Towards a unified network theory of space, time and matter: A Conceptual and Philosophical Exploration*

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Abstract

A new theory is proposed which unifies space, time and matter. This is accomplished by introducing a dynamical network in which the nodes and links follow simple rules. Geometry emerges from the network, though this geometry will now be dynamic and probabilistic in nature. Matter emerges from the network as self-sustained dynamical structures. Quantum fields are described as extended oscillating structures of the network. Matter, as a structure in the network, will modify the surrounding network, thereby providing a framework to develop a new quantum theory of gravitation. The symmetries in the standard model of particles can be understood as a direct result of the symmetries of the underlying network. The movement of a particle is described by a propagation in the network, providing a new understanding of the particle-wave duality. Entanglement arises naturally from the fundamental structure of the network.

Keywords

Discrete spacetime, Emergent geometry, network dynamics, quantum foundations

1. Introduction

String theory, despite its mathematical elegance and promise of unifying gravity with quantum mechanics, remains fundamentally background-dependent. It assumes a fixed spacetime geometry upon which strings propagate, rather than allowing spacetime itself to emerge dynamically from the theory. This reliance on a pre-defined geometric backdrop stands in contrast with general relativity, which is fully background-independent. Furthermore, string theory lacks predictive power due to the enormous "landscape" of possible vacua, estimated to be on the order of 10^{500}, making it difficult to identify a unique low-energy limit that corresponds to our observed universe. It also fails to offer direct experimental evidence after decades of development. As Smolin [1] has argued, "string theory does not yet constitute a complete theory of nature" and struggles with issues such as background dependence and the absence of observable. Even in critical evaluations within the mainstream literature, string theory is acknowledged to lack full background independence [2] and to face challenges in connecting with empirical reality [3]. The contrast with relational and emergent models of spacetime, such as those based on discrete networks or spin foams, is striking in this regard.

Loop Quantum Gravity (LQG) [4] presents a bold attempt to quantize general relativity in a background-independent manner by replacing the smooth geometry of spacetime with discrete quantum states of geometry, so-called spin networks. While this is a conceptual strength compared to string theory, LQG also faces several fundamental challenges. Chief among them is the artificial introduction of discrete quanta of area and volume, which emerge from the formalism but are not derived from deeper physical principles or observed phenomena. The resulting "quantization" of geometry remains largely kinematical, with serious unresolved issues in the formulation of the dynamics, particularly the implementation of the Hamiltonian constraint and the problem of time. Moreover, despite decades of development, LQG has yet to produce clear low-energy limits that reproduce classical general relativity and the Standard Model in a compelling way. As Nicolai, Peeters, and Zamaklar [5] point out, LQG's dynamics are only partially understood, and its relation to observable physics remains obscure. Dittrich and Thiemann [6] also emphasize that LQG still lacks a well-controlled semiclassical limit and suffers from ambiguities in the construction of physical observables. These concerns suggest that while LQG is valuable as a framework for exploring quantum geometry, it may not yet provide a complete or physically grounded theory of quantum gravity.

In recent decades, a number of competing approaches have sought to reconcile quantum mechanics with general relativity, each exploring different routes toward a fundamental theory of spacetime. One such approach is causal dynamical triangulations, which model spacetime as a sum over causally ordered simplicial geometries [7]. Another direction involves group field theories and tensor models, which treat geometry as emergent from combinatorial or field-theoretic interactions on abstract group manifolds [8]. A third approach, known as asymptotic safety, posits a nontrivial ultraviolet fixed point of the gravitational coupling under the renormalization group [9]. While each of these frameworks introduces compelling mathematical ideas, such as background independence, discreteness, or renormalizability, they remain, at present, incomplete. Most lack a clear derivation of low-energy physics, consistent inclusion of matter, or definitive empirical predictions, and no consensus has emerged on a uniquely successful theory [10].

