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Computational versus mathematical languages in physics 1/2

Are mathematical languages suitable for physics?

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Abstract. This brief first part of the article demonstrates that neither infinitist nor finitist mathematics can provide exact values for the vast majority of physical magnitudes related in a more or less complex mathematical way. This raises the question of whether mathematical language, whether infinitist or finitist, can be considered correct if the values it provides can almost never be exact.

Keywords: finitist mathematics, infinitist mathematics, impossible exact calculations, mathematical languages and physics.

1. Introduction

As its name suggests, discrete mathematics deals with discrete, separable mathematical structures and objects, such as natural numbers, which are not densely ordered as real numbers. But discrete mathematics is also infinitist because it assumes the Axiom of Infinity, i.e., the existence of infinite sets whose infinity is the actual infinity, not the potential infinity (which has been, and continues to be, absent from mathematics for more than a century). Therefore, current discrete mathematics is both discrete and infinitist mathematics.

The other mathematics considered here are discrete and FINITIST. And their finitism obviously has to do with the inconsistency of the actual infinite repeatedly demonstrated by the author (among the many works on this subject, I always recommend a very short paper [3] and a very comprehensive book [2]). This inconsistency is taking a lot of time and effort to get people to simply consider it; even if only for a few minutes, which is the time it takes to read and evaluate the content of [3].

After more than a century of successes, especially in infinitesimal calculus in physics, infinitesimal mathematics seems truly definitive and immovable from its absolutely hegemonic position in contemporary science. But there is one detail that, as far as I know, no one has considered: the evolution toward a final limit through a succession of values that successively approach that limit is actually a discontinuous evolution, in leaps and bounds. The author has already made these fundamental facts of infinitesimal calculus public [4, 5] and recalls them again in the following section.

But the main problem that arises here (explained in the third and final section of this first part of this article) is that neither infinitist nor finitist mathematical calculations can give exact results for the physical magnitudes involved in most of these calculations. And so, the following question is inevitable: can a mathematical language (finitist or infinitist) be appropriate to explain and describe the physical world when it inevitably gives rise to calculations that are mostly inaccurate and cannot avoid being inaccurate? From a fundamental point of view, rather than the unattainable exactitude of data, it is more important to ask why this exactitude is unattainable. Are there alternatives that overcome this incompetence? The answer to the last question will be given in the second part of this article, to be published next week.

2. The success of infinitesimal calculus

Surely no contemporary theoretical physicist (among other scientists) would ever think that they are using formally inconsistent mathematics, but they are because they assume an inconsistent axiom: the Axiom of Infinity [3]. Certainly, infinitesimal (and infinitist) calculus has been and continues to be truly productive. However, for the reason mentioned above, it is not actually a continuous calculus but a discrete calculus, a calculus in leaps and bounds, which would be the infinitesimal calculus proper to discrete mathematics.

Furthermore, the jumps are always over the same number of different values: exactly $2^{\aleph_0}$ values in the case of real numbers, and exactly $\aleph_0$ values in the case of rational numbers. And the reason is mathematically indisputable: neither real numbers (nor rational numbers) have **IMMEDIATE** successors, as is the case with natural numbers and integer numbers. In their natural order of precedence, it happens that between any two considered real numbers, whatever they may be, there is always the same uncountable infinite number of other different real numbers, all of them greater than the first and less than the second of those two considered real numbers.

Consequently, in all operations involving the limits that are essential in differential calculus and integral calculus, these limits can only be achieved in regular jumps: jumping at each jump over the same uncountable infinite number ($2^{\aleph_0}$) of real numbers whose values are always greater than the first of the two real numbers considered and less than the second of those considered real numbers in any approximation to a mathematical limit. A limit that is never reached and in many cases is a mathematical impossibility or indefiniteness. And final results that can never be exact when calculations involve numbers with infinitely many decimal places, as is the case of all irrational numbers.

Therefore, it can be concluded that the successful infinitesimal calculus is not a continuous calculus as almost everyone believes. In reality, it is a discrete calculus, a calculus in jumps, in which the same uncountable infinite number of values (real numbers) is always jumped over in all approximations to mathematical limits, approximations that are omnipresent in infinitesimal calculus.

Thus, the success of infinitesimal calculus in experimental sciences such as physics would herald a new finitist and discrete mathematics, as well as one that is formally consistent. This consistency is made impossible in contemporary infinitist mathematics by the inconsistency of the actual infinity. What we do not know is how long it will take for the scientific community to consider these facts fundamental and foundational to its mathematical language.

But the big problem is that, as explained in the following section, neither infinitist (and inconsistent) mathematics nor finitist mathematics can give correct exact values in almost all cases where their respective calculations are applied to natural physical processes. This raises a very important question: From the point of view of physics, can a mathematical language that can never give exact results for the vast majority of physical processes be considered correct? Are there alternatives that do give them? The author will answer this last question in the second part of this article.

3. The inevitable physical inexactitudes of current mathematical languages

Let us consider the speed of physical objects, one of the simplest magnitudes in physics. Physically, all speeds v are a fraction of the speed c of light in a vacuum:

$$v = k \times c; \; k \in [0, 1) \tag{1}$$

For example, $k = 5/6 = 0.8333333\ldots$. If we want to express v with a single and exact number, we will have to perform the arithmetic operation of multiplying k by c. In the case of infinitist mathematics, we will have to take a finite number of decimal places of k from its infinitely many decimal places, and whatever that finite number is, the result of multiplying it by 299792.458 will never be the exact value of v, no matter how close it is to that exact value. In the case of finitist mathematics, $5/6$ is not a number but the definition of a potential infinite sequence of exact rationals numbers [6]:

$$0.8, 0.83, 0.833, 0.8333, 0.83333, 0.833333, 0.8333333, \ldots$$

And whatever number is chosen from that sequence, the result of multiplying it by c will not be the exact value of v, no matter how close it may be to that exact value. We would reach the same conclusion for a potential infinite number of different velocities. And for practically all physical magnitudes arithmetically related.

Thus, we must conclude that neither infinitist (and inconsistent) mathematics nor finitist mathematics can give exact values for the vast majority of physical magnitudes that are arithmetically related in more or less complex ways. And two final questions are then inevitable: can a language that, like mathematical language, cannot give the exact results of physical processes be considered correct and appropriate? Are there alternatives that can provide these exact values in all cases?

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