New Results Bolster Penrose's Quantum Consciousness Hypothesis

Terry Bollinger
2024-05-13.15:44 EDT Mon (with 2024-05-17 comments addendum)

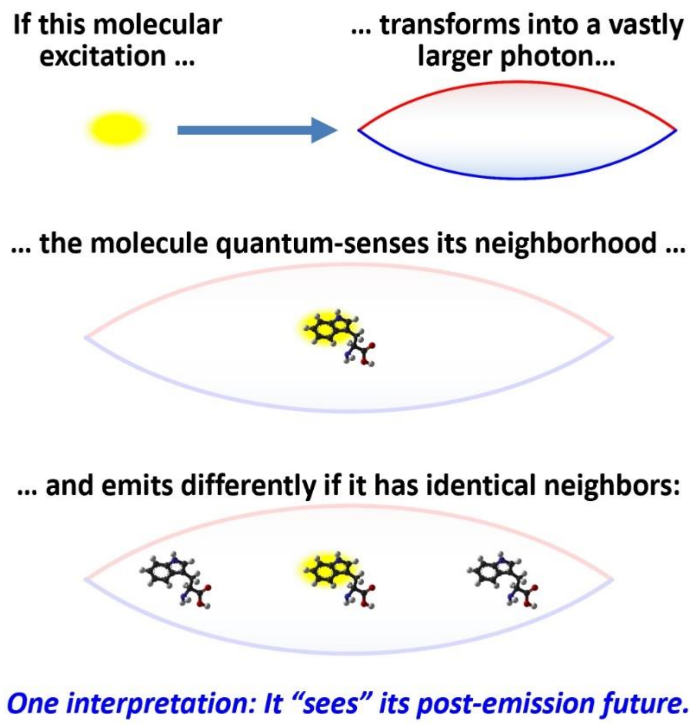

Figure 1. *Tryptophan networks, common in brains, can support durable "superradiance" quantum states.*

(The YouTube video for this comment is available at [5]. This article began as a Patreon-only comment [6].)

An interesting quote from the Babcock *et al.* paper [1]: "Our work thus showcases the many orders of magnitude across which the brightest (hundreds of femtoseconds) and darkest (tens of seconds) states can coexist in these Trp lattices."

The term for this effect is superradiance, and observations of such effects in dye solutions date back to 1936 [2]! The great Robert Dicke coined the term superradiance much later, in 1954 [3], and his article provides a nicely understandable introduction to the topic. A more recent article [4] on whether superradiance can occur in quantum dots (it can) also provides some nice explanation.

My point is this: This is anything but "wild" or "fringe" quantum science. It's just that no one seems to have applied superradiance theory to regular tryptophan networks, which, in retrospect, is kind of "duh" since tryptophan is the only amino acid with the easily florescent indole group (or "moiety"). It seems no one ever *thought* to look for superradiance in structured tryptophan networks before — at least, not until Babcock et al.

The old quantum literature is mercifully free of modern "entanglement" angst (sorry) and instead applies solid math models in unexpected ways. Superradiance has ties to coherent emission and lasing but is much weirder. Dicke [3] nicely explains this point, emphasizing, for example, that doing nothing more than placing an unexcited neutron in a magnetic field at some nicely classical distance from an excited neutron *increases* the probability of the excited neutron flipping and emitting a photon. Say what?

What's going on is that even though the *neutrons* are classically separated and unentangled, the photon has a far larger wavelength that encompasses both neutrons. That's the trick: Involving an entity (the photon) whose wavelength is large enough to bridge the classical bits and lead to an overall coherence. Regularity in the classical part helps, but there's also much tolerance. It's a great way to get quantum (large-wave) effects in messy biological systems.

But, for the devil's advocate position, is it *only* a wave effect? Is superradiance no more exotic than ocean waves causing otherwise isolated buoys to bounce up and down in unison?