Quantum Graphity is a background-independent model aiming to explain the emergence of spacetime geometry from an underlying, pre-geometric network. The theory starts from a complete graph of N nodes, where links represent adjacency relations and evolve dynamically under a chosen Hamiltonian. At high energies, the system is fully connected (disordered), while at low energies, a graph with local connectivity (interpreted as a low-dimensional geometry) is expected to emerge. Originally proposed by Konopka, Markopoulou, and Smolin [11], and later refined in various forms (e.g., Caravelli & Markopoulou [12]), the model introduces link variables and operators that encode the presence or absence of edges, inspired loosely by spin systems. Despite its appealing goal of geometric emergence, the framework faces several major difficulties. First, it begins with a fixed, finite number of nodes, without a natural mechanism for node creation or topological change, being an essential feature for modeling dynamical spacetimes or cosmological singularities. Second, the choice of Hamiltonians and operators is largely ad hoc, often tailored to produce desired ground-state graphs, raising concerns about physical motivation and uniqueness. Furthermore, the representation of matter or standard quantum fields within this graph-based formalism remains largely undeveloped or absent, making it unclear how particles or interactions would arise. Finally, the absence of node splitting or branching dynamics limits the model's capacity to describe spacetime growth or topology change, especially in the early universe. These limitations have so far prevented Quantum Graphity from maturing into a predictive or testable theory.

One of the guiding themes in the history of physics has been the progressive unification of concepts once thought to be distinct. In the 19th century, Maxwell's equations revealed that electric and magnetic fields are two aspects of a single electromagnetic field, laying the foundation for a deeper understanding of light. The advent of special relativity further unified space and time into a single spacetime continuum, and showed that energy and mass are interchangeable, as famously captured in Einstein's equation $E=mc^2$ [13]. In the 20th century, the electroweak theory merged the electromagnetic and weak nuclear forces [14], and ongoing efforts have sought to unify all fundamental forces, including gravity, into a single framework. These historical milestones suggest a deep structural principle in nature: seemingly disparate entities may be different manifestations of the same underlying reality.

Yet, one major division remains: the sharp distinction between the geometry of space (or spacetime) and the matter or fields that inhabit it. General relativity treats spacetime as a dynamical entity influenced by matter, but the two are still conceptually and mathematically distinct. A truly fundamental theory may require us to go further, namely, to unify space

and matter into a common ontological substrate. In the following chapter, we take a step in this direction by introducing a network-based approach in which both geometry and matter arise from the same underlying structure.

2. Unified Dynamic Network Theory (UDNT)

Here, a new theory will be proposed, designated by Unified Dynamic Network Theory (UDNT). UDNT is a theoretical framework in which both space and matter arise from the dynamics of a common underlying dynamic discrete network structure.

2.1. Nodes and links as Fundamental Entities

The basic building blocks of the network are nodes and links (we prefer the term link over edge to emphasize their conceptual role). A link connects two nodes but carries no intrinsic length, direction, phase or weight or amplitude of some sort. Similarly, nodes themselves possess no predefined attributes. However, we will require that the nodes possess a state, as will be explained later. We adopt the strong assumption that all physical properties, of both space and matter, emerge entirely from the network's structure and its dynamics. This radical simplification places the full explanatory burden on the relational architecture and evolution of the network.

2.2. Network rules

We assume that the network is intrinsically dynamic. The number of nodes is not fixed: nodes can split into two (but not into more), and when they do, the newly created node must merge with the same or another node in the following time step.

This continual fluctuation reflects the zero-point activity characteristic of quantum mechanics. In gravitationally stable regions, the number of nodes in a given volume will fluctuate statistically around a constant average. In contrast, in an expanding region of space, node splitting may occur without immediate recombination, leading to an increase in node number and volume. Although we will not attempt here to describe the Big Bang, we assume that initially there were only a few nodes (or only one) which started splitting in an exponential way. In this paper, we concentrate on stable regions of space which do not expand.

Links are topologically robust: a link between two nodes can never simply disappear or snap, a principle inspired by the conservation of quantum information. The only way for a link to vanish is through the merging of the two nodes it connects.

When a node splits, new links are introduced. Suppose node A splits and gives rise to a new node B (with a link between A and B). This is shown in Figure 1. Node A could split in several ways; it could split such as the split node B is directly (1 link) connected to (a1,a2) or (a1, a3) or (a2, a3). Here we have chosen the option that B is connected to (a1, a2). If node A was initially connected to nodes a_1, a_2 and a_3, we require that the new node B also maintains links to those same nodes. In this way, the links effectively split as well, preserving local connectivity. So, because of this, you see now the extra (dashed) line between B and a3. This can be interpreted as the splitting/duplication of the link A-a3. When A and B eventually merge again, these duplicated links also merge. However, it is not a requirement that B merges next with A again. B could also merge with a1 or a2, with equal probability. A fundamental constraint is that there can be only one direct link between any two nodes at a given time. Interestingly, in Figure 1, node A could have been split differently, namely (in the drawing) downward to the right. In this case, A remains connected to a1 and a2 and also here an extra link is created between A and a3. The final network is the same (with A and B swapped). Now, since the total number of nodes must remain the same, A or B have to merge in the next step but not both at the same time. If A merges, B cannot

