

A Simple Quantum Argument Against the Block Universe

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To speak of block universes is to speak of the physical reality of worldlines. However, here is a simple question that needs to be answered before worldlines can be considered to be a physically and experimentally meaningful postulate:

If worldlines are real, wouldn't energy-time uncertainty make stable particles infinitely massive?

In his famous 1908 "Space and Time" lecture, [1] Minkowski introduced the concept of worldlines and thus of a block universe with a single remarkable sentence: *"To never let a yawning emptiness, let us imagine that everywhere and at any time something perceivable exists."*

In Minkowski's substance-filled block universe, the worldline of a particle such as a proton would require a finite mass-energy density per unit of time simply for the particle to exist and have a finite rest mass. However, in modern quantum theory — which was in its pre-infancy in 1908 — time as measured in experiments has no such sharp boundary. Time at the experimental level instead has a thickness that is inversely proportional to the mass-energy stability of the particles involved.

This is a curious thing, since defining the mass of a particle in any experimentally meaningful version of a substance-filled block universe necessarily requires some form of integration of the mass-energy density of the experimentally accessible subsegment of that particle's worldline, which is defined by the rules of quantum mechanics. Unfortunately, those rules do not provide any obvious method by which to define the extremely precise time brackets needed for a well-defined, stable rest mass. Quite the contrary is true, in fact, since energy-time uncertainty would appear to suggest that the more stable the particle is, the broader the brackets of its mass-defining worldline time integral will be. The *reductio ad absurdum* is that protons and electrons left undisturbed for long periods of time in a block universe should acquire rest masses that trend towards infinity. Similar arguments would of course also apply to other particle properties such as electrical charge, which to be experimentally meaningful would also require integration of an associated charge density per unit of worldline.

So my question is this: For modern block universe interpretations that implicitly (and as best I can see, unavoidably) accept Minkowski's casual insertion of "substance" throughout spacetime, what is the precise, quantum-compatible mathematical model by which the stable masses of fundamental particles are derived from their worldlines in the presence of energy-time uncertainty?

References

- [1] H. Minkowski, "Space and Time," *80th Assembly of German Natural Scientists and Physicians*, 1908.