No. The problem is that this is a probability wave, not a traditional wave. If you look carefully at what I said, you may have noticed something odd: How can a photon *not yet emitted* "sense" tryptophan molecules in a way that results in a coordinated response? These waves defy typical expectations of how time works, reflecting that they are quantum rather than ordinary waves.

I tried long, long ago in a few emails to Roger Penrose (he even replied to one, most likely in amusement, I suspect) that he should be looking at very-low-energy quasiparticles rather than direct coherence between his microtubules, the latter being what I got (and, um, still get) when I read those papers. What I like about this Babcock et al. insight and experimentation is that it solidly pulls the idea of "time tolerant" coordination back into the low-energy domain, where it makes good quantum mechanical sense and has solid experimental support.

For whatever it's worth, I don't buy into the idea that quantum "collapse" is the important feature of how something like this might add to the computing power of a neural system. It's that same "time tolerant" wave effect — the idea that a photon *not yet emitted* can coordinate behavior coherently across a large, well-structured tryptophan network — that smells suspiciously of what is needed to give a computation boost.

And yes, if you insist on getting into the consciousness-angst mode, the idea of non-standard-time coordination *might* provide a nice path to define "qualia" and such. Playing games with short-range time flow — they can never grow larger than the bounds defined by speed-of-light-limited setup times, which is how you keep from violating causality in these classes of quantum phenomena — has a nice ring to it for attempting to define complex computing "devices" in sloppy biological networks.

More bluntly, perhaps "red" and "blue" qualia are nothing more than particular combinations of tryptophan excitations that define *unique* "structures" of time-free coordination. In that case, the neural trick would be *creating and sustaining* these not-quite-classical, not-fully-time-bound complexes of structured tryptophan excitations.

That's testable. The fact that folks have been doing solid lab work using not-exactly-in-classical-time superradiance effects in media such as structured dyes says point-blank that the *outcomes* of such non-standard-time coordination are entirely real and can be studied.

The first goal is this: Can researchers create more complicated examples of superradiance constructs containing different scales and types of excitations within a single connected structure? It sounds plausible. You could even use those quantum dots [4], which are notoriously difficult to control, to implement patterns.

And that's an interesting thought: Might quantum dots be hard to control precisely because they are *already* accessing some of these partially "atemporal" coordination structures, just not in an orderly fashion? In that case, the computing power of the interacting atemporal coordination domains would tend to randomize the results.

Apologies, all. I do science out loud, not in stealth mode. More fun!

Addendum: The conversation on the next three pages elaborates on several points.

---

sycamore, 2024-05-15.05:11 EDT Wed
https://medium.com/@yavorva/didnt-know-about-those-modes-could-you-pls-elaborate-thx-21fcdde2ce49

Terry Bollinger said: *"Apologies, all. I do science out loud, not in stealth mode. More fun!"*

didn't know about those modes, could you pls elaborate? thx)

Terry Bollinger, 2024-05-16.00:17 EDT Thu
https://medium.com/@terrybollinger/i-have-no-interest-in-hiding-hypotheses-that-i-assess-as-having-a-high-probability-of-proving-1091c9dafaed

I have no interest in hiding hypotheses that I assess as having a high probability of proving correct. That means nothing if my assessments are no good, but that's an evaluation for others to make, not me.

I prefer that approach because collective intelligence almost always works better for solving hard problems. It's also just way, way more fun. It's more like solving a jigsaw puzzle, as opposed to stressing out to get a publication record that, in the long term, probably means nothing.

Despite how casually I threw this out, this Babcock et al. work is so solid from a physics perspective and enticing from a quantum logic perspective that the single paper has completely flipped me into being a Penrose advocate. My only quibble is that Penrose is focused on collapse, whereas he should be focused on sustainment. Qualia and consciousness are sustainment issues, not collapse issues, although how they process information invokes collapse.

