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The implications of considering so-called "elementary" or "fundamental" particles

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Abstract

In this paper we tackle the question of the consequences of the assumption that there exists elementary particles. We work in the framework of the existence of fields while this raises some conceptual problems which are explained. In that context, we show that the existence of an elementary particle for a given field (gravitation, electric, etc.) brings to the existence of a well-founded binary relation. We then apply the axiom of dependent choice and come to the conclusion that the world needs to be discrete and finite. Finally, we raise the question according to which noticing, from maybe inaccurate measuring tools, that the world is discrete and finite might imply the existence of elementary particles, bringing us into a circular reasoning. To get out of the trap, we should, in such a case, abandon the assumption of the existence of fundamental particles and come back to equivalence classes, to be defined as the bricks of physics as Wigner wrote in his celebrated paper [1].

1 Introduction

Let us begin with a reference to Wikipedia: *In particle physics, an elementary particle or fundamental particle is a subatomic particle that is not composed of other particles. Particles currently* ***thought*** *to be elementary include electrons, the fundamental fermions (quarks, leptons, antiquarks, and antileptons, which generally are matter particles and antimatter particles), as well as the fundamental bosons (gauge bosons and the Higgs boson), which generally are force particles that mediate interactions among fermions. [1] A particle containing two or more elementary particles is a composite particle*.

The important word here is "**thought**" and we bolded it on purpose. This means that we do not know if the particles are "elementary" or not.

Let us, however, raise the question of why we should consider elementary particles made of no components. Indeed, if we take the example of the electron, what looks strange is that this particle has no components, it has no volume (in quantum physics but has one in classical physics [2], [3]), no trajectory when moving, but it has a mass, a charge and a magnetic momentum. We shall not answer, in this paper, these questions whereas we have developed a specific theory about it [4], [5].

We could not find the history of how the concept of fundamental entity was forged. It seems, however, that it is issued from a mathematical model, so-called standard and its birth is due to complicated mathematics [6]. But this remains a model! The elementary units appear with specific mathematical characteristics, but it seems that no one ever asked the question of whether we need such kinds of objects in physics and what the implications of such an existence are.

This is the purpose of this paper to tackle this problem and to give some answers. We shall start gently, but in the end we shall use deep mathematics issued from set theory with some outstanding results. And we shall end in asking more questions than giving answers, leaving room for future work.

2 About the fields

Actions at a distance have been "invented" by Sir Isaac Newton, through gravity theory. Soon, the Coulomb law and the one of Biot and Savart came to complete the landscape with a fading of the force

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in $1/r^2$, where r is the distance between the two bodies. Richard Feynman, in his celebrated courses, made the notion of a field very popular. Its inventor is Faraday. But this was in the context of the existence of an ether. Canceling the latter and keeping a field is conceptually a bit more difficult.

Indeed, let us consider, say, a permanent magnet and, at some distance from it, a volume of a vacuum of $1m^3$. There is a field in it. Now, let us wrap the magnet into a foil of µ-metal. This cancels the field obviously. What has changed in the empty volume between the two cases? Physics says that there is nothing in the vacuum and if nothing changes, then what does it mean to have a field? This brings us to Einstein's expression of "spooky action at a distance."

But the notion of a field is even more problematic. For this, let us refer to any book of Feynman, the one about gravity, for example [7]. He starts from Newton's law of attraction

$$\vec{F} = G\frac{mm'}{r^2}\vec{u}$$

With well-known notations and where $\vec{u}$ is the unit vector of the line joining the two centers of mass of the two bodies. And what Feynman [7] says and which is generally repeated by all physics teachers and professors is that this is strictly equivalent to writing

$$\vec{F} = m'\left(G\frac{m}{r^2}\vec{u}\right) = m'\vec{g}$$

Where $\vec{g}$ is called the gravity field. And this is the same for the other fields. However, if the mathematics is correct, we say here that the physical interpretation is wrong. Why? It says that the mass m creates a field around it whose intensity decreases as the square of the distance. What is false? Simply that in Newton's approach the problem is a two-body problem while in Feynman's we face a one-body problem. Of course, as soon as you are going to consider interactions, the mistake will play no role and your results will be right as much as your model is good. But on the grounds of logic, this is a deep mistake!

At the time of Faraday, this would **not** have been one. Indeed, the interactions between the mass and the ether, step by step, are going to propagate the effect and the ether itself might dim the effect with the distance. However, as soon as we consider a vacuum, this story no more works and we get a real problem.

