Did the Universe Construct Itself?

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Nonlocality is now fully established. Therefore, in a choice between locality and nonlocality as fundamental, there is no longer firm a priori ground to choose locality. The consequences of choosing nonlocality as fundamental are enormous. Any theory that relies on locality cannot be fundamental. Thus, General Relativity, String Theory, and Loop Quantum Gravity cannot be fundamental. More, the AdS/CFT duality and Holographic Principle cannot be fundamental. Both require locality on the D – 1 dimensional "surface" where the CFT lives.

If we begin with nonlocality, we need not explain nonlocality but must explain locality. I take nonlocality to be constituted by N entangled coherent particles chosen from SU(3) x SU(2) x U(1). By assumption, if locality – spacetime – is to emerge, that emergence must somehow depend on the N entangled coherent particles. This flatly contradicts the assumptions of General Relativity, which is local, there is no "emergence" of spacetime in GR, and GR can be formulated without matter fields, so the very existence of spacetime cannot depend upon matter.

Starting with nonlocality seems to require that matter somehow "creates" spacetime. If true, General Relativity must be altered.

I have published one article, "Quantum Gravity if Nonlocality Is Fundamental", and a second is online on OSF and submitted: "Did the Universe Construct Itself?", references below. More, it now begins to appear at least possible to develop the ideas into a quantitative theory for Dark Matter and Dark Energy.

The paper on quantum gravity posits that sets of four mutually entangled particles sequentially actualize to events that construct successive adjacent tetrahedra that constitute the growing classical spacetime. Each new event forms a new tetrahedron with defined classical distances – on some classical length scale – to three events forming one face of an old tetrahedron. Therefore, a time orientation, old to new tetrahedron, can be specified. This yields a quantum arrow of time independent of the Second Law. The choice of four mutually entangled particles is needed to assure the "Faithful Manifold" requirement of Causal Set Theory. Four connected vertices can be embedded in three – dimensional space as a tetrahedron. The theory is similar to Causal Dynamical Triangulation.

The “Did the Universe Construct Itself?” paper reports for the first time that the particles of SU(3) x SU(2) x U(1) are capable of collective autocatalysis, rather like origin-of-life theories.

With one working hypothesis, the theory with numerical simulations using the Gillespie Algorithm to study the rich branching stochastic dynamics among the particles, starts the universe with no matter and no spacetime, and achieves baryogenesis via the autocatalysis, breaking matter-antimatter symmetry. Actualization among these particles then yields a rapid power law construction of spacetime that seems a candidate for an Inflation that both starts and stops. Together, these hope to constitute Cosmogenesis, see references.

For a short period, conservation of matter and energy is not conserved. However, no global conservation of matter and energy exists in GR, and Dark Energy itself implies a steady increase in the energy of the universe.

The most recent, very tentative, efforts bear on Dark Matter and Dark Energy. We have found no particles to account for Dark Matter. MOND does much to eliminate a need for Missing Matter by proposing that Newtonian gravitation, scaling as 1/ R ^ 2 transforms as R increases to scale as 1/R. This suggests that some modification of General Relativity, where Newton’s law somehow “weakens” with distance from galactic centers, might eliminate a need for Dark Matter. MOND, however, is always attractive so can never explain Dark Energy.

The theory I propose is a construction of spacetime that has some hope of explaining both Dark Matter and Dark Energy. Therefore, it seems of considerable interest that the theory requires that the rate of construction of spacetime varies as the density of matter to the 4^{th} power. But this may well correspond to the Baryonic Tully Fisher Relation, where matter scales as the fourth power of galactic rotation velocity. The BTFR holds over five orders of magnitude in galactic size.

Therefore, the still crude theory might now be quantitatively testable using simulations for galactic formation that are based, in part, with an assumption of Dark Matter, by replacing Dark Matter with a defined universal local rate of construction of spacetime as the local baryon density to the 4^{th} power. The hope would be to obtain the observed Galactic Rotation Curves.

A Candidate Universal Law for the expansion of spacetime: In the theory, 3- dimensional spacetime time is constructed proportional to matter to the 4^{th} power. This suggests that along any line locus, the one dimensional creation of spacetime is an acceleration that scales linearly in the distance, R, between two loci. The creation of 3D spacetime derives from creation of new

tetrahedra. Any creation of new distance must involve a minimum of one new vertex on the tetrahedron. Therefore the rate of creation of spacetime along a line may scale as Kex (M x R).

Near a galactic disc, gravitational attraction is far greater than repulsion, so Kex must be very small. For any choice of Kex, there is some distance from the disc, Rc, beyond which expansion of spacetime is faster than contraction. Our galactic cluster to 500,000 light years is gravitationally bound. Andromeda at 2.537 million light years away is not. Ignoring the mass term, this sets a rough upper bound on Kex = 10 ^ -11 G.

There may be a further striking way to test the fundamental requirement of any theory starting with nonlocality that matter must play a role in a construction of spacetime. If such construction is not spatially isotropic, some regions near galaxies will construct spacetime faster than other nearby regions. The implication, like erupting molten magma and fault lines on the earth and displaced plate tectonics, is that expanding faster growing spacetime regions will displace slower growing spacetime regions. With respect to fault lines on the two-dimensional surface of the earth, theorems assure that fault lines join in three junctions and tend to lie along Great Circle geodesics.