Also, for the very first time, I feel as though there's a path forward for understanding qualia and consciousness from a physics perspective. I've always thought that true, but I never thought the quantum approach worked due to the lack of localization of the information processing components.

I love that this paper used century-old physics to blow that out of the water! I can't even tell you how many intriguing pathways this opens up. The study used ultraviolet light, unrealistic inside the brain but vastly easier to verify in the lab.

Far from being a detriment to their idea, using lower-energy activations of tryptophan networks, such as by some neural triggering activity, produces *better* delocalization, not worse. Wow.

The activations can compete with each other, and when they do so, they do it by bending the normal boundaries of time and space. We call that bending quantum uncertainty, but that *so* understates the potential power of local blurring of time.

My point about local excitations "seeing" wave release events that have not yet happened captures the impact of quantum uncertainty better in this context. Conversely, if you focus only on uncertainty, you could easily miss that.

I'm seeing the possibility that the physical maps of the external world that are well-known in neurology could have excitations that overlap, compete, and compute with each other. These curious maps of the external world may have been trying to tell us something important, but we never knew how to read them.

I mean, dang… Penrose may have nailed this decades ago! He just needed an experiment like this to determine which aspect of quantum delocalization is robust enough to exist in brains. This work not only does that, but it points to easy possibilities for activation and interaction between the resulting domains. Qualia may be nothing more than specific configurations of these quantum-anticipatory releases of local energy.

The concept makes me itch to propose experiments and look for new connections. I've never had anything in this area make me feel that way, and that alone fascinates me.

Someone once asked me what my favorite theory of consciousness was. My cheeky (but honest) answer then was "my own, which I had not yet invented."

Well, it's time for an update on that! I would now say that the correct path forward is almost certainly Penrose tryptophan networks combined with Babcock robust quantum delocalization.

Hyperradiance produces many juicy potential "homework problems" that should be well within current neurological testing capabilities. That's an area I've been keeping up with, and I think our technologies are up to this task.

Intriguing! Very, very intriguing.

---

sycamore, 2024-05-16.01:25 EDT Thu
https://medium.com/@yavorva/are-babcock-et-al-9c1b7cf5160f

are Babcock et al. aware of your perspective? it could be a wider phenomenon, applying to animal neurology too.

Terry Bollinger, 2024-05-16.02:43 EDT Thu
https://medium.com/@terrybollinger/i-have-no-idea-who-these-folks-are-so-unless-they-have-read-some-of-this-discussion-i-would-416df8f22df7

I have no idea who these folks are, so unless they have read some of this discussion, I would assume not.

From their paper, I suspect they view this as an extremely broad biological effect. Anything that uses sets of neurons would have at least limited access to HC (hyperradiance computing). However, most would be limited in complexity by the smaller size of the networks — not enough media to create or sustain complex states. Think simple qualia, at best.

What's nice is that once you get a large enough medium with greater connectivity, HC can explode in complexity — a bit like networking quantum computing, but without the severe qubit constraint.

What we call consciousness would be an especially complex form of complex sustained states closely correlated to the concept of short-term memory. That might be why we can only hold a handful of items (about seven?) in our heads simultaneously: Our brain sizes and topologies don't have room for more than that number of top-level sustainable HC states.

---

sycamore, 2024-05-15.05:05 EDT Wed
https://medium.com/@yavorva/did-you-mean-terry-that-entanglements-defining-probabilities-across-space-and-time-were-at-play-1f954f5c3757

Did you mean, Terry, that entanglements (defining probabilities) across space and time were at play before the collapse: emitting photon?

Terry Bollinger, 2024-05-16.00:26 EDT Thu
https://medium.com/@terrybollinger/yes-dickes-paper-does-a-particularly-good-job-of-explaining-why-this-entire-structure-violates-332c6ae94d0e

Yes. Dicke's paper does a particularly good job of explaining why this entire structure violates classical information flow assumptions. The other molecules were particles too far away to be seen by the excited one. Yet if, in the future, that excited particle can release a wave that would encompass those other particles, they have relevance to the excitation *now*, not later.

