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# Computational versus mathematical languages in physics 2/2

## Physics and computational languages

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**Abstract**. This second part of the article recalls the inevitable inaccuracy of mathematics as the language of physics. This raises the problem of the suitability of mathematical languages, both infinitist and finitist, which cannot give the exact results that one would expect them to give. As an alternative, the article considers computational languages and discrete models such as cellular automata, in which such accuracy could indeed be fully achieved.

**Keywords**: mathematical languages, computational languages, cellular automata, observable universe.

## 1. Introduction

The main objective of this second part of the article is to show that there is a finitist, discrete, and exact solution to the problem posed in the first part of this article: the inability of mathematical languages, both infinitist and finitist, to cease being what they are: inexact descriptive approximations that cannot help but be inexact descriptive approximations of the real physical world, no matter how close those approximations come to exactness. This inevitably leads to the question of the suitability of formal languages that are incapable of providing exact descriptions of the real physical world. Why cannot they provide exact descriptions of the real physical world? Is it because they are inappropriate? Are there alternatives?

After recalling this problem, this second part of the article shows that there are alternatives in which such exact descriptions of the real physical world are indeed possible: computational languages. Languages that, as is well known, are used in cellular automata, which makes it inevitable to consider the possibility that our observable universe can be explained from a logical perspective similar to that of these cellular automata. Above all, considering that the space and time of the observable universe, if they are consistent [4, 3], would also have to be discrete, with minimal indivisible units in both cases (*qusits*, quantum space units; and *qutits*, quantum time units). The same applies to space and time in cellular automata.

Finally, I must confess that I feel overwhelmed, almost incapable of addressing the issues raised in this two-part article. And even more so, to propose the discrete innovations suggested here, especially the proposal to consider the possibility that computational languages, rather than mathematical ones, are the most appropriate for expressing and calculating with complete accuracy the results of all the physical processes that occur in the observable universe, and that this universe could function in the manner of cellular automata (a possibility that has already been considered by other authors for quantum mechanics, although with infinitist mathematics [1]).

## 2. Inaccurate calculations and incorrect theories

If the actual infinite is inconsistent, the only consistent mathematics would have to be finitist and discrete. A mathematics in which all infinities would have to be potential infinities. On the other hand, finiteness and discreteness have already been accepted for some physical magnitudes, such as electric charges. But it would have to be accepted for all physical magnitudes if the actual infinity were inconsistent, as could be the case [3, 4]. Hence the extreme importance of analyzing the formal consistency of the actual infinity, whose set theoretical existence is established by the Axiom of Infinity. This analysis has been overlooked for 125 years, as if the Axiom of Infinity were an unquestionable truth. It is not, and it is not difficult to demonstrate - precisely in the theoretical terms of set theory - that it is in fact an inconsistent axiom [4].

It seems that physicists are not even aware that they are using actual infinities instead of potential infinities, which are the infinities that implicitly appear in the vast majority of their texts, although without the label "potential". We should remind them all that the infinity of their mathematics is the actual infinity, from which it immediately follows, for example, that a line one-tenth of a millimeter long has as many different points ($2^{\aleph_0}$ different points) as the entire observable three-dimensional universe ($2^{\aleph_0}$ different points), which does not seem very physical. Can this actual and uncountable infinity serve as a model for the real physical space? Because, in fact, for 10 years now, the physical reality of space has had to be admitted: it is a physical object that can vibrate, transmit its vibrations at the speed of light, and interact with the interferometers that detect its vibrations (gravitational waves). Nothingness has no capabilities; if it did, it would be SOMETHING with those capabilities.

But, as we will see in this section, it could be that finite and discrete mathematics are also inappropriate for describing and explaining the physical world. To do this, we will consider the simplest case of two discrete physical magnitudes, space and time, which define a third magnitude, velocity. Suppose that the quantum length is just Planck's length $l_p$, and the quantum time is just Planck's time $t_p$; and let there be an object, for example a subatomic particle, moving at a velocity $v$ given by:

$$v = \frac{m \times l_p}{n \times t_p};\ m < n; m, n \in \mathbb{N} \tag{1}$$

$$= \frac{m}{n} \times c \tag{2}$$

where $c$ is the speed of light in a vacuum, and $\mathbb{N}$ is the potentially infinite set of natural numbers. For m = 5 and n = 6, we have:

$$v = 0.8333 \cdots \times c \tag{3}$$

In finitist mathematics, in which all rational numbers are exact rational numbers, the expression $0.8333\ldots$ does not represent an exact rational number, but rather a potentially infinite sequence of exact rational numbers [5]:

$$0.8, 0.83, 0.833, 0.8333, 0.83333, 0.833333, 0.8333333,\ \ldots \tag{4}$$

none of whose successive terms will give the exact value of $v$ when multiplied by $c$. In infinitist (and inconsistent) mathematics, the number $0.83333\ldots$ has an actual infinite number of decimal places, which poses exactly the same problem as in the case of the potential infinity: it is necessary to take a finite number of the decimal places of that number to multiply it by $c$, and whatever number is chosen, the result of multiplying it by $c$ will only be an approximate, not exact, value of $v$. We will have to conclude that, in the previous example, mathematical language (finitist and infinitist) cannot give the exact value of $v$, it can only give approximate values.