merge and vice versa. So, the link between A and B must serve as a channel to transmit the state of the node (allowed to merge or not). The link is in fact similar to entanglement. Still another possibility is shown in Figure 1d.
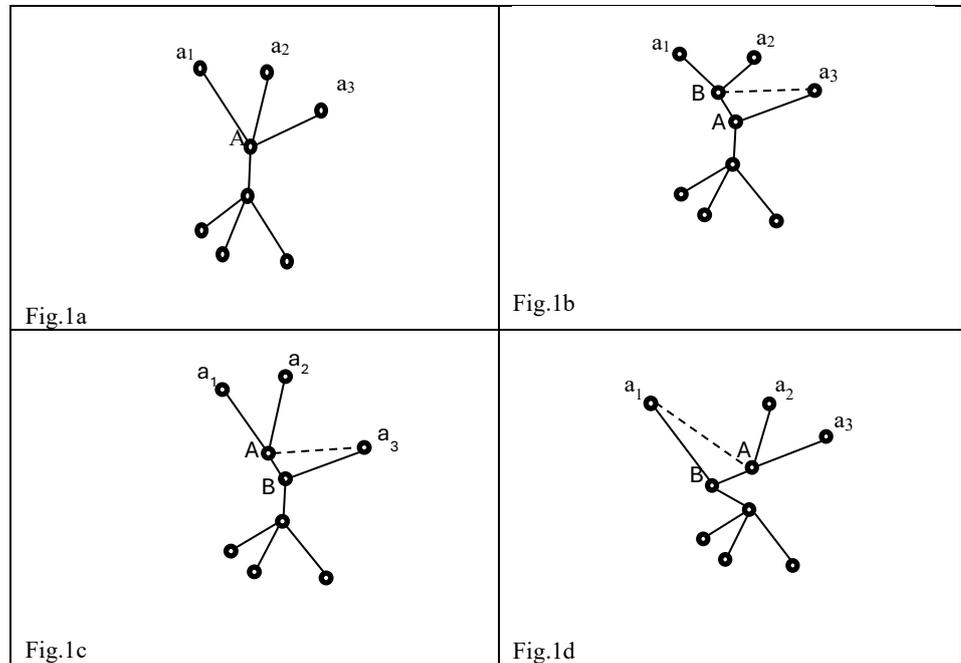

Figure 1. Fig.1a is the original (local) network. In Fig.1b, node A splits into nodes A and B, creating new links in the process. In Fig.1c and Fig.1d node A splits in still different ways.

A node with only 3 links cannot split, as this would lead to a situation with a node having only 2 links, making the node superfluous. Further, a node cannot have less than 3 links.

More rules might exist, but we want to stress that these rules should be as simple as possible, only relate to the local node environment, and not require calculations.

In order to maintain some order in the network activity, we are forced to assign some minimal properties to the nodes, namely the following two states should be assigned: 1) allowed to merge or not, 2) allowed to split or not, so in total 4 possible states. So, each node is assigned two bits; one bit (called "d" for destruction) for the status allowed merging (1= allowed, 0= not allowed) and one bit for the status of splitting (1= allowed, 0= not allowed), called "c" for creation. We deliberately chose the names of "destruction" and "creation" in analogy with the creation and destruction operators used in quantum field theory, since there is some analogy between the two.

  Considering for instance 2 connected nodes, this gives 16 possibilities. Of these possibilities, some will have the possibility to split for both nodes or to merge for both nodes. In these cases, only one of the connected nodes is allowed to split or merge. This rule ensures that the number of nodes will overall remain constant. For each of these possibilities, random choices need to be made.

Things become more complex when nodes are for instance connected to 6 other nodes. If such a node merges, it signals to all the connected nodes to change their d-bit to zero. If the node would split instead, it signals to all other connected nodes to change their c-bit to zero. This signaling must be seen in the context of entanglement, i.e., it happens instantaneously.

Further, it is important to emphasize that we do not impose any Hamiltonian or Lagrangian to describe the evolution of the network, in contrast to what is done in Quantum Graphity [11]. The evolution of the network should follow from these simple, random actions. Despite this simplicity, a very rich set of coherent structures (fields, waves, particles, etc.) will emerge. A significant aspect in this are the initial conditions; once a local, specific structure is imposed, the network rules could keep this structure stable, or let it propagate in a particular direction.

