How Gamma Ray Studies Disproved Wheeler's Quantum Foam Speculation

Terry Bollinger
2023-08-25.00:05 EDT Fri (with 2023-08-26 addendum: QM as an xyzt frame algebra)
https://youtu.be/uvubLp5o5Wg&lc=UgwWslJVKqLuPm9nFMp4AaABAg

A Comment on the PBS Space Time (YouTube) post:
What If Space is NOT Empty? (Aug 24, 2023)
https://youtu.be/uvubLp5o5Wg

First, Matt, I am sincerely sorry, but your delightful Mad Libs quote at the very start of your excellent video had me rolling on the floor: *"Let me tell you why we should take [description then noun] seriously, even though we've never seen any evidence of it."* Oh my, my, my… with no evidence, one could put anything into those brackets, and you get a valid Mad Lib! Is it [jumping green Leprechauns]? Plausible, at least if they are not of the magical variety! Or perhaps… [One-Eyed, One-Horned Flying Purple People Eaters]… Nah, too many words! But again, with no evidence required, who even cares? All bets are off! It's just… perfect! You've captured most of modern non-condensed-matter, no-evidence-required theoretical physics in a single one-sentence Mad Lib nutshell!

More seriously, it's incorrect to say there's no experimental evidence for this. There exists robust evidence, but of the negative variety. In 2020, the HAWC Collaboration eliminated Wheeler's Planck foam hypothesis — and that's all it ever was — by using superbly done large-scale experiments on extreme cosmic gamma rays [1]. The HAWC Collaboration showed that the very existence of such extreme gamma rays required spacetime to be at least *1800 times smoother* than Wheeler's hypothesis proposed.

Here that is using Matt's boat analogy: If you were riding on one of these extreme gammas and expecting Planck waves 1.8 meters in average height, you would see… nothing. The actual waves, if any, would be no larger than a centimeter high. Einstein nailed this one with his special relativity Lorentz invariance, perhaps even better than he realized. Wheeler was just… well, flatly wrong.

Now, after that, you may be surprised to hear that I found myself heartily agreeing with one point Matt made, which is this: Spacetime most definitely does become ratty after a certain point, to such an extent that our very definitions of travel, motion, and even time itself begin to unravel and loss specificity. That part is spot on for a simple reason: We have a vast preponderance of evidence. It happens in labs all the time.

Uh… huh?

It's just not at the scale everyone was expecting. Have you ever heard of double-slit experiments? You know, the ones in which it becomes impossible to say where some relatively large object moved when two separated paths are available? Yeah, that one.

Here's the trick — two tricks, really:

(1) The only way you can ever measure space or time is with rulers and clocks — and those are always, always, always made out of matter and energy, not "spacetime." The 1905 version of Einstein was excruciatingly careful on this point before his former instructor persuaded him over to infinitesimally perfect, classically-inspired formal maths to replace grubby rulers and clocks. The point is this: If only matter can measure space and time, then the resolution of space and time is determined not by arbitrarily assuming spacetime to be a fabric but by when matter becomes quantum. Since the energy scales at which matter becomes quantum are tens of orders of magnitude milder than those of Wheeler's disproven foam hypothesis, they become readily accessible in ordinary labs. We even have a name for the physics of variable-resolution spacetime: quantum mechanics. [Notice that in this view, even curved space converts into a precise set of relations between instances of mass and energy. General relativity keeps the same math, mainly, but the interpretation of how that math maps onto physical reality changes profoundly.]

(2) Why should folks think every shared-frame collection of matter must use the same level of xyzt precision? For example, a sheet of metal with two slits is mind-bogglingly well-defined in space and time precisely because it has many atoms and a vast mass. But why should this level of xyzt precision hold for an electron that couples only briefly and weakly with the sheet during its journey? The precision of our condensed matter world is a mask that fools us into thinking every entity must see the "same" spacetime as us, even when quantum mechanics incessantly and relentlessly harangues us not to assume that what we see from the large-matter observer view is not what tiny object experience.

