two theories are not commensurable we say they are incommensurable.*

This gives a more precise meaning to Kuhn's notion [10, 11]. According to this definition, incommensurable theories are the ones we cannot compare with complete, absolute precision, but in no way it means that they cannot be compared at all.

Open theories are always incommensurable in this sense. Classical and quantum mechanics are the perfect example of this. Roughly, we can say their differences, but, currently, nobody can say precisely which postulates make them different. They use different mathematical formalisms and there are many discussions about the quantum/classical limit, and difference between quantum and classical information, probability, correlations, etc. *This is the true meaning of Kuhn's incommensurability thesis*, but it has been misunderstood by scientists, or it was not clear enough. The essence of his thesis is that comparing two scientific theories is not something as simple and as precise as comparing two axiomatic theories. It says that closed theories are an idealized notion and science is not currently composed of closed theories. ∞

Finding the closed formulation of our physical theories is the solution to this problem and the answer to most of the foundational questions. But *what is the starting point for all physical theories? What is in common with all of them? What is the fundamental language and framework for all physical theories?*

3 The Final Theory

The *final theory of physics* is the answer to all these questions. It is the most general closed physical theory possible. Once we have a closed formulation of all our fundamental theories, the final theory will be the intersection of all them; the simplest and most elegant physical theory; the one with the smallest number of postulates; the one that serves as foundations for all the other physical theories. Beauty will be one of its main traces.

The final theory of physics (FTP) is *the fundamental mathematical and conceptual framework upon which the physical theories can be built*. It is the fundamental or foundational theory of physics, the theory that cannot be generalized, from which no postulate can be removed because it contains no physical postulate at all. Actually, *it defines what is a physical postulate*.

∞

Closed theories are not necessarily physical theories. I cannot state precisely the difference between physical and non-physical closed theories, especially because a closed theory of chemistry, for example, would probably use the framework of the FTP. But we can state that *every closed physical theory uses the framework of the FTP*, in other words, every closed physical theory contains the FTP in its formulation. Then, we can define:

- *The physical postulates of a closed physical theory are its postulates that were added to the postulates of the FTP; in other words, the postulates that are not present in the FTP.*

Therefore, the FTP is the physical theory that contains no physical postulate! This is why it cannot be made more general or simpler. *It doesn't make a single assumption about the physical world.*

This distinction between postulates and physical postulates is similar to the distinction between axioms and logical axioms. Logical axioms are universally valid, while simply an axiom might be specific to a mathematical theory. ∞

Now we are close to answer what a physical assumption is. Physical assumptions and physical postulates are two very close notions; actually, a physical assumption is a physical postulate. The difference is subtle. Assumptions enforces constraints, they restrict the domain; while a postulate may be just an interpretation or a definition.

- *Physical assumptions are physical postulates that restrict the domain of validity or imposes constraints on a theory.*

New assumptions restrict the domain of validity of a theory, while new definitions or interpretations simply add new elements to the theory. Adding new definitions or interpretations we extend the theory, that is, the theory is still valid in the same domain, but it is richer, has a larger language and conceptual framework. Adding assumptions we restrict the domain of validity of the theory, but it usually increase the number of results of the theory, that is, the number of theorems we can prove. *An assumption is wrong when it does not hold in the domain we were using it.* ∞

The language of the FTP is *the fundamental language of physics*, a precise language we can use to establish the foundations of the other physical theories. The FTP gives a precise meaning to some of our fundamental concepts and provides the basis for *the unified worldview of physics*. ∞

The precise answer to, which are our physical assumptions, and which of them are wrong, *will have to wait* until we have a closed formulation of the final theory and our main physical theories. However, I've been working on the FTP and the foundations of it were proposed in "On the Nature of Reality" [1]. There, *reality* becomes a closed and completely precise notion. Therefore, I have means to say that the *main wrong assumption of physics* is not a physical assumption, but a millenary logical assumption: *the principle of excluded middle*¹. It is the source of most of the paradoxes and misunderstandings about quantum theory and is precisely the assumption that gives rise to the classical world.

¹This principle says that a proposition is either true or false, in other words, either the proposition or its negation is true. In quantum theory it would mean that, if the cat is not dead, then it is alive; and also that every observable has a defined value. It is closely related to Bell's like [12, 13] and Kochen-Specker's [14] no-go theorems and also EPR's paradox [15].

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