It is important to ensure and check that the chosen set of rules can lead to a stable region of space. Further, it is required that the chosen rules lead to a network structure which remains rotationally and translationally symmetric (in the absence of matter).

The proposed rules do not follow from deeper principles at this stage but are introduced as minimal dynamical assumptions that aim to capture essential features of quantum indeterminacy such as zero-point fluctuations, and information conservation, being in line with observed physical behavior. They are guided by physical intuition rather than derived from first principles and will be assessed by the extent to which they reproduce known phenomena.

At each stage of its evolution, the network may follow many possible microscopic configurations (node splittings, link connections, and local structures), which are not uniquely determined. Instead of selecting one specific evolution, we assume that all allowed possibilities coexist in a superposed state, consistent with the principle of quantum superposition. This intrinsic indeterminism is not added on top of the network model but is built into the very rules that govern its evolution. Although many global network configurations are theoretically allowed at each time step, only those differing locally in regions relevant to a given physical process contribute meaningfully. This local coherence drastically reduces the effective number of configurations that must be considered. A more detailed discussion of the quantum behavior and informational implications will be given in a later section.

2.3. No Background Space or Geometry

The distance between two nodes is defined as the minimal number of links (or nodes) one must traverse along the network to connect them. However, since the network itself is intrinsically dynamic, with nodes continually merging and splitting, such paths are constantly changing. As a result, the distance between any two nodes is not fixed but fluctuates in time, making the very notion of length inherently probabilistic. In this view, geometry is not imposed externally but emerges from the collective behavior of the network. One may wonder if a 3D geometry can really be emergent from a topological network in which even the links are not directional. Here, gravitational fields (resulting from a distortion of the network by the presence of a mass) could provide the required network structure, thus acting as an overall organizer.

A central requirement for any fundamental description of reality is that it must reproduce the internal symmetries of the Standard Model, notably the gauge groups SU(3) × SU(2) × U(1) that govern the strong, weak, and electromagnetic interactions. In the UDNT framework, such symmetries are not imposed externally but are expected to emerge from intrinsic symmetries of the network itself. This principle acts as a powerful constraint on the possible topological and combinatorial structures of the network. For instance, local link arrangements and permissible node configurations must exhibit invariances under discrete transformations that mimic continuous gauge symmetries in the effective limit. Similarly, the rules governing node-link dynamics (such as splitting, merging, or reconnection) must respect these internal symmetries at a coarse-grained level. As a result, the very architecture and evolution rules of the network are not free to vary arbitrarily but must be selected, or evolve dynamically, to preserve these deep symmetries. This perspective not only helps to explain why such symmetries exist in the first place but also offers a promising route to understanding why only certain types of particles and forces are realized in nature.

2.4. Time as an Emergent Measure of Network Activity

In UDNT, time is not introduced as an external parameter or imposed background structure. Instead, it emerges from the intrinsic dynamics of the underlying node-link network. Specifically, time is associated with the fluctuating behavior of local network configurations, where links may transiently shift, and nodes may split and merge in reversible processes. In regions of the network that are spatially stable, i.e. not undergoing net expansion or large-scale structural change, such activity does not result in permanent alterations to geometry or connectivity. However, these fluctuations still represent

physical processes, and their cumulative count serves as a natural candidate for measuring the passage of time. Just as spatial distance is defined by the number of links connecting two nodes, temporal duration is defined by the number of local network transitions (e.g., oscillatory split-merge cycles) that occur within a given region. This approach offers a relational and quantized concept of time, grounded in the network's internal evolution rather than imposed from outside. Time is effectively a count of change, and it only "progresses" where such change occurs. This has several immediate consequences: Time dilation can be interpreted as a local reduction in the frequency of network fluctuations, understood as fewer transitions per external comparison interval. In extreme cases (e.g., frozen regions or bound states), time may effectively "stop" if network dynamics are suppressed. In special and general relativity, local clocks (as well as rulers) play an essential role in the understanding of physical laws and the understanding if spacetime in general. Within out theory, these local clocks are now represented by local fluctuations.

The arrow of time may arise statistically from an imbalance in the likelihood of splitting versus merging, particularly in an expanding or evolving network.

