Quantum Geodesics and Gravity Emergence

Terry Bollinger
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This dialog began with observations on how deeply the experimentally disproven Wheeler concept of "quantum foam" has permeated physics for about 70 years. After several pointed questions, it quickly became a discussion and source of a name for a new concept of "quantum geodesics," a version of geodesics in which the lack of acceleration emerges from the incomplete spacetime emergence. The idea provides an arguably novel approach to unifying gravity and the other forces. It has a nice potential for explaining the standard rules of quantum mechanics as emerging whenever a single, large, well-defined, "classical" observer inertial frame imposes its definition of space and time on a much smaller system. The dialog began with an excellent summary by Sandeep Singh [1] of a 2013 overview article [2] on emergent spacetime strategies.

Terry Bollinger [3]: Sandeep Singh, thanks. This paper [Emergent Spacetime and Empirical (In)coherence, https://arxiv.org/abs/1206.6290] is an excellent resource!

The paper is a reminder, at least to me, of how powerfully and deeply Wheeler's 1955 "Planck foam" ("geons," then) speculation influenced the next 70-some years of physics. For example, all sections of this paper reflexively assume reality to emerge at the Planck scale, even the section on non-metrical causality networks closest to Lamport network logic.

The phrase "Planck scale causality" is odd if you think about it since experimental causality uses only entities with finite energy and mass — Einstein's rulers and clocks, generalized — to define causality. "Empty" space becomes an oxymoron in causality relationships since until you place mass or energy in that space, there's nothing to measure. It is an oxymoron even for the virtual pairs surrounding an atomic nucleus. Without the polarizing charge of that nucleus, such pairs become causally unobservable.

When I read papers like this, math that uses *xyzt* concepts of metrical location that, in turn, depend on complicated heuristic assumptions increasingly troubles me. Poincaré rules reality, not Euclid. You need a pure relationship space to overcome the relativistic paradoxes of overextending the Euclidean shortcut.

Michal Grochol [4]: Shouldn't you use GR?

Terry [5]: Good question. My most honest answer is that unconstrained GR applied at the quantum level produces nothing but mathematical noise, with Wheeler's experimentally disproven Planck foam being the most pointed and extreme example.

Michal [6]: Right. We don't have a theory of quantum gravity, so you can speculate as you want.

Terry [7]: Good point. One problem-solving technique is to take a different perspective on the same problem, so here's a different angle on force unification: Why does the electron in a hydrogen atom behave as if it is in a zero-gravity environment, that is, as if it feels no acceleration forces at all, and thus has no need to radiate its energy?

Michal [8]: Are you suggesting there should be gravitational waves for an electron in the hydrogen atom?

Terry [9]: I am suggesting that the link between gravity and the other forces is far more intimate than we think. Just as the van der Waals forces are incredibly weak shadows of the electromagnetic force left over after most of those forces have canceled themselves out, gravity is an incredibly weak shadow of how quantum mechanics deals with acceleration. We've been looking at the problem backward.

Michal [10]: How would you understand "looking at them forwards"?

Terry [11]: When I say current approaches to unifying General Relativity and quantum theory are approaching the problem backward, they assume that flat-space quantum mechanics does not use the concept of curved spacetime.

It's the other way around: Even at the modest energies of electron orbitals, quantum mechanics uses geodesic paths so extreme that they make the curvatures even of black holes look like shadows and mists.

Bold claim, Terry! Where is your evidence?

The simplest test for curved space is the presence of trajectory paths —geodesics — that allow a body to move without experiencing acceleration. Satellite orbits are one example.

Surprisingly, well-studied systems exist in which fast-moving, electrically charged bodies move in atomically sharp curved paths for indefinite periods without experiencing acceleration. Due to being charged, these bodies would emit electromagnetic radiation if accelerated. The absence of emissions shows they follow exceptionally severe versions of curved-spacetime geodesics instead.

Terry [12]: *Uh… Terry? You* do *know that you just described an electron's lowest energy (base state) in an atomic orbital, right?*

Sure, that's what I said: Electron orbitals are the second most extreme form of naturally occurring geodesics in nature, surpassed in severity only by quark orbitals (the real "strings") of protons, neutrons, and other hadrons. We don't notice these *quantum geodesics* because quantum theory accepts the absence of electromagnetic emissions as an axiom-level given instead of looking for a deeper explanation.

The Einstein metrical systems we call "flat" spacetime emerge from the mostly self-canceling interactions of large, highly structured collections of such quantum geodesic constructs — from condensed matter. The "mostly" is important since that tiny bit of leakage is the source of the extremely weak, large-scale-only curvatures we call gravity. It is not a coincidence that Einstein insisted on defining all experimentally meaningful coordinate systems, including time, by starting with the "rigidity" of condensed matter.

The deeper issue is that there are simpler forms of spacetime than *xyzt*, whose geodesics give rise to the traditional forces.