3 The action-reaction principle

Let us stay in the case of forces induced by fields. The fact of saying that the mass m creates the field $\vec{g}$, implies that the action of the mass m over m' is linked to the field it creates and this field is

$$\vec{g} = G\frac{m}{r^2}\vec{u}$$

On the other hand, the field created by m' one m is given by

$$\vec{g}' = -G\frac{m'}{r^2}\vec{u}$$

Obviously, the exerted forces will be the same on both masses, but the fields are different and these are the fields which are supposed to act…! However, the writing of the forces gives the same expression, fortunately, and this saves Newton's principle of action and reaction while the acting fields do not on qualitative grounds. Strange, isn't it?

4 Looking for elementary particles

Let us be more accurate in the context of the existence of fields. Let us consider our two masses on the x axis as in the figure below.

Figure 1: interaction between two particles

Let us now consider we put in the place of m smaller and smaller particles $\{m_i, i \in I\}$. We shall have the creation of smaller and smaller fields, say $\vec{g}_i < \vec{g}_j \Leftrightarrow i < j$. We only consider the field created on m', therefore we have defined a binary relation

$$m_i \Re m'$$

And this relation cannot be, by definition, symmetric, because still by definition, m' is supposed to be fixed and remote from m_i.

Let us assume, therefore, at this stage, that there exists at least one fundamental particle with the least mass as possible. This means that there exists a mass m under which no relation is any more possible. In a more mathematical way, we can write

$$\forall m'' < m, \neg(m'' \Re m)$$

Where $\neg$ is the negation of a proposition in formal logic. The "equation" above means, still in mathematical terms, that m is $\Re$-minimal.

Now, let us remind the reader what a well-founded binary relation is. This is a relation in which, if we are in a set A and if $\Re$ is a binary relation over it, every non-empty subset of A will have an $\Re$-minimal element. And if we consider the set of masses, saying that we have an elementary particle implies that the field "creation" property in one point defines a well-founded binary relation.

Of course, we chose the mass, but we might have chosen the electric charge or whatever characteristic giving rise to a field. This result therefore is general.

We apologize to the mathematicians to have given a proof which is not rigorous enough here since we should have considered equivalence relations on a quotient set, which we did not do, because applying to physicists first.

5 Consequences

5.1 Physical consequences

We saw that the binary relation $\Re$ is well founded. This implies that the induction principle is valid! What does it mean?

Let us consider, for example, the set of masses and the relation $\Re$ which is well founded. Then, let us consider a property $P(m)$ which defines, through the separation principle, a set. Now, if the property verifies that for any mass m, if $P(m')$ is true for any m' such that $m' \Re m$, then $P(m)$ is true for any mass.

Among the different conclusions which we draw out of this is that we will have the same behavior of all the masses in our universe, how big they are. This is a point which is never raised by physicists and considered as obvious, but it is (was) not!

5.2 Logical consequences

Despite all the promises we got through this approach up to now, it is going to be somewhat tarnished with the result we present in this subsection.

Indeed, if we consider the weak version of the axiom of choice, better known as the axiom of dependent choice, we have the following result [8].

Theorem:

Any binary relation is well founded if and only if it does not admit any infinite descent.

This might seem as being no surprise since we admitted, through the assumption of the existence of an elementary particle (i.e., a minimal one), that there would be a limit to any descent. But the theorem is much stronger! It means that we shall have sorts of levels and that these levels will be in finite number, hence discrete!

Now, quantum physics views the world as discrete[2] and the question we ask is: does the discrete approach of quantum physics imply that there are elementary particles? And we think this question is worth because of the "*if and only if*" in the theorem above. We shall not answer it even if we have clues about this.

5.3 Discussion & conclusion

The Greeks inferred the existence of the atom, an entity which could not be split, and modern physicists proved that, in fact, it has components. Today's physicists believe that there are fundamental particles which cannot be split and, even more, have no components[3]. But isn't it the approach by itself which brings to such a result and aren't we led into a no way in the sense that at some point we are stuck and can no more progress?

If the answer to the question of our previous subsection is positive, we might have a circular reasoning in quantum physics which would build its own limits. Our goal therefore should be to try to escape this trap if it is one. Indeed, let us consider the circular reasoning we could make without being aware of it: we observe discrete phenomena, in a finite number, this gives a clue about the existence of elementary particles, but, in the context of field physics, this would imply a finite number of discrete phenomena.

In conclusion, we propose to abandon this point of view and turn to the nonexistence of fundamental particles. The discrete phenomena we see in fact are not discrete, but look like this because of our lack of accuracy in our measuring tools. The problem we face then is to group together in equivalence classes what we consider as identical entities and which formally are not, but could be regrouped like suggested in the famous paper of Wigner [1].

6 References

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[2] In fact it is also necessarily finite because of the existence of the ground state.
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