This formulation avoids introducing a separate Hamiltonian or global clock and allows time to be understood as a derived, emergent quantity, tightly bound to the structure and activity of the network itself.

2.5. Mass, Energy and Fields as Emergent Network Quantities

In the UDNT framework, mass and energy are not introduced as external parameters but are instead understood as emergent properties of network dynamics. Two guiding principles support this interpretation:

(1)Local Suppression of Network Fluctuations.

Matter configurations are understood as stable patterns in the network that restrict or reduce the range of allowed local fluctuations. In this sense, energy is identified with a loss of dynamical freedom in the vicinity of a structure: the presence of matter limits the set of accessible link rearrangements. This aligns with the view that energy reflects deviation from a maximally fluctuating "vacuum" state.

(2) Interaction with Surrounding Network

A second, complementary interpretation links energy and mass to the influence a structure exerts on its surroundings. A persistent configuration may alter connection probabilities, reorganize link directions, or suppress the formation of nearby nodes. This external "field-like footprint" mirrors how mass in general relativity curves the geometry of space. In UDNT, however, this influence arises not from curvature but from the structure's redistribution of network activity around itself. The larger or more disruptive this footprint, the greater the associated mass-energy. These principles were anticipated in earlier proposals linking energy to the suppression of quantum degrees of freedom in space itself [16] and find natural expression in the dynamic, discrete setting of UDNT. This perspective opens a path toward understanding gravity not as a fundamental force, but as a secondary effect emerging from how matter modulates the network's intrinsic dynamics

Einstein's Field Equations describe mathematically how matter curves spacetime. However, a major shortcoming is that no physical mechanism is provided. UDNT on the other hand, provides a clear mechanism for this (in line with [16]).

Fields in UDNT are understood as fluctuating modes of the network, extending across its dynamic structure. These modes behave analogously to ensembles of coupled harmonic oscillators, with different types of fields corresponding to different allowed dynamical excitations of the network. Interactions between fields arise through specific configurations or

resonances within the network's local connectivity, enabling couplings between, for example, electromagnetic and fermionic modes. Each field encodes, at every location, the relevant quantum numbers (such as charge, spin, etc.) associated with its corresponding particle, such as for instance, a photon, gluon, or electron. Importantly, during the detection process of a particle, all the necessary information to "reconstruct" the particle from the field is already present locally in the network.

Although these fields are inherently extended, particles appear as localized excitations within them during interactions or measurements. In the UDNT framework, such localization arises naturally from the network dynamics itself. It reflects a temporary concentration of activity; a self-sustaining pattern of oscillations stabilized within a small region. This can occur through constructive interference of modes, resonance effects, or dynamic constraints imposed by the surrounding network topology. Thus, the particle is not an independent object but an emergent, sharply peaked field excitation, a coherent configuration in an otherwise fluctuating medium. Localization is therefore not imposed externally but emerges as a natural consequence of the network's internal dynamics, reconciling the wave-like nature of fields with the observed particle-like behavior.

In the UDNT framework, particles are not localized defects, but stable excitations of global fields encoded in the network's dynamic structure. Spin is interpreted as a cyclic localized pattern in the network. This naturally accounts for quantized spin behavior (such as spin-½) without invoking substructure.

Charge is attributed to persistent asymmetries or topological features in the excitation's configuration, possibly connected to internal symmetries of the network rules. These properties determine how excitations interact with specific fields and may reflect deeper conservation laws inherent in the network dynamics.

The present approach naturally supports the view that the wave function represents a real physical structure, rather than merely a computational tool for predicting measurement outcomes. In standard quantum mechanics, only the squared norm of the wave function is directly observable as a probability density, but the full complex-valued wave function contains phase and interference information essential for describing physical phenomena such as tunneling, superposition, and entanglement. This tension between formalism and interpretation has long been recognized in foundational discussions. Several authors have argued for an ontological status of the wave function, including in the context of pilot-wave theory (de Broglie–Bohm), objective collapse models, and certain realist many-worlds interpretations (see, e.g., [17, 18,19]). Yet no consensus has emerged as to what the wave function actually represents in physical terms. Within a network-based framework, however, the wave function may be interpreted more directly as a manifestation of the underlying network connectivity as a distributed configuration of links, phases, or topological constraints, that governs how a quantum object interacts with space and other systems. This view restores a form of physical realism to quantum theory and invites reinterpretation of wave phenomena as emergent features of discrete dynamical structure.