Michal [13]: How big are these bodies? Do you assume that an electron in a hydrogen atom should emit radiation? Isn't that an old, well-known idea?

Terry [14]: (This is Terry physics): Since classical "space," "time," and "locations" (points) are always and only interpretations attached to inertial observers, a fundamental fermion or boson can only be truly "point-like" to itself. To an outside observer, its quantum geodesics orbit acquires precisely the math and form we see in quantum mechanics: It becomes an orbital — that is, a diffuse, non-point cloud of mass, charge, and spin. Geodesics would not replace Schrödinger's equation but would instead make into the emergent mathematical description of how an electron geodesic looks from the perspective of a classical inertial frame.

Michal [15]: Are you claiming that geodesics and curved space could explain an electron's lack of EM radiation in quantum physics without invoking quantum mechanics?

Terry [16]: Yes. The absence of acceleration while moving is shared by both theories. But I am not saying geodesics "instead of" quantum mechanics. I am saying this is how quantum mechanics achieves stationary states.

Michal [17]: Are you then suggesting that we could observe these geodesics in our classical inertial frame and avoid the collapse of the wave function?

Terry [18]: Good question. That's getting into interesting turf!

Answering it requires new maths. To create these new maths, one must avoid mathematical formulations that assume, as a given, full orthogonality of the quantities involved. Safe use of fully orthogonal mathematics, such as Schrödinger's equation, arises only with massive, well-defined inertial frames as observers.

Wigner phase spaces, which include the delightfully counterintuitive possibility of negative probabilities, certainly hint in the right direction. Wigner was one of the founding fathers of quantum mechanics. What an amazing mind!

Another mathematical avenue I think is likely to prove critical is the Lamport protocols that keep the Internet coherent and non-paradoxical. When every particle has its own little spacetime, that's exactly the kind of non-centralized accounting needed.

The most critical factor, though, is acknowledging that universal spacetime is a nonsensical concept. We have change, separation, and causality (emergent information), but none of these intransigent features require *one xyzt* spacetime, which is a far more rigid set of constraints.

That is why every inertial observer has their own spacetime. But we need to go deeper.

Terry [19]: Earlier in this discussion, you asked me a delightfully difficult question: If my claim that current strategies to unify gravity and quantum mechanics are going about the issue "backward," what, exactly, do I claim would be going "forward"?

It's a hard question, but it forced me to look at exactly what I meant or figure out how to say it better. The final answer was truly "opposite" enough to standard unification approaches that it was worth capturing in a short (one-page) open-access PDF note:

Quantum Geodesics and Gravity Emergence [NOTE: That is this document.]
https://sarxiv.org/apa.2024-03-23.1707.pdf

The most amusing part of my earlier answer was a one-liner where I casually declared "strings" to the universe's deepest source of curved-space dynamics. Why is that funny? Because I mean *real* strings, the ones from the 1960s: quark orbitals, also called flux tubes.

That's another way of saying our universe is much lower resolution than the whole "Planck foam" debacle would have us think. Still, and somewhat remarkably, the universe does have some nicely stringy behaviors, and those stringy behaviors relate in a non-trivial way to gravity.

Michal [20]: It seems you are pointing towards string theory, and possibly a graviton can also be seen there.

Terry [21]: No. "Super" string theory is unavoidably an aether theory since it fills space with a dense network of tiny resonators, which leads to issues such as infinite vacuum densities. I still recall my shock when I read a paper by Brian Randolph Greene (he has papers, not just books) and finally realized he was stuffing all of space with these incredibly complicated, highly classical (length, inertia, rotation) devices. *[Note: In that sense of filling space with tiny classical machines, "super" strings are fancier versions of Maxwell's early and explicitly aether-based "molecular vortices" model that similarly filled empty space with a dense fluid of fully classical machines [22].]*

I had always assumed “super” strings were just versatile, multistate particles that fully respected Einstein’s aether-free version of spacetime and took on different particle appearances depending on how they vibrated.

These “super” string resonator aethers were first proposed in the late 1970s [23][24] when the completion of the Standard Model left everyone with nothing to do. They don’t provide enough resolution to deal with known extreme gamma-ray experimental data. They are too large and clunky by at least 2000 times [25]. The same problem applies to loop gravity and gravitons, all of which rely on Wheeler’s experimentally disproven Planck foam (“geon”) speculation [26][27] as a given.

Hadronic strings turned out to be quark orbitals and, thus, components of ordinary particles. They don’t assume aethers like “super” string theory does.

Michal [28]: I guess that the contemporary candidate for an ultimate particle theory is the string theory, which is fully quantized. I am unsure about D-branes’ role and whether an electron is a string. But string theory can predict gravitons, although we don’t know if we need this particle.

Terry [29]: Pauli and Fierz first proposed gravitons in the late 1930s [30]. I can’t help but suspect that Pauli was uncomfortable with General Relativity since his typical way of dealing with an issue he did not understand was to declare that it did not exist. His first step in creating gravitons was to declare that only flat space exists. He then postulated a quantum-by-definition “graviton” force in its place.

