

Letter of appeal regarding manuscript PHYSSCR-125221

November 23, 2023

Dear Editors:

First of all, we would like to thank the editorial board for the consideration of our article, “The unphysicality of Hilbert spaces.” Stepping back, the main line of inquiry of this paper, and our work more in general, is determining whether a particular mathematical structure is the “correct” one to represent a physical system. While we are convinced that no real progress can be made in the foundations of physics without establishing a precise link between mathematical models and the physical systems they are supposed to represent, the academic community does not seem set up to encourage these discussions. Since the problem sits right in between mathematics and physics, and given that the fields have separate training, conferences, journals, culture, etc., most physicists do not have enough of the technical mathematical background required, and most mathematicians do not have the physical intuition that in the end must guide the decisions.

For example, one of us is working on the ill-definition of the path integral formulation of quantum field theory. That is, one of the most successfully used frameworks in physics assumes a measure that is mathematically proven not to exist. While one may think this is an important problem to address, most mathematicians consider the discussion settled that there is no solution, without looking for ways to address the problem, and most physicists simply do not care given that the calculations can be made to work, sometimes boasting of the fact that they do not care.

As another example, two of us have worked on the physical significance of the Lagrangian and the action principle, clarifying what the action is, and why, under specific physical assumptions, it is minimized. The paper was rejected without review by a good number of journals, including one specialized in the foundations of physics, claiming that the topic is not of general interest. It was published in a “catch-all” journal. Given this context, we are grateful that the current paper was at least sent for review.

Regarding the current paper, the aim was to show that not all elements of an infinite-dimensional Hilbert space in quantum mechanics can represent physical objects. The main point is a physical one: we cannot prepare or measure infinite quantities; therefore, pure states identified by infinite quantities cannot be physical. Moreover, time evolutions that transform finite expectation values into infinite ones in finite time cannot be considered physical, either. The main mathematical point is to show that it is the completeness requirement of Hilbert spaces that forces us to include pure states that correspond to infinite quantities.

In the cover letter we specifically recommended “not relying exclusively on reviewers who would focus primarily on the mathematical aspects” because “the core new idea is to look for physical justification of the mathematical structure, not simply internal mathematical consistency.” We found, in fact, that the vast majority of physicists who read the paper concurred that having a time evolution oscillating between finite and infinite expectation values is an objective problem. On the other hand, most mathematicians either abstained (as it is a physical matter), or argued that the mathematics is consistent, and therefore there was no problem. Unfortunately, both reviewers focused mainly on the math, and as predicted, “missed the main point of the paper.” For example, one reviewer contends that the expectations were undefined, rather than infinite, as if somehow undefined expectations for a physical quantity (e.g. energy) are better than infinite ones. The other argues that the infinity comes from infinitely many samples, failing to understand that a pure state corresponds to a single instance of preparation. Please see the separate attachment in which we provide a detailed consideration of each reviewer’s report.

Note that neither of the two reviewers disputed the mathematical point. However, neither of the two reviewers, in our opinion, seriously and knowledgeably considered the physical point. Neither seems bothered, for example, that the infinity is frame dependent and can be achieved in finite time. Thus, we would like to appeal the decision made by the journal.

While the immediate interest is for this paper, we feel that it is more important to recognize and mention the bigger problem, of which these reviews are a particular instance. We strongly believe that working toward mathematical tools that see their foundation/motivation in physical ideas and requirements is the only way to proceed toward a better understanding of our physical theories. This will have practical advantages in better understanding, better intuition and better generalized tools. This cannot happen if we can't even make the absolutely simple point that we cannot have pure states whose position or energy is undefined/infinite.

We are actively looking for a journal in which such line of research can be discussed. We would welcome harsh criticism if it were on point and would push us towards our goal. We realize that it is hard to find reviewers on these topics precisely because, for various reasons, there is little active research on them... but one of the reasons there is little active research on them is because they are very difficult to publish.

Naturally, it is the prerogative of the editorial board to decide whether this line of research is appropriate for the journal, particularly given the additional problem of finding suitable reviewers. We would completely understand if, even if in principle you agree with the spirit of our research, practical considerations make it unrealistic to pursue within the journal. In such case, we only ask you to let us know if you are aware of people, conferences or other journals that would be sympathetic to our endeavor.

Sincerely,

 Christine A. Aidala