2.6 Movement of particles

In the UDNT framework, a particle is not a localized object traveling through a pre-existing space, but rather a coherent excitation of a field, itself a dynamical pattern embedded within the fluctuating network. Movement, then, is reinterpreted as a directed propagation of this excitation across the network, realized through local splitting and merging of nodes and the redistribution of links. Unlike the random fluctuations characteristic of vacuum activity, this propagation exhibits a statistical bias (preferred direction) that embodies the concept of motion and gives rise to inertia. In this view, inertia is not a fundamental property but emerges from the application of network rules under specific conditions, such as when the dynamics of node splitting and merging give rise to a persistent, directional pattern of propagation.

The familiar de Broglie wavelength naturally arises in this setting: the periodic structure of the excitation pattern, as it advances across the network, gives rise to an interference-scale wavelength whose inverse is associated with momentum. This also provides a new angle on classic quantum phenomena. For example, the double-slit experiment, often analyzed through wavefunction evolution or path integrals in conventional quantum mechanics, is rarely explored from a quantum field-theoretic perspective in which the field itself explores all paths. In UDNT, the excitation of the field propagates through the many available paths offered by the network's dynamic structure, and the resulting interference is a

consequence of superposed network histories. This suggests that the duality of wave and particle is not a paradox, but a manifestation of a deeper, unified structure, namely the network, whose excitations can both disperse and re-localize.

When looking into more detail in the relative motion of two particles, we encountered some interesting issue: Consider two particles, A and B, approaching each other with equal and opposite velocities in flat space. In standard physics, either particle can be regarded as stationary, with the other in motion, both descriptions are equivalent under the principle of relativity. However, in a dynamic network model where motion results from node merging or link rearrangement, this equivalence is challenged. If the network shortens the distance between A and B by merging nodes preferentially near A rather than B (or vice versa), it implicitly selects a preferred frame, violating the core symmetry of relativity.

This suggests that a minimal network alone is insufficient to uphold relativistic motion. Instead, something more must be present to preserve symmetry in the dynamics. Fields, understood as extended excitations or patterns distributed across the network, provide a natural candidate. They offer a way to encode propagation rules without local asymmetry. Moreover, in quantum settings, the vacuum itself carries structure, specifically, entanglement, spanning across space. It is through this entangled background that particles can move without breaking symmetry, since the network evolution need not be localized to either A or B but can proceed in a delocalized, coordinated fashion consistent with both perspectives. This explanation thus implies that fields should be described as entangled structures, which is not really the view in standard physics. In standard physics, entanglement arises between states of the field in different regions, and not between the field itself as a structure.

The maximum speed (speed of light) is obtained when nodes merge or split at the maximal possible rate in a given direction; that is when every step (operation) is effectively used in the process of movement. When some steps are lost and used instead only for internal reconfigurations, the overall distance (number of links) traversed in a given period (number of node/link transitions) will be lower.

2.7 Quantum Entanglement

In the UDNT model, entanglement arises naturally from the fundamental structure of the network. When two particles are created in a joint event (such as a decay or scattering process) they may retain direct network connections linking them beyond their initial interaction. These links persist even as the particles propagate and become spatially separated. This allows the network to maintain shared information between distant excitations without requiring any communication across space. Observable quantum correlations, such as those involving spin or polarization, may be encoded in the configuration or symmetry of these non-local connections, though the precise mechanisms remain to be explored.

In the UDNT framework, particles are not isolated point-like objects but localized excitations of quantum fields that extend across the network. As these excitations propagate, they are supported by multiple configurations of the underlying dynamic network and thus are not confined to a single node or path. Instead, they exist as distributed entities, coherently spread over many regions. This distributed presence gives rise to a form of self-entanglement, where the same excitation is coherently encoded across multiple parts of the network. Such internal correlation naturally explains quantum phenomena like delocalization and interference: a particle moving through the network is effectively entangled with itself along multiple potential trajectories, which interfere in a way consistent with observed quantum behavior.

Beyond self-entanglement, the UDNT framework also accommodates entanglement between distinct particles. When two particles are created through a common interaction, such as in a decay process or pair production, they may retain direct network links that were established at the moment of creation. These persistent, non-local correlations in the network structure act as conduits of entanglement, enabling the particles to exhibit coordinated properties across large separations, as observed in experiments violating Bell inequalities. While such entanglement is easiest to visualize for spatial correlations (e.g., in position or momentum), it also extends to internal properties like spin or polarization, which are encoded in the dynamic modes of the field excitations and their interlinked configurations.