The same problem arises with a potential infinity of other different speeds, namely those for which $m/n; m < n$ is not an exact rational number. Therefore, we must conclude that either there is an infinite number of physically impossible speeds, or neither infinitist nor finitist mathematics are appropriate languages with which to express something as simple as the exact speed of physical objects. Mathematics can only give approximate values, however approximate they may be, for a physical magnitude as simple as uniform velocity.

We would reach the same conclusion, and for the same reasons, for the rest of the physical magnitudes that have more complex arithmetic relationships between them. The problem is that if a theory cannot provide exact values for the magnitudes that describe the physical world, we will have to conclude that that theory cannot be the correct theory to explain the physical world; or conclude that the physical world does not admit correct and exact descriptions. The following section proposes an alternative that, although it may seem too bold, solves the problem.

## 3. Cellular automata and computational languages

I know that I am not the first to propose the theory of cellular automata as a model of the physical world (although based on infinitist mathematics, this theory has already been proposed for the quantum world [7]). I have not proposed any specific theory, except for the possibility of considering cellular automata theories to solve the old problem of change [3, App. B], [2, Chp. 68], a fundamental physical problem that has remained unsolved for 25 centuries and has been practically forgotten by physics, the science of change; the science of the regular succession of events in Maxwell's words [6, p. 1].

I return here to propose that analytical perspective that could solve the problem of change, and that could also solve the problem posed at the end of the previous section, which is worth repeating because of its extraordinary importance and because contemporary physics has not even considered its existence:

> *A mathematical language for which it is impossible to give the exact results for the natural physical processes cannot be the correct language explaining those natural physical processes. It cannot be the correct language explaining the origin and evolution of the physical world.*

And that is the case, no less, with mathematics, both infinitist (and inconsistent) and finitist (which at least would not be inconsistent for the same reason that infinitists are).

Let us consider again the case of the object (a subatomic particle) moving at a velocity $v = 5/6 \times c$ (expressed in arithmetic terms) which, as we have seen, cannot be calculated exactly, either with infinitist or finitist mathematics. As an alternative to this impossibility see Table 1. Its successive odd columns indicate the successive quantum units of time (qutits) taken in increments of 6. The successive even columns indicate the corresponding quantum units of space (qusits) traveled by the particle m in that qutit: 1 qusit in each of the first successive 5 qutits indicated in the column to its left, and none in the 6th of such successive qutits. The last row indicates the resulting quantum velocity of the

| Qutits | Qusits traveled | Qutits | Qusits traveled | Qutits | Qusits traveled |
|---|---|---|---|---|---|
| 1<br>2<br>3<br>4<br>5<br>6 | 1<br>1<br>1<br>1<br>1<br>0 | 7<br>8<br>9<br>10<br>11<br>12 | 1<br>1<br>1<br>1<br>1<br>0 | 13<br>14<br>15<br>16<br>17<br>18 | 1<br>1<br>1<br>1<br>1<br>0 |
| Speed | v = 5\|6 | | v = 10\|12 = 5\|6 | | v = 15\|18 = 5\|6 |

**Table 1** – Discrete motion of a particle whose velocity is 5|6: indicating that this particle moves in 5 successive qusits in 5 successive qutits, and none in the 6th of such successive qutits.

particle, where the symbol "|" in "n|m" indicates "n of each m". In computational language, the physical reality collected in Table 1 can be expressed immediately and accurately, for example:

1 For n = 1 to 5 step 1: Move: Next n
2 NotMove: GoTo 1

*where each step is executed at each successive qutit.* Obviously, I am not suggesting that this is the solution to the problem posed by the inevitable inaccuracies of mathematical languages in physical processes, but rather indicating that solutions to this problem could exist. Although I am aware of the seriousness and enormous importance of the language change proposed here: replacing mathematical language with computational language. The universe could function as a large cellular automaton of, say, $2.66 \times 10^{185}$ spatial cells (qusits) whose states would be updated in each of the successive quantum units of time (qutits), and the update would be governed, not by more or less complex mathematical formulas, but by the execution of discrete and finitist computational algorithms such as the one above.

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