Gravitons only create a pseudo-gravity force, not gravity. Even for that narrow goal, no one has ever developed a mathematically self-consistent formulation of gravitons.

Why do I call anything involving gravitons a pseudo-gravity force?

Because once you remove Pauli’s *ex-cathedra* declaration that GR is wrong and space cannot curve, real gravity returns with a vengeance. You end up with two forms of gravity: The real gravity created by curved space and a pseudo version created by Pauli’s mathematically inconsistent gravitons.

Sadly, a few folks in physics take cheap shortcuts. They then work hard to get enough papers published to give the idea momentum, even if it blatantly contradicts experimental results. There are a few cheaper shortcuts than gravitons, which discard instead of explaining General Relativity.

Michal [33]: I agree that we need new mathematics that encompasses both dark and bright matter and manifests itself as the Schrödinger and Dirac equations in the limiting cases. However, I am not convinced that probabilities can be negative and that universal spacetime can disappear, though I think that non-locality should be a feature.

Terry [34]: Michal, thanks again for many great questions. I have some quick comments, and then I need to move on. I’ll add a long answer to your latest questions in the Apabistia Notes version of this dialog, but not in this LinkedIn comment. I’m tired of jumping through the LinkedIn “no more than 1250 characters” loop and getting lost in all the disappearing and reappearing comments (hence all my direct links).

One more time, the citation info and link for the paper version — which I expanded yet again on Monday — is:

T. Bollinger, *Quantum Geodesics and Gravity Emergence*, Apabistia Notes **2024**, 03231707 [Mar. 23] (2024). https://sarxiv.org/apa.2024-03-23.1707.pdf

Seriously accepting Albert Einstein’s 1911 argument [35] that the only way to make *xyzt* inertial frames meaningfully measurable to physicists is to (a) Leverage as a starting point the rigidity property of condensed matter — a fancy way to say “use rulers”; and (b) instrument the resulting 3-space with *lots and lots of physical and* *physically synchronized clocks* to add the time dimension for that space changes more than you might think. I am not merely nitpicking about a lack of data since this is precisely the argument Einstein made — mostly with himself, I suspect — to predict that time dilation in fast-moving objects is real and measurable in physics. It's easy to forget how radical that was at that time.

What Einstein did not explore — he was moving on to General Relativity by then — was the implication of his 1911 model that all physically meaningful coordinate systems of "space" and "time" are trapped, rather messily, within the future light cones of whichever observer begins the coordinate building process anew.

Even worse, *every* acceleration nominally upsets this stability and nominally resets the slower-than-light coordinate construction process. The observer must then — slowly, within her light cone — reestablish a new *xyzt* definition. This definition must always include at least a bit of what we think of as fermionic matter, that is, matter capable of the remarkable and extremely complex property of "rigidity."

One can mostly ignore the reset process for small accelerations and still give us good metrical results. However, the resets are always measurably real and always have an impact. Why? Because these resets collapse any open quantum systems associated with that observer. You cannot accelerate and stay quantum; you must reset and begin again. That's why devices such as SQUIDS are so incredibly sensitive: They detect the collapse of your metrical space due to some seemingly trivial acceleration.

Why bring all of this up here? Because the process of *xyzt* collapse and reconstruction *has no scale limits*. Going up affects the cosmos, and going down affects particles, particularly particles with spin is self-acceleration and thus self-collapse of the particle's private definition of "space" and "time."

I do not know what dark matter is, though I have some strong suspicions. No current model can tell us what it is because their representations of space, time, momentum, and energy at cosmic levels contain no mechanism for tracking the effects of expanding and collapsing fabrics of competing spacetimes.

I suspect folks will find answers to dark matter there. It's most likely some interesting consequence not of particles *per se* but multi-scale cosmic collections of matter competing for who has the best definition of time.

Dark energy is a structural issue for how folks like Penrose and Steinhardt achieve cosmic cycling.

As for "universal" spacetime, or, even worse, "universal" wavefunctions, they can't exist and are not needed. All violate special relativity by assuming that spacetime definitions can grow indefinitely and never collapse. Reality is a lot messier than that — and why is that a surprise? We know darned well that everything we see is approximate. The "perfect" universe is always and only in our minds, and only if we ignore what physics keeps trying to tell us.

What *is* universal is causality: Once something happens, it never "unhappens" in a universe that supports the existence of information. It's universal causality, which is brutally strict, that enables one to look outward with telescopes and see a meaningful issue. Contrary to popular perceptions, "space" and "time," as we think of them, are *not* as fundamental as causality. Three cheers to Robert Spekkens on that point! [36]

I'm speculating, but I suspect Wigner's negative probabilities are little more than an odd imaging effect related to entanglement. Both arise from attempting to force *all* deep physics into local *xyzt* coordinate systems. Whatever they are, looking for deeper definitions of change and separation than local-only *xyzt* should help understand them.

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