These curious tweaks on time excited people about the potential of qubits and quantum computing many decades ago. However, since they tried to superpose some of the most non-superposable systems imaginable — those being information-rich computers — that path has not worked as well as it should have.

This path, in contrast, has simple potential and better physics. Again, this is century-old physics!

Terry Bollinger in reply to Ethan Siegel, 2024-05-16.18:46 EDT Thu
https://medium.com/@terrybollinger/thank-you-ethan-siegel-afdfd08e2cb5

Thank you, Ethan Siegel [for your insightful reply]. We agree that molecular aethers are a nonsensical concept for General Relativity! It is truly an awful analogy. Aethers also fail horribly for Special Relativity.

The analogy is not mine. The amazing James Clerk Maxwell created it with his space-filling ocean of twirling, fully mechanical "molecular vortices." He then used this rather bizarre model to calculate the speed of electromagnetic waves. That was how he proved light was a form of electromagnetic radiation. Wow!

Maxwell did that *before* he abandoned his molecular vortices and switched to quaternion-based differential equations. After Heaviside later converted Maxwell's 20-some quaternion equations into the 4 Maxwell equations we know today, they became the inspiration and model for modern field theories and explorations of symmetries.

I'm nothing more than a bewildered debugger. Nonetheless, from that debugging perspective, there's an aspect of Maxwell's transition from lumpy molecular vertices to continuous differential equations that bothers me.

Maxwell knew that the finite sizes of his molecular vortices introduced a graininess not seen in electromagnetic phenomena. This lack of evidence for grainy behavior remains true, including for the most energetic gamma rays ever observed.

Maxwell fixed this by switching to differential equations. The resulting smoothness matched all observed electromagnetic behaviors perfectly! All done. Right?

Well, not quite. Maxwell's differential equations removed the grainy behavior of molecular vortices not by eliminating the vortices but by shrinking their behaviors down to point size on a mathematical continuum.

Here's a question: If you shrink the oscillators of an explicitly aether-based field theory until they are point-sized — yet still get the same results as the aether-based version — did you truly get rid of the aether?

Or did Maxwell inadvertently do nothing more than sweep the aether question under a prettier clean-equation rug?

sycamore, 2024-05-17.12:53 EDT Fri
https://medium.com/@yavorva/of-course-you-did-get-rid-of-the-always-finite-size-83b9cd91041d

of course, you did get rid of the (always finite-size!) aether by shrinking oscillators to infinitesimal points, regardless of the same results; let alone getting rid of aether's unobservable grainy effects, all is good.

Terry Bollinger, 2024-05-17.23:03 EDT Fri
https://medium.com/@terrybollinger/sycamore-great-points-thanks-461860093985

sycamore, great points, thanks! Here's my mild edit of your quick note to make sure I understood you rightly:

[*Of course*, Maxwell eliminated the always finite-size aether by shrinking oscillators to infinitesimal points! Shrinking his oscillators into infinitesimal points eliminated his earlier aether particles [by converting them into pure math]. It doesn't matter that his new theory gave the same result as the older model. And don't forget, Maxwell also eliminated the unobservable (and thus invalid) grainy effects of his earlier aether models. So, all is good!]

This is a classic calculus limit problem! So, here are two points that are delightful puzzles to contemplate:

(1) A what point in this shrinking process does the oscillator aether stop being an aether? Only at infinity or at some point before? Or, more importantly, *why* do the oscillators stop being oscillators? There's nothing in the calculus process that forces this disappearance to happen. The summation process points in the *opposite* direction. Far from eliminating the aether particles, shrinking them increases the *number* and *density* of the oscillators in a given region of space. It's like moving from a pool filled with balloons to marbles: Everything gets *more* intense, not less. If you are familiar with renormalization, that's kind of why folks like Feynman *created* normalization: As a way of getting around the blatantly increasing infinities that seem to point in the wrong direction as the scale shrinks. The same problem is also (and always) the true root of calculations that seem to end in the universe collapsing or exploding. If empty space has infinitely many infinitely small but highly complex coupled oscillators, how can it not collapse? Feynman once publicly made fun of his own Nobel-Prize-winning QED theory, asserting at Princeton that it didn't make much sense to fill a cubic centimeter of empty space with infinitely dense calculations. His suggestion? "It's probably something simple, like a game of checkers." Good advice.