Thus, yes, space and time fall apart constantly. We call the oddly well-structured way it falls apart "quantum mechanics." Ironically, this means spacetime breaks down most not at high energies and masses but in systems with the lowest masses and energy — precisely the opposite of what Wheeler's speculation suggested. When space and time fall apart in smaller systems under human observation, such as in double slits and quantum erasure experiments [2], they do so in highly perplexing ways if we insist on interpreting them using only our enormously more massive, and thus more precise, observer xyzt frames. Interestingly, you are reading these words by relying on such a blurring of spacetime for low-energy entities. The photons entering your eyes don't have enough resolution in their version of xyzt to "see" the many irregularities in your cornea and lens. Instead, they get only a blur containing just enough information — the shapes and refractive indexes of your corneas and lenses — to calculate their optimum paths.

So Terry: If you are so sure you are right, where are your peer-reviewed papers?

Take a look at that HAWC paper. It has about 80 outstanding physicists listed as authors. Have you seen them doing interviews? Have you seen the string theory and quantum gravity communities falling over backward to consult with them, discard their failed Wheeler-inspired speculations, and brainstorm with the experimentalists on how to get rid of the genuinely appalling infinite-vacuum-density that pops out when attempting to apply the otherwise highly successful quantum field theory at cosmic scales? No?

Neither have I. So, I think I'll keep working hard on a few interesting modeling problems that, at this point, require quite a few unsetting deep-assumption resets. We call it backtracking in AI, but it works, even when it's unsettling from the complex perspectives of human societies that often operate under more complex parameter sets.

QM as an Algebra of Interacting xyzt Instances

Addendum comment made at 2023-08-26.12:28 EDT Fri

https://youtu.be/uvubLp5o5Wg&lc=Ugzo30Bvq5nJ09YUqDJ4AaABAg

Matt, thank you! Your emphasis on spacetime "falling apart" at the Planck level helped me see a new and, I think, more quantifiable interpretation of quantum mechanics as an algebra of interacting xyzt instances created by varying-scale collections of closely interacting mass-energy parts. Each frame xyzt has a resolution, orientation, and… hmm, yes, a spin! Interesting… I wonder if some Planck foam maths might be relevant if rescaled attached to mass-energy limits? An xyzt instance algebra of multi-scale spacetimes that interact and rescale (collapse) each other, with the high-mass units tending to dominate, opens up new paths… Perhaps that's all collapse is: Joining the larger local Inertial Frame Club. Again, thanks!

References

[1] A. Albert et al., *Constraints on Lorentz Invariance Violation from HAWC Observations of Gamma Rays Above 100 TeV,* Physical Review Letters 124, 131101 (2020). https://arxiv.org/abs/1911.08070. From the abstract: *"HAWC finds evidence of 100 TeV photon emission from at least four astrophysical sources. These observations exclude, for the strongest of the limits set, the [Lorentz invariance violation] energy scale to … over 1800 times the Planck energy."*

Translation: The universe experimentally requires empty space to be at least 1800 times smoother than the absurd figure calculated by the great (and he was) John Archibald Wheeler. Wheeler made a mistake. He was a clever fellow, but he also made many errors. Where's the other antimatter half of the universe? He was dead wrong on that one. He was also experimentally wrong on his Planck scale postulate since the most energetic gamma rays observed cannot exist on a lattice as grotesquely large as the Planck limit. [An amused observation of my own phrasing: When was the last time you saw someone apply the phrase "grotesquely large" to the Planck scale?]

Sadly, even three years after those amazingly well-done experimental results, I've only seen one prominent theoretical physicist acknowledge fully that the HAWC Collaboration invalidates the concept of spacetime losing smoothness at the Planck scale. That would be Sir Roger Penrose, and I heard him say it live and first-hand in a small Zoom chat.

[2] S. Hossenfelder, *The Delayed Choice Quantum Eraser, Debunked,* Sabine Hossenfelder (YouTube), Oct 30, 2021 (2021). https://youtu.be/RQv5CVELG3U