In this view, all quantum fields in UDNT are inherently entangled structures, with coherence spanning wide regions of the network. The act of measurement corresponds to a local disentangling process: a previously extended excitation becomes confined to a particular region or outcome, through interaction with a measurement apparatus that alters the local

network state. This transition is not a destruction of the field but a reconfiguration of its correlated structure, guided by the rules and connectivity of the network itself.

3. Open Questions and Outlook

While the UDNT framework offers a promising conceptual foundation for rethinking space, matter, and quantum behavior as manifestations of an underlying dynamic network, many essential questions remain open. Addressing these will be crucial to evolving the current ideas into a predictive and testable framework.

3.1. Need for Formal Rules

At present, the network evolution rules, such as node splitting and merging are guided by physical intuition and analogies with known quantum phenomena. However, a key challenge is to formulate these rules mathematically, ideally as a minimal set of principles or an algorithmic process from which known physical laws can be derived as emergent phenomena. Questions include:

• What determines when and how nodes split or merge?

• Can the probabilistic network dynamics be described by a path integral formalism or by a discrete evolution equation akin to the Schrödinger equation?

A successful formalization would not only reproduce familiar physics but also predict departures from it under extreme conditions, such as near singularities or at ultra-high energies.

3.2. Embedding Standard Model Matter

A major challenge is whether and how the UDNT structure can account for the rich internal structure of matter fields as described by the Standard Model. Since in UDNT, all properties are hypothesized to emerge from network geometry and dynamics, one must explain:

• How do the observed particle species (electron, quarks, neutrinos, gauge bosons) arise from distinct excitation modes of the network?

• Can spin and charge be derived from persistent, topological, or symmetry-related features of the network?

• How are gauge symmetries (U(1), SU(2), SU(3)) realized as structural or dynamical symmetries of the underlying graph?

Progress in this direction may require identifying specific network configurations or symmetry groups that constrain and shape the space of possible excitations, possibly even reproducing known particle families and interaction strengths.

3.3. Network Simulation vs. Traditional Equations

In the UDNT framework, traditional mathematical equations lose much of their relevance. Equations in physics, such as differential equations used in general relativity or quantum field theory, depend critically on continuous, well-defined quantities such as position, momentum, or field strength. However, in a fundamentally discrete and fluctuating network, quantities like position or mass do not exist a priori but are emergent from the underlying dynamics of nodes and links.

Moreover, derivatives with respect to space or time, which are essential in conventional physics, have no clear definition when space and time themselves are emergent and probabilistic. As such, trying to describe network dynamics through conventional equations may not only be difficult, but misleading or conceptually incorrect.

More fundamentally, this viewpoint challenges the common assumption that the universe "obeys equations". Instead, we propose that nature follows no equations at all. Equations are powerful tools for modeling and approximation, but they are not embedded in reality. The universe evolves through local rules and actual processes, and not through abstract relations "floating" independently of the system.

Given this, the only faithful way to study such a system is through simulation. Specifically, due to the quantum nature of the network, simulations would need to capture quantum superposition, entanglement, and nonlocality. Classical simulations can only provide partial insight. In the long term, only quantum computation, with its ability to naturally represent quantum parallelism, offers the correct toolset to simulate the dynamics of the UDNT network.

Such simulations will likely not yield neat formulas or closed-form answers. Their output may be difficult to interpret or predict analytically. But this is perhaps a more faithful reflection of physical reality itself, namely one governed not by equations, but by complex, entangled, rule-based evolution.

4. Conclusions

A new theory has been proposed which unifies space, matter and time. The network provides a pregeometry from which spacetime emerges. Matter emerges from this network as self-sustained dynamical network structures. Therefore, this new network is designated as Unified Dynamic Network Theory (UDNT). This theory also smooths the path for developing a quantum theory of gravity. Using the dynamical network concept, in which many networks are in superposition, several concepts such as the wave-particle duality, entanglement and the collapse of the wave function can now be understood. It has been argued that physics, at the deeper level of the network, cannot anymore be described by mathematical equations such as is presently done for instance in the Lagrangian formulation of the standard model of particle physics. Instead, one should resort to massive simulations of the network configurations. It might be that such simulations will only be possible on advanced quantum computers. Although this network theory hints to a much deeper level of reality, we do not want to claim that this is the final level. Even deeper levels may exist which are presently beyond our imagination.

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