(2) The other and greater problem with infinitesimal models producing the *same* results as aether models is that aethers exist only within a *single* inertial frame. Lorentz called this coordinate frame the "system at rest relative to the aether" [7]. Thus, if the new theory gives the same results as the aether theory, it gives them only for the frame of that explicit aether — the laboratory frame. There is nothing mysterious about this, except that everyone seems to forget it when they express theories in equations. The equations accept any number you put into them, but where did those specific, non-quantum, non-relativistic (scalar) numbers come from? From you. In *your* well-defined, well-instrumented inertial frame. You can get your completion number by adding an *implied* parameter to the equations. The missing or hidden parameter is the *frame of analysis*. It is missing in a great many physics theories.

As a computer scientist trained to look for and pay careful attention to missing parameters, the degree of inattention to this critical issue in physics startles me. Equations are independent of material systems if you *imagine* them to be, which parts of our neural circuitry powerfully encourage as an extremely useful sensory processing shortcut. Even the equations in your head are bound by special relativity since they are information and thus can move slower direction of travel than in the opposite direction [8].

Is all of this nitpicking? No. Quantum field theories produce horrifyingly dumb predictions at cosmological scales precisely because *they only describe one frame of reference*. Surprise! Special relativity says the universe doesn't work that way. And if you copy the same global-variable omission into general relativity, expect some dark issues.

References

[1] N. S. Babcock, G. Montes-Cabrera, K. E. Oberhofer, M. Chergui, G. L. Celardo, and P. Kurian, Ultraviolet *Superradiance from Mega-Networks of Tryptophan in Biological Architectures*, The Journal of Physical Chemistry B **128**, 4035–4046 (2024). https://pubs.acs.org/doi/epdf/10.1021/acs.jpcb.3c07936

[2] E. E. Jelley, *Spectral Absorption and Fluorescence of Dyes in the Molecular State*, Nature **138** (3502), 1009–1010 (1936). https://www.nature.com/articles/1381009a0

[3] R. H. Dicke, *Coherence in Spontaneous Radiation Processes*, Physical Review **93** (1), 99 (1954). https://journals.aps.org/pr/abstract/10.1103/PhysRev.93.99

[4] M. Scheibner et al., *Superradiance of quantum dots*, Nature Physics **3** (2), 106–110 (2007). https://www.nature.com/articles/nphys494

[5] T. Bollinger, comment in "S. Hossenfelder, *Brain Really Uses Quantum Effects, New Study Finds*, Sabine Hossenfelder (Patreon) **2024**, 0512 (2024). https://www.patreon.com/posts/brain-really-new-103951878"

[6] S. Hossenfelder, *Brain Really Uses Quantum Effects, New Study Finds*, Sabine Hossenfelder (YouTube) **2024**, 0512 (2024). https://youtu.be/R6G1D2UQ3gg

[7] A. Einstein, *The Theory of Relativity* [with Figures], Naturforschende Gesellschaft, Zürich, Vierteljahresschrift **56**, 1–14 [Jan. 16] (1911). https://sarxiv.org/ref.1911-01-16.figs.pdf. See page 5, five lines up from page bottom (page 6 in German original).

[8] T. Bollinger, *A No-Math-Needed Explanation of Time Dilation*, Apabistia Notes 2024, 04212315 [Apr. 21] (2024). https://sarxiv.org/apa.2024-04-21.2315.pdf