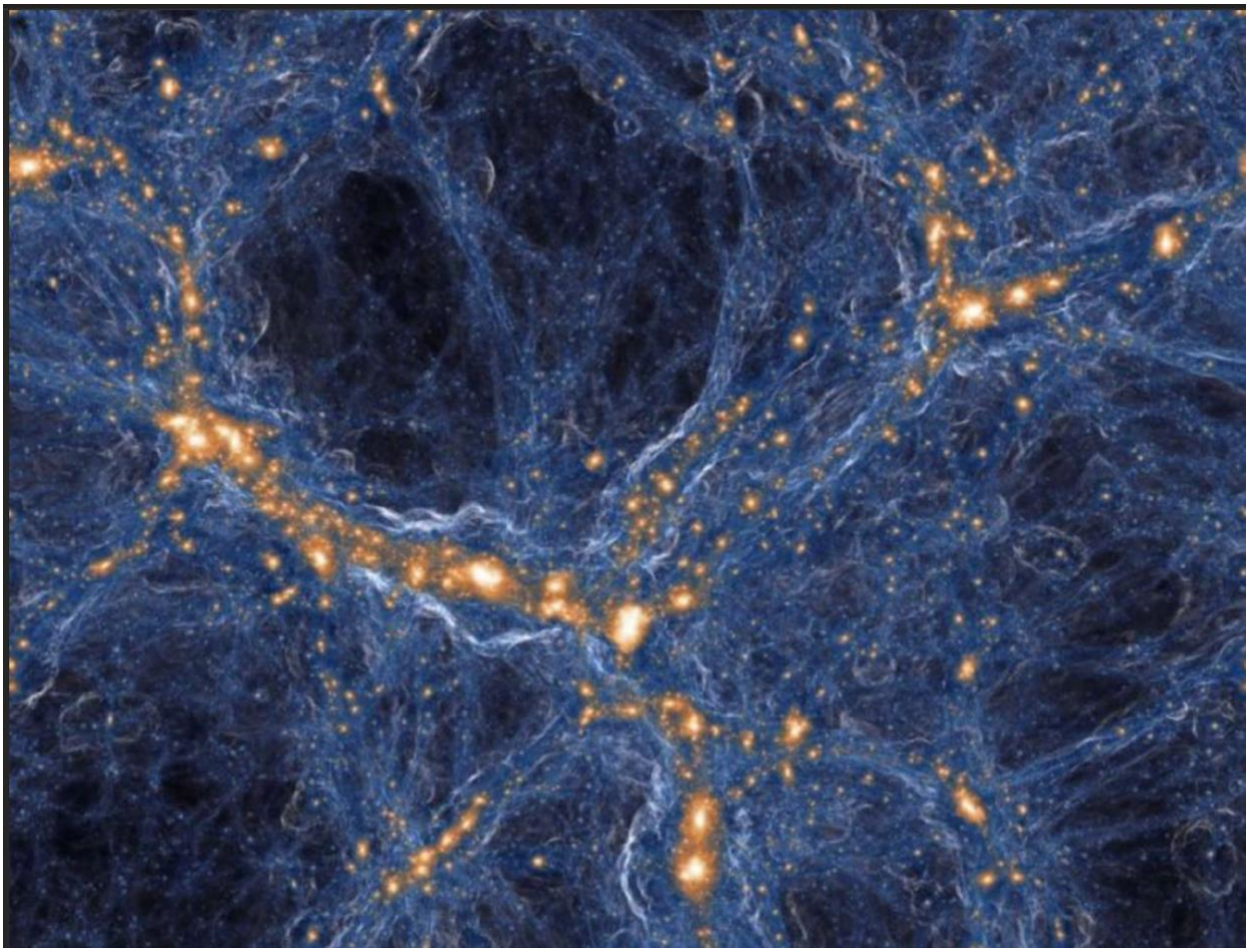
This may hold for Dark Matter. I attach an image. Dark Matter forms roughly along lines strewn with galaxies. There appears to be an abundance of 3-junctions. Why 3- junctions? There may well be established theory for this, but it may not be unique. Are the Dark Matter lines Cosmic Fault Lines with rapid creation of spacetime, hence 3 junctions? There are massive voids. Are these voids the very low mass density regions displaced by Cosmic Fault Lines? It should be easy to quantitate the number of 3-junctions, and other junctions in sky maps of Dark Matter. Cosmic fault lines, if real, may be powerful evidence that matter indeed plays a role in constructing spacetime.

A universal construction of spacetime, even where matter density is low, becomes a candidate for Dark Energy. These factors may play a role in the current Hubble tension. Matter density is low at the time of the CMB. Galaxies are formed over the life of the Cosmos.

All this is very tentative, but it seems hopeful and testable in part. If true, General Relativity requires fundamental modification for a construction of spacetime by matter.

References:

1) Kauffman, S. (2022), Quantum Gravity if Non-Locality Is Fundamental. *Entropy*, *24*(4), 554; https://doi.org/10.3390/e24040554 (registering DOI)
2) Kauffman, S. (2023), Did the Universe Construct Itself? April 12, 2023, OSF link. PNAS NEXUS SUBMITTED June 10, 2023. : https://osf.io/s5t9p



SKY MAP